From: Frazer, Gary
To: james_cason@ios.doi.gov; Maureen Foster; Virginia Johnson; Jim Kurth; Casey Hammond
Cc: Tasha Robbins; Charisa Morris; Roslyn Sellars; Thomas Irwin; jean_parrish@ios.doi.gov
Subject: Re: Updated Invitation: NOTE: New title and agenda added -- Briefing on Pending E... @ Thu Feb 9, 2017 4pm - 5pm (gary_frazer@fws.gov)
Date: Wednesday, February 8, 2017 5:10:09 PM
Attachments: Briefing Paper for Notices 1-30-17_HOO.docx
Briefing Paper 2017 02 08 Red wolf ANPR.docx
ALL_STAFF-_1835026-v1-EMPF_4_5_2_SECURED_DRAFT_ESA_SECTION_4_DEADLINE_SUITS_(
Final FWS 2017 Conference Invite.PDF

"ALL STAFF 1835026..." Document withheld in full -Draft GAO Report to the Ranking Committee on Natural Resources House of Representatives; Unable to attach redacted 51 pages due to security settings embedded in document.

Attached are briefing materials for tomorrow's 4p meeting on pending ESA actions

Gary Frazer
Assistant Director -- Ecological Services
U.S. Fish and Wildlife Service
(202) 208-4646

On Wed, Feb 8, 2017 at 2:55 PM, Tasha Robbins <tasha_robbins@fws.gov> wrote:

This event has been changed.

Changed: NOTE: New title and agenda added -- Briefing on Pending ESA-Related Actions more details »

Changed: Agenda:

-Notice of application for ESA sec 10 permit -- Hoopeston wind farm draft HCP
-ANPR and scoping notice -- revision to red wolf experimental population rule
-Comments on draft GAO report on ESA deadline lawsuits
-Invitation to speak at National Mitigation Banking Association meeting in March
-Heads up on separate upcoming briefings on litigation RE: Our recent habitat rules and an overview of the ESA

When Thu Feb 9, 2017 4pm – 5pm Eastern Time

Where 5112 (map)

Video call (b) (5) CIP(b) (5) CIP(b) (5) CIP(b) (5) CIP(b) (5) CIP(b) (5) CIP

Calendar gary_frazer@fws.gov

Who
- maureen_foster@ios.doi.gov - organizer
- tasha_robbins@fws.gov - creator
- virginia_johnson@ios.doi.gov
- tasha_robbins@ios.doi.gov
- charisa_morris@fws.gov
- james_cason@ios.doi.gov
- russell_roddy@ios.doi.gov
- jim_kurth@fws.gov
- gary_frazer@fws.gov
- roslyn_sellars@fws.gov - optional
- thomas_irwin@fws.gov - optional
- jean_parrish@ios.doi.gov - optional

Going? **Yes** - **Maybe** - **No** more options »

Invitation from Google Calendar

You are receiving this email at the account gary_frazer@fws.gov because you are subscribed for updated invitations on calendar gary_frazer@fws.gov.

To stop receiving these emails, please log in to https://www.google.com/calendar/ and change your notification settings for this calendar.

Forwarding this invitation could allow any recipient to modify your RSVP response. Learn More.

Briefing Paper for Departmental Clearance of Federal Register Notices

I. Title of notice document:
Hoopeston Wind Farm Draft Habitat Conservation Plan; Draft Environmental Assessment

II. Title(s) of any document(s) the notice is making available to the public:
Hoopeston Wind Farm Draft Habitat Conservation Plan and Draft Environmental Assessment for the Proposed Habitat Conservation Plan and Incidental Take Permit

III. Document tracking number: **format: [FWS–R3–ES–2016-N094]**

IV. Summary of action (briefly describe **what** the action/project does or would do, if approved):

The purpose of this notice is to make available, to the public, the draft documents listed above for comment. (b) (5) DPP(b) (5) DPP(b) (5) DPP(b) (5) DPP(b) (5) DPP(b) (5) DPP(b) (5) DPP(b) (5) DPP(b) (5) DPP(b) (5) DPP(b) (5) DPP(b) (5) DPP(b) (5) DPP(b) (5) DPP(b) (5) DPP by the Hoopeston Wind Project in Vermilion County, Illinois. Take of these species has been requested by Hoopeston Wind, LLC for operation of the wind turbines at this project location. Review by the public is necessary step required by NEPA before the permit can be issued.

V. Is timing critical? ☒ Yes ☐ No If yes, answer the following questions. If no, go to the next section.

a. By what date must the FR notice publish?
February 8, 2016

b. What is driving the timing?

The documents to be noticed in the Federal Register must be open for public review before a permit can be issued and the subsequent implementation of the Habitat Conservation Plan can begin. (b) (5) DPP(b) (5) DPP(b) (5) DPP(b) (5) DPP(b) (5) DPP(b) (5) DPP(b) (5) DPP(b) (5) DPP(b) (5) DPP(b) (5) DPP(b) (5) DPP(b) (5) DPP(b) (5) DPP(b) (5) DPP(

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VIII. Is this an information collection notice? ☐ Yes ☒ No If yes, answer the following questions. If no, go to the next section.

a. Does the notice seek ☐ a new OMB control number or ☐ a renewal of an existing approval?

b. If the notice is for a renewal, what is the OMB control number? **format: 1018–xxxx**

IX. Approval is requested to send the notice to:

☒ The Office of the Federal Register for publication, and/or

☐ OMB for review (information collection notices only)

X. Primary contact (someone who can answer questions about subject matter):

Name: Kraig McPeek (Supervisor, Illinois and Iowa ES Field Office)
Phone: 309-757-5800 x202
Email: Kraig_McPeek@fws.gov

Briefing Paper
Departmental Clearance

Title of Document: **Endangered and Threatened Wildlife and Plants; Nonessential Experimental Population of Red Wolves (Canis rufus) in North Carolina**

RIN, if applicable: **RIN 1018–BB98**

Popular Short Name, if applicable: Advance notice of proposed rulemaking; notice of intent to prepare an environmental impact statement.

Summary (Clearly and very briefly explain what the document does and, if applicable, where the subject of the document is located):

This document gives notice to the public that the Fish and Wildlife Service (FWS) will prepare a draft environmental impact statement pursuant to the National Environmental Policy Act (NEPA), in conjunction with development of a proposed rule to revise the existing nonessential experimental population designation of red wolves in North Carolina under section 10(j) of the Endangered Species Act (ESA). As such, we are announcing the initiation of a public scoping process to engage Federal, Tribal, State, and local governments; special interest groups; and the public in the identification of issues and concerns, potential impacts, and possible alternatives to the proposed action. Information obtained during the public scoping process will be used to develop the draft environmental assessment and promulgate a proposed rule.

Is timing critical? ☒ Yes ☐ No

If yes, date the document must publish or other action must occur: As soon as posible

What is driving the timing? Scheduled Event; Two public scoping meetings need to be scheduled as soon as possible. We must give the public at least 15 days notice of the meetings. Additionally, our target due date for the draft environmental assessment and proposed rule is December 2017.

What happens if the deadline is missed?

We will have to reschedule the public meetings, including rebooking facilities where the meetings will be held. Additionally, a delay in the scoping process will delay our development of a draft environmental assessment and proposed rule, which leaves us less time to draft these actions and meet our December 2017 target date. Although this action is not court-ordered, it is part of active litigation. If we do not move forward with our commitment to complete a proposed rule by December 2017, it could set us up for additional work and leave us vulnerable to more litigation in the future.

Background: *[Briefly provide any background information, in understandable language, that will help a reader quickly understand what the document is trying to do and why, along with additional information that is useful. Assume the reader knows little about the subject matter. Minimize use of acronyms or abbreviations and do not use them at all unless they are clearly defined. Is the document a high-profile, litigated matter?]*

Based on evaluations of the red wolf recovery program and the nonessential experimental population (NEP) in North Carolina, it became clear that the management of the nonessential

experimental population of red wolves under the existing experimental population rule ("10(j) rule") is not longer supported by local landowners and the State. The Service is initiating a revision of the current 10(j) rule, which will include changing the goal of the NEP project from solely that of establishing a self-sustaining wild population to a goal of also supporting viability of the captive wolves of the red wolf breeding program. Per our regulations, to allow public participation and input, we must announce initiation of the public scoping process and the dates and times of public scoping meetings.

The proposed revision, as currently envisioned, would recognize that the size, scope, and management of the NEP will be re-focused on maintaining a wild population on only Federal lands within Dare County, North Carolina and on protecting the species by increasing the number and genetic diversity of wolves in captivity. These revisions will allow removal of isolated packs of animals from non-Federal lands at the landowners' request, incorporation of these animals into the wild/captive metapopulation, and better management of the remaining wild animals in accessible areas to minimize risks of hybridization. Management of wolves occupying Federal lands in Dare County will include population monitoring, animal husbandry, and control of coyotes and hybrids.

Issues: *[Controversial? What are the significant **issues**, **who will care**, and **how strongly** will they care?]*

We anticipate both support and opposition to the revision of the 10(j) rule. North Carolina Wildlife Resources Commission (NCWRC) supports a revision of the current 10(j) rule as they have recognized, along with the FWS, that improved management of the nonessential experimental population of the Red wolf is needed. The FWS will engage NCWRC in both the drafting of a proposed 10(j) rule and draft EIS.

We anticipate opposition to the revision of the 10(j) from several members of Congress and NGOs, as they have expressed concerns and objections to our proposed path forward for the red wolf recovery program. In particular, they object to a perceived abandonment of management of red wolves in the wild and shift in focus away from establishing a self-sustaining population.

Additionally, there may be public outcry via news stories and social media due to the perceived abandonment of the red wolf recovery program associated with our intent to revise the current 10(j) rule for the NEP project.

Communications:

Media POC: Press release to be issued by Region 4: Jeff Fleming, 404-679-7287

Other outreach: County governments within the NEP project area, other Federal agencies, private landowners and the community adjacent to the NEP project area, and other interested parties, such as NGOs, will be contacted.

Is there an information collection associated with this document? ☐ Yes ☒ No

If yes, does it have a currently approved OMB Control Number? ☐ Yes ☒ No

OMB Control Number(s): Click here to enter OMB Control Number.

Does the document require a ☐ new OMB Control Number or ☐ a renewal of an existing approval?

If a new number or renewal is required, what is the current status? Click here to explain status.

If a regulatory action, has it been on a 90-Day List for the current stage? ☐ Yes ☒ No

If yes, on which 90-Day List did it first appear at the current stage?

Click here to enter response.

Did OIRA provide comments or change the significance? ☐ Yes ☐ No

If yes, summarize comments and resolution.

Click here to summarize OIRA comments and DOI response.

This approval is to go to ☐ the Federal Register for publication. ☐ OIRA for review.

Primary Contact:

Name: Gary Frazer

Phone: 202/208-4646

Email: Gary_Frazer@fws.gov

NATIONAL MITIGATION BANKING ASSOCIATION

January 30, 2017

Mr. Gary Frazer
Assistant Director, Ecological Services
U.S. Department of the Interior
1849 C Street, NW
Washington, DC 20240

Dear Mr. Frazer,

On behalf of the National Mitigation Banking Association (NMBA), please accept this invitation for you and other officials of the Fish and Wildlife Service (FWS) to join NMBA for our First Annual Policy Conference on March 21st and 22nd in Washington, DC. The Policy Conference will open with a reception at the U.S. Capitol from 3:30-5:30 pm on March 21st, followed by an all-day conference from 8:30 am-5:30 pm on March 22nd at the University Club. Invited attendees include mitigation bankers, conservation experts, investment managers, non-governmental organizations, and other senior federal agency officials.

We ask you and your colleagues at FWS to join NMBA for the Policy Conference because FWS works closely with stakeholders in the mitigation banking industry to implement the Endangered Species Act and ensure the integrity and success of mitigation projects across the country. We are planning multiple panels and segment sessions that review recent regulatory actions related to the ESA, the 2008 Mitigation Rule, and the recently enacted Water Infrastructure Improvements for the Nation Act from the perspectives of legislators, nationally recognized counselors, and the private sector. The goal of our Policy Conference is to productively facilitate discussion on more efficient and effective mitigation projects that enhance and conserve our nation's natural resources.

Thank you for your consideration of our invitation. We are hopeful the FWS will expeditiously process our request for agency officials to attend the Policy Conference. Please do not hesitate to reach out with any questions.

Sincerely,

Sara L. Johnson

Sara Johnson
Executive Director

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8270 Greensboro Drive, Suite 700, Tysons, VA 22102
Phone: 804-771-9516 Fax: 804-644-0957 www.mitigationbanking.org

U.S. FISH AND WILDLIFE SERVICE

RED WOLF RECOVERY PROGRAM

STANDARD OPERATING PROCEDURE

Title: **Trapping and handling a live red wolf** ***SOP Number:*** **6.1**

Exceptions: The only permissible exceptions to the procedure described herein are those specified under an approved separate study. Otherwise, deviations from this SOP will only be permissible by having a new version approved.

Background: The capture of live wild red wolves is a necessary management action to facilitate monitoring, for translocations of wolves, and to address health, behavior and complaint issues. Trapping via leg-hold traps is currently the most efficient and effective means of capturing wild red wolves. Traps need to be maintained and trap lines conducted in such a way as to increase capture success with minimal damage, avoid non-target captures, and to facilitate relationships with private landowners.

Purpose: This SOP identifies practical traps and trapping techniques that continue to improve efficiency, selectivity, and the welfare of trapped animals. Guidelines are provided for trap preparation and use in the field, and procedures on running a trapline on refuge lands anytime, or on State and private lands outside of the designated trapping season. State trapping regulations are followed when trapping on private and State game lands outside of trapping season, as outlined in trapping permit issued by North Carolina Wildlife Resources Commission.

Trap Specifications and Preparation

1. #3 soft-catch traps (manufactured by Oneida-Victor) with 4 coil springs, a 6” jaw spread, and rubber pads on slightly offset jaws are used (other brands may be used but specifications should be similar). The use of rubber pads increases the surface area of the jaw on a trapped animal’s foot and may minimize animal injury.
2. Pan-tension set at a minimum of six pounds may improve selectivity and foot position in the trap and help prevent the capture of smaller non-target species.
3. The anchoring system is critical in that it must always be strong enough to hold the targeted wolf. Drags are typically used to allow the captured animal to find cover, and to give the foot time to swell, thus decreasing the chance of pulling out. A minimum of 8 feet of heavy chain (e.g. #5 straight-link) is used with a well-designed drag that is strong enough to prevent parts from bending or breaking and heavy enough to limit the distance

a wolf or other large animal can move from the capture site. When stakes are used, two 24" stakes with cross-staking should be used to ensure the stakes will not pull from the ground after the catch. Cable or chain stakes may also be used when sufficiently anchored. A drag may also be used as a backup in addition to a stake in case the stake is pulled from the ground.

4. Traps are to include in-line shock springs on anchoring systems, whether they are stakes or drags, in order to reduce injury and/or prevent escape. Shock springs should be of high quality and adequate strength to resist a captured animal's ability to destroy the spring (e.g. JC Conner t-bar shock spring).
5. In order to prevent injury to the captured animal, proper swivels should be used to prevent the chain or cable of an anchoring system from binding at the stake or drag (e.g. Minnesota Brand crunch proof in-line swivels).
6. Inspect traps, chains, swivels and all connections thoroughly for damage or potential separation prior to setting.
7. All traps must be labeled with an attached identification tag or stamp.

Set Location and Procedures

1. Traps should always be set and used in a fashion that limits the risk of capturing non-target animals, including domestic animals, while increasing the chances of capturing the targeted wolf or wolves.
2. Traps should be set in locations that prevent entanglement with fences, structures, or other objects that might result in injury, and that will minimize the chance that objects or debris will prevent swivels from functioning properly. Care should be taken to prevent entanglement near canals, bridges, and water control structures as well to prevent injury and even drowning. If using drags, consider that animals captured on drags may travel far from the location where captured. Also be cognizant of potential rain or snow events that may make following 'drag marks' and finding the trapped animal more difficult.
3. If environmental conditions could potentially harm target animals in traps, cease trapping or check the traps as frequently as needed. Note that an increase in the frequency of monitoring traps will often decrease the likelihood of a capture due to disturbance, particularly during corpuscular hours when wolves and wildlife are generally more active. Heat-related injury is a major concern when trapping wolves. Capture efforts should be coordinated in such a fashion as to avoid temperatures in excess of 80°F, as canids are extremely susceptible to hyperthermia when stressed at these temperatures. As such, trapping efforts cease during consistently high temperatures, a procedure consistent with other large carnivore programs and AZA guidelines (Henry et al. 1995, AZA Canid TAG 2012). Trapping efforts are also suspended when temperatures drop below 32°F, as freezing weather greatly increases the risk of injury via frozen tissue in a trapped foot. **In the case of instances where wolves represent a human safety concern, or are a threat to livestock/pets or personal property, traps may be set in inclement weather. However, care must be taken to minimize injuries to captured animals to the greatest extent possible. For example, traps may be checked throughout the night in freezing weather, or covered after monitoring in the morning when temperatures and humidity are high (e.g., >80°F).**
4. All traps must be physically checked a minimum of every 24 hours, preferably each

morning.

5. Animals should be removed from foot-hold traps as quickly and safely as possible. Extended time in these traps can cause foot tissue damage through decreased circulation to the trapped foot. Extended time in a trap also increases potential for an animal to injure itself during escape attempts. Note that not all injuries, especially tissue damage to the trapped foot or even broken toes, are immediately apparent.
6. Captured canids not immediately released should be placed in a secure transport kennel until processing can occur.
7. Non-target animals captured will be released alive, or disposed of in accordance with any applicable federal or state permits.
8. Captured animals intended for release, relocation, or captivity will be handled (see SOP Immobilizing and Processing a Live Canid) and transported appropriately to achieve Program objectives.
9. When trapping on public lands, coordination must take place with the appropriate land managers. Prior to setting on private lands, written consent of the landowner or his/her designee must be obtained and filed with Recovery Lead.

Approved:

Recovery Lead Date

Literature Cited:

AZA Canid TAG 2012. Large Canid (Canidae) Care Manual. Association of Zoos and Aquariums, Silver Spring, MD. 138 pages.

Henry, V. G., M. K. Phillips, W. Waddell, and T. E. Lewis, Thomas E. 1995. Protocol for Island Propagation Projects. Red Wolf Management Series Technical Report No. 11, U.S. Fish and Wildlife Service Southeast Region, Atlanta, Georgia, 52 pages.

U.S. FISH AND WILDLIFE SERVICE

RED WOLF RECOVERY

STANDARD OPERATING PROCEDURE

Title: The sterilization and monitoring of coyotes on the Albemarle Peninsula ***SOP Number:***

Commented [PMB1]: Should we include red wolves in the title?

Commented [BA2]: Yes – just hadn't gotten that far. Wanted to see if working wolves into this protocol would work.

Purpose: The purpose of this SOP is to provide instruction and guidance on the sterilization and monitoring of coyotes used for the control of hybridization in the red wolf population and for coyote and red wolf population and placeholder analysei~~s~~.

Exceptions: The only permissible exceptions to the procedure described herein are those specified under an approved separate study. Otherwise, deviations from this SOP will only be permissible by having a new version approved.

Procedure: The protocols below, unless otherwise stated, refer to coyotes and red wolves collected by Red Wolf Recovery Program (Program) personnel within the Red Wolf Recovery Area (Beaufort, Dare, Hyde, Tyrrell, and Washington counties), sterilized, and released with GPS collars provided by and for study by the North Carolina Wildlife Resource Commission (WRC).

Commented [RH3]: Does this still exist? ES staff?

Capture and Processing

1. Authorization to capture coyotes on private lands and State Game Lands comes from the WRC Research Permit (attachment A). All conditions of the Permit must be followed. A copy of the Permit must be carried when engaging in the covered activities. Licensed trappers operating under a cooperative agreement with the Program may conduct activities authorized under this Permit and must carry a copy of this permit and a signed copy of the cooperative agreement.
2. Coyotes and wolves are captured by Program personnel using padded foot-hold traps including: #3 soft-catch traps, MB_500.
3. Biological and genetic samples are to be taken from each captured canid according to the standard operating procedure: The Collection and Handling of Biological Samples for NCWRC (see attachment _)

Selection of Animals and Location

Coyotes and hybrids

1. The selection of coyotes used for sterilization and GPS monitoring will be made by Program staff and be determined by field management needs. Although supposed breeding age coyotes believed to be territory holders will be targeted, every effort will be made to deploy as many GPS collars on sterile coyotes as possible, including coyotes believed to be transient.
2. If coyotes captured on private lands are determined suitable for sterilization and monitoring, signed permission to release such coyotes will be required by the landowner where it was captured.

Red Wolves

~~2.~~

~~3.~~ All red wolves captured and released will be equipped with monitoring devises. These can include VHF or GPS collars or abdominal transmitters. Young animals will generally not be targeted for capture. In the event that young animals are captured any animals weighing less than xx pounds or with neck diameters less than yy will have abdominal transmitters inserted prior to release. Wolves greater than 8 months of age and that are in good health ~~meeting these weight and size requirements~~ will be fitted with an appropriate sized radio ~~transmitter~~ collars so that the population can be closely monitored. First preference will be to utilize VHF collars given the superior battery life and durability of these devises which allow us to meet program management needs while limiting the likelihood of needing to recapture the animal. Red wolves captured on private lands and slated for release may be eligible for GPS collars provided they meet the criteria of an appropriate study design. Only wolves 9~~8~~ months of age or older, and of adequate size and health as determined by Program staff, will be outfitted with a GPS collar. In addition, established breeders of a wolf pack *~~,~~ would not be eligible for a GPS collar. This will allow the Program to manage these wolves long-term without recapture and help ensure hybrid events and pack stability are maintained.

Sterilization

1. Coyotes and hybrids are to be taken to a local veterinary clinic for surgical sterilization.
2. Male and female coyotes are to be reproductively sterilized by vasectomy and tubal ligation, respectively.

GPS Collar Programming and Monitoring

~~4.~~3. WRC will program all GPS collars prior to deployment. Changes to the programming can be made as needed based on the data received, performance of the collars, and changes in data needs or requirements.

~~5.~~4. WRC will be responsible for downloading data and can provide assistance to the Program regarding location information as it relates to field needs. VHF function will also allow Program staff to monitor general locations to aid in field management.

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Commented [RH4]: I thought we're still in limbo about these landowner agreements…they've been perpetually 'under review' in the RO or with the SOL. Can we release animals with signed permission, or only with explicit landowner agreements?

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Commented [PMB5]: Can we establish some sort of minimum sizes like this or does it need to be more case-by-case?

Commented [BA6]: I would like to keep an age component here as regarless of size, if it's a young wolf, say lest than 8 months or so, it still has a period of growth remaining that will cause problems with a collar. We can be general in stating the wolf has to be large enough size/neck to accomadate the appropriate sized collar.

Commented [RH7]: ?

Data Management

Approved:

Field Coordinator Date

Commented [RH8]: This is a big deal and requires careful consideration. I would like to see something in here stating that per our policy that radio frequencies are confidential and not subject to FOIA (http://www.fws.gov/policy/272fw2.html). As such, both agencies should agree in writing not to release this information to the public.

Similarly, how will these data be shared between agencies? How will they be shared with the public? Do commissioners get weekly map updates as they do now? Will information be available on the web? What is the time lag? I am concerned about animal safety.

Appendix A.

Updated September 1, 2016

Table 1. Causes of mortality in wild red wolves (*Canis rufus*) 2013-2016.

Cause of Death	# of Total Mortalities 2013	# of Total Mortalities 2014	# of Total Mortalities 2015	# of Total Mortalities 2016
Natural				
Health-related		3	1	
Intraspecific competition				
Human-related				
Management-related actions		2		
Non-management-related actions	1	2	2	
Vehicle strike	3	3		1
Suspected or confirmed gunshot	9	4	4	
Poison			1	
Unknown				
Lack of biomaterial		1	5	2
Suspected illegal take	2		3	
Pending necropsies			1	1
Total Mortalities	15	15	17	4
Population Estimates				
Known wild red wolves (End of Year)	66	62	45	45
Estimated total wild red wolves	90-110	90-110	50-75	45-60

Definitions:

Health-related: mortality as a result of acute illness, disease (e.g., heartworm, mange), starvation, and old age.

Intraspecific competition: injuries caused by other red wolves.

Lack of biomaterial: mortalities in which not enough of the carcass remains (e.g., partial skeleton or hair mat) to determine cause of death.

Management-related actions: mortality related to USFWS conservation actions, including trapping, denning, monitoring, handling, and animal processing.

Non-management-related actions: mortality related to private trapping.

Pending necropsies: cause of death initially undetermined; waiting for official necropsy results

Suspected or confirmed gunshots: mortality related to gunshot. Most of these cases are ongoing investigations with the USFWS Office of Law Enforcement. Confirmed cases include official necropsy results and/or x-rays showing evidence of gunshot, or when the mortality was reported by the shooter as mistaken identity (e.g., coyote) or as a threat to life or property.

Suspected illegal take: evidence of foul play exists (e.g., a cut or removed radio-telemetry collar), but cause of death has not yet been determined. These cases may include ongoing investigations with USFWS Office of Law Enforcement. Take is defined as "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" (Endangered Species Act of 1973, as amended).

Vehicle: mortality sustained from the collision with a motor vehicle (including farm equipment)

For more information on the Red Wolf Recovery Program activities, please visit our website.

Potential Follow-up Studies to Conduct in Louisiana

To make informed decisions regarding the canid population and possible existence of red wolves in Louisiana, we propose the following as very preliminary steps:

1. Collect hair and scat samples – This method will be used for general sampling of areas. It is low effort, little training is needed, and can be conducted throughout the year. However, it is likely that a lot of non-target hair samples will be collected.
    - Replicate the study conducted by Murphy et al. (2018), but potentially adjust protocol to increase usable sample size.
    - Arkansas State University (ASU) is planning to conduct a general survey (hair and scat samples) of canids in the region (AR, LA, MO, and eastern OK).
        - Could collaborate with them on this particular sampling. At the very least, we should coordinate efforts and methodology.
    - Possibly include new areas not sampled in Murphy et al. (2018).
    - These surveys could inform potential areas for future trapping efforts.

2. Targeted trapping efforts – This method will be used in areas of interest (i.e., areas where potential red wolves are identified via hair and scat sampling). Trapping can only be conducted January through February and by persons authorized, trained, and equipped to safely and effectively conduct canid capture operations.
    - Based on the results of Murphy et al. (2018), trapping efforts should be initiated in Sabine NWR.
    - Protocol (see page 2) will include:
        - Recording locations (GPS)
        - Body measurements
        - Blood drawn
        - Vaccinations (?)
        - Photos
        - Radio collar animals that fall within accepted morphological measurements of red wolves.
    - Blood will be sent to University of Idaho for genetic testing

Potential partners: Refuges, Louisiana Department of Wildlife and Fisheries (LDWF), ASU, USDA-Wildlife Services, Animal Welfare Institute, other universities

Draft Trapping Protocol for Louisiana

- If possible, a good initial step would be for Sabine NWR to pre-bait areas (with road kill or something similar) in areas where there appears to be active canid use, and place remote sensing cameras. This will prime these areas for trapping shortly after and give a visual of what animals visit those areas.
    - Additionally, hair snares should be placed at those pre-bait sites and other canid use areas. This provides a lower effort/lower need for training way of obtaining samples for genetic testing. All hair samples will be sent to the appropriate lab for analysis. It is likely that a lot of non-target hair samples will be collected.

- If local Sabine NWR staff, Wildlife Services, State of Louisiana personnel, university researchers or private trappers are authorized, trained and equipped to safely and effectively conduct canid capture operations, trapping could begin in January. If not, two staff from the Eastern NC ES Sub-office's Red Wolf Recovery Program, in coordination with Refuge staff, will conduct canid capture operations throughout the appropriate habitats of the refuge in February.
    - If they are not able to operate independently, staff/personnel can provide additional support during trapping efforts.
    - Trapping window should be a minimum of two weeks, if not longer. Trapping past February is not recommended due to breeding season, subsequent denning and birth, and then heat issues.

- All canids captured will have the capture location GPS'd, full measurements taken (e.g. body length, skull, weight, etc.), blood drawn, vaccinated (?) and the canid photographed. All capture and handling operations will be conducted in accordance with the SOPs utilized in the North Carolina nonessential experimental population. Coordination with Refuge staff will determine the appropriate steps if non-canids are captured. For example, if the animal should be released immediately or if they would like them processed for other purposes.

- Blood samples will be sent directly to the University of Idaho for genetic testing.

- All animals will be released at or in close proximity to where they are captured as soon as they are able to be released. Unless

- All, or a sampling of animals, that fall within the accepted morphological measurements of red wolves will be radio collared before release for the purposes of tracking their movements to determine general habitat use and home range (e.g., how much of their movement is on the refuge) and to more easily facilitate recapture should it become desired.
    - Radio collars and frequencies to be used would need to be coordinated with Sabine NWR, university researchers and or the State of Louisiana.

- Collared canids should be monitored for general location and mortality from the air or ground at least once a week to get a sense for their movements.

Commented [WE1]: Joe, this was in the original draft plan…should something be included here?

NOTE TO REVIEWERS

ACTION: Possible follow-up canid studies to conduct in Louisiana

STAFF ORIGINATOR: Emily Weller SUPERVISOR: Aaron Valenta

IS THE ACTION LITIGATION DRIVEN? No
IF SO, WHO SUED US AND WHEN:
ANY COURT-ORDERED DEADLINES? No

ACTION REQUESTED:

SIGNATURE_____ REVIEW AND COMMENT__X_
SURNAME___ FYI ONLY _____

VERY BRIEF BACKGROUND ON ISSUE/ACTION:

Following the Murphy et al. (2018) study that identified a possible red wolf in Sabine National Wildlife Refuge, Louisiana, members of the red wolf recovery program offer these suggested follow-up actions in Louisiana: 1) general hair and scat sampling and 2) targeted trapping efforts. While we have a general plan and protocol, details will need to be finalized with partners. Additionally, before sampling begins, and particularly before trapping begins, criteria should be developed for identifying red wolves. In particular, criteria should be defined under genetics, morphology, and behavior, as these were used in the National Academy of Sciences study on red wolf taxonomy and its determination that the red wolf is a distinct species.

Potential Follow-up Studies to Conduct in Louisiana

1. Collect hair and scat samples – This method is for general sampling of areas for genetic testing. It is low effort, little training is needed, and can be conducted throughout the year. It is likely that many non-target hair samples will be collected.
   - Replicate the study conducted by Murphy et al. (2018), but potentially adjust protocol to increase usable sample size.
   - Arkansas State University (ASU) is planning a study (hair and scat samples) of canids in the region (AR, LA, MO, and possibly eastern OK) (no timeline yet).
     - Could collaborate with them on this particular sampling. At the very least, we should coordinate efforts and methodology.
   - Possibly include new areas not sampled in Murphy et al. (2018).
   - All samples will go to a qualified laboratory for analysis.
   - These surveys could inform potential areas for future targeted trapping efforts.

2. Targeted trapping efforts – This method will be used in areas of interest (e.g., Federal lands, areas where potential red wolves are identified via hair and scat sampling, or areas with animals suspected of higher red wolf DNA). Trapping provides opportunity to gather genetic, morphology, and behavioral data.
   - Due to the breeding season, trapping would likely be limited to December through February and be based on weather conditions. Trapping will only be conducted by persons authorized, trained, and equipped to safely and effectively perform canid capture operations.
   - Potential red wolves have been identified in Sabine NWR (Murphy et al. 2018); therefore, trapping efforts should be initiated there first.
   - See draft trapping protocol below
   - Blood samples will go to a qualified laboratory for genetic testing.

Potential partners: FWS Refuges, Louisiana Department of Wildlife and Fisheries (LDWF), ASU, USDA-Wildlife Services, Animal Welfare Institute, other universities; Ecological, Evolutionary and Conservation Genetics (University of Idaho) or other qualified laboratory

Draft Trapping Protocol

- To prime target areas for trapping and get a visual of what animals visit those areas, target areas will be pre-baited, if possible, with road kill or something similar, and remote sensing cameras set up.
  - Due to the presence of alligators, and based on local expertise, it might be preferred to pre-bait with scent lures and not carcasses.
  - Areas where there appears to be active canid use should also be pre-baited.
  - Hair snares will be placed at pre-bait sites and other canid use areas.

- Trapping can begin in December, weather permitting, if Sabine NWR staff, ES staff, Wildlife Services, LDWF personnel, university researchers or private trappers are authorized, trained and equipped to safely and effectively conduct canid capture operations.
    - If not, two staff from the Eastern NC ES Sub-office's Red Wolf Recovery Program, in coordination with Refuge staff, could potentially conduct canid capture operations throughout the appropriate habitats of the refuge during portions of the trapping season.
    - Trapping window should be a minimum of two weeks, if not longer. Trapping past February is not recommended due to breeding season, subsequent denning and birth, and issues related to the health and safety of the trapped individuals in hotter temperatures.

- All capture and handling operations will be conducted in accordance with the SOPs utilized in the North Carolina nonessential experimental population. The following will be recoded for all captured canids:
    - Recording locations -GPS
    - Sex
    - Body measurements
    - Weight
    - Breeding condition
    - Blood drawn
    - Photos
    - PIT tags
    - Vaccinations – if determined to be appropriate by FWS Refuge and LDWF staff

- Animals that fall within accepted morphological measurements of red wolves will be radio collared for the purposes of tracking their movements to determine general habitat use and home range (e.g., how much of their movement is on the refuge) and to more easily facilitate recapture should it become desired.
    - There may be instances where we may want to radio collar individuals outside of the morphological measurements (i.e. suspected mate of a red wolf).
    - Radio collars and frequencies to be used would need to be coordinated with Sabine NWR, university researchers and/or LDWF.
    - Collared canids should be monitored for general location and mortality from the air or ground at least once a week to get a sense for their movements.

- All animals will be released at or in close proximity to where they are captured as soon as they can be safely released. Unless an individual needs to be held for purposes such as receiving veterinarian care for injuries or disease.

- No canids will be euthanized unless it is determined to be the best course of action for the health of the animal (e.g. severe trap injury).

- Coordination with Refuge and/or LDWF staff will determine the appropriate steps if non-canids are captured. For example, if the animal should be released immediately or if they would like them processed for other purposes.

Points to Consider Prior to Implementation

- Before collecting data, especially before trapping animals, we need a study design (sampling plan and criteria).
- Possibly assemble a team to determine criteria for red wolf
    - Nucharin Songsasen, head of the research group formed at the Smithsonian Workshop, is willing to form a team to answer this question
- NAS study used a 3-part test (genetics, morphology, and behavior).
    - Genetics – consult geneticists on which specific alleles or percentages of red wolf lineage are needed to meet the genetics portion.
        - In NC, it is 87.5% red wolf ancestry (founders), although it was 75% in the beginning stages of the program.
        - However, alleles that may be representative of red wolf genetics not accounted for by the founders, but present on the landscape, will not be accounted for in genetic results.
    - Morphology – consult with Nowak, Hinton, etc. for morphological and weight specs.
    - Behavior – telemetry (for home range size) and other data are needed to evaluate the behavioral portion.

Collaring canids

- Should we have an intermediate set of morphological standards in case no "full standard" animals are captured or at least have the understanding that some "larger" non-red wolf canids might be collared in an effort to study the local current canid population.

Potential red wolves

- Should we hold an animal that is within the morphological characteristics of a red wolf and looks/acts like a red wolf, for at least as long as the blood work would take, if not permanently, to ensure that we do not lose this genetic line? One new individual to the SSP population could substantially boost genetic diversity.
    - If this is a potential option, we need to do some advanced planning (e.g., coordination with SSP), possibly NEPA, etc.
    - Will need to weigh the pros and cons of removing that animal

Trapping team

- The Eastern NC ES Sub-office has limited staff who have trapping obligations in NC, as well as St. Vincent NWR. We need to plan our team(s) ahead of time to ensure that we have an adequate number of authorized, trained, and equipped people to safely and effectively perform canid capture operations.
    - We could potentially provide training, if needed.

Cost

- Funding
    - Particularly genetics testing

  If we hold potential wolves until genetic test results, it may be beneficial to line up funding this FY so that samples can be sent and tested right away.

AGENDA

N.C. WILDLIFE RESOURCES COMMISSION
July 12, 2018, 9:00 a.m.
1751 Varsity Drive
NCWRC Conference Room, 5th Floor
Raleigh, North Carolina

CALL TO ORDER - *Chairman John Coley*

This meeting is being recorded as a public record and is audio streaming live at www.ncwildlife.org. As a courtesy to others please turn off all cell phones during the meeting.

PLEDGE OF ALLEGIANCE – *Commissioner David Hoyle, Jr.*

INVOCATION - *Commissioner Richard Edwards*

RECOGNITION OF VISITORS

MANDATORY ETHICS INQUIRY - North Carolina General Statute 138A-15(e) mandates that the Commission Chair shall remind all Commissioners of their duty to avoid conflicts of interest and appearances of conflict under this Chapter, and that the chair also inquire as to whether there is any known conflict of interest or appearance of conflict with respect to any matters coming before the Commission at this time. It is the duty of each Commissioner who is aware of such personal conflict of interest or of an appearance of a conflict, to notify the Chair of the same. *Chairman John Coley*

APPROVAL OF MINUTES – Take action on the April 26, 2018 Wildlife Resources Commission meeting minutes as written in the exhibit and distributed to members **(EXHIBIT A)**

ADMINISTRATION

Financial Status Report - Receive a financial status report on the Wildlife Operating Fund and Wildlife Endowment Fund – *Melissa Earp, Finance Office Chief* (**EXHIBIT B)**

RECOGNITION OF 2018 NATIONAL FISHING AND BOATING WEEK LICENSE WINNERS - Present Lifetime Unified Sportsman License donated by Russell Rhodes of Neuse Sport Shop in Kinston and Lifetime Freshwater Fishing License donated by the N.C. Council of Trout Unlimited, from drawings at fishing events held during the 2018 National Fishing and Boating Week – *Chairman John Coley*

PHOTOS

COMMITTEE REPORTS

Small Game and Wild Turkey Committee Report – *Garry Spence, Chair*
Fisheries Committee Report – *Tommy Fonville, Chair*
Big Game Committee Report – *John Litton Clark, Chair*
Habitat Nongame and Endangered Species Committee Report for June 20, 2018 – *Mark Craig, Chair*
Habitat Nongame and Endangered Species Committee Report for July 11, 2018 – *Mark Craig*
Land Use and Access Committee Report – *Tommy Fonville, Vice Chair*
Committee of the Whole – *Chairman John Coley*

AGENCY SPOTLIGHT – **CANID RESEARCH ON THE ALBEMARLE PENINSULA –** *Andrea Shipley, Mammalogist*

WILDLIFE EDUCATION DIVISION

Education Division Update – Receive a staff update on activities of the Wildlife Education Division – *Kris Smith, Wildlife Education Division Chief*

INLAND FISHERIES DIVISION

Fisheries Division Update - Receive a staff update on activities of the Inland Fisheries Division – *Todd Ewing, Aquatic Wildlife Diversity Supervisor*

WILDLIFE MANAGEMENT DIVISION

Wildlife Management Division Update – Receive an update on the activities of the Wildlife Management Division – *Dr. David Cobb, Wildlife Management Division Chief*

Temporary Rulemaking Final Adoption – Consider final adoption of temporary rules regarding the importation of cervid carcasses and carcass parts – *David Cobb* **(EXHIBIT C)**

Alligator Management Plan Addendum – Consider an addendum to Alligator Management Plan options - *Allen Boynton, Wildlife Diversity Coordinator* **(EXHIBIT D)**

LAND AND WATER ACCESS SECTION

Land Acquisitions and Property Matters

Phase II Land Acquisition – Consider final approval to proceed with acquisition of the following property – *Brian McRae, Land and Water Access Section Chief* (**EXHIBIT E**)

- Knox Landing – Caldwell County

Easement Request – Consider a request from NC Department of Transportation for an easement across Shocco Creek Game Land – *Brian McRae* (**EXHIBIT F)**

Property Exchange Request – Consider updated request and proposed final plan for the Dare Challenge project property exchange – *Brian McRae* **(EXHIBIT G)**

Temporary Rulemaking – Consider final adoption of temporary rulemaking for Green Swamp Bear Sanctuary – *Brian McRae* **(EXHIBIT H)**

Temporary Rulemaking - Consider final adoption of temporary rulemaking for game lands – *Brian McRae* **(EXHIBIT I)**

- Extended archery season at South Mountain and Buffalo Cove game lands
- Introductory gun either-sex season at Cold Mountain Game Land

WATER SAFETY RULEMAKING

Final Adoption – 15A NCAC 10F .0300 – Local Water Safety Rules – Consider final adoption of 13 amendments to water safety rules and final readoption of four water safety rules as part of the 2016 Periodic Review of Rules - *Betsy Haywood, No-Wake Zone Coordinator* **(EXHIBIT J)**

Final Adoption, No-Wake Zone – Queens Creek, Hubert, Onslow County – Consider final adoption of an amendment to 15A NCAC 10F .0320 – Onslow County, for a no-wake zone at a boating access area on Queens Creek in Hubert – *Betsy Haywood* **(EXHIBIT K)**

CONSIDERATION OF NONGAME WILDLIFE ADVISORY COMMITTEE APPOINTMENTS – Pursuant to North Carolina General Statute § 113-335, consider appointment of members to the Nongame Wildlife Advisory Committee – *Gordon Myers, Executive Director* **(EXHIBIT L)**

COMMENTS BY CHAIRMAN – *Chairman John Coley*

COMMENTS BY EXECUTIVE DIRECTOR – *Gordon Myers*

ADJOURN

U.S. Fish & Wildlife Service

Alligator River
National Wildlife Refuge

Yours to enjoy...
Alligator River National Wildlife Refuge encompasses a broad expanse (152,000 acres) of mysterious wildlands and waters. Visitors are welcome to explore this unique upland swamp refuge. Designated wildlife drive and trails offer the best wildlife viewing opportunities. Black bear, deer, river otters, and red wolves, along with a variety of birds, reptiles, and amphibians may be seen. During the winter months, large numbers of waterfowl and other migratory birds are present. Wildlife viewing is best from a safe distance. If you plan to venture into areas not designated as roads or trails on this map, please inform a responsible person of your plans. Be aware that poison ivy, ticks, insect pests, poisonous snakes (cotton-mouths, copperheads, and timber rattlers), and other natural nuisances and hazards may be encountered. This is your National Wildlife Refuge. Please enjoy your refuge experience, but handle with care.

Tips for Wildlife Viewing
Wildlife are usually most active at dawn and dusk.

Walk or drive slowly and quietly; stop frequently to watch and listen.

Be friendly to other visitors; often they will share information!

Bring binoculars or spotting scopes and field guides.

Bring insect repellent and a non-alcoholic drink.

You Can Help
By obeying regulations and respecting the refuge, wildlife, and other visitors.

By volunteering your time. Contact the Volunteer Coordinator at 252/473 1131 ext. 227.

By joining the Coastal Wildlife Refuge Society, P. O. Box 1808, Manteo, NC 27954

100% of your membership fees and donations support refuge programs.

In addition to these provisions, all State laws, County codes, and Title 50 of the Code of Federal Regulations apply on the Refuge. If you have any questions about the legality of any activity, please contact the Refuge Manager.

Regulations
General
The Refuge is open during daylight hours only (1/2-hour before sunrise to 1/2-hour after sunset).

Camping, open fires, feeding or baiting of wildlife, swimming in Refuge canals, or entering any area posted with "Area Closed" signs is prohibited.

All domestic pets (dogs, cats, horses, etc.) must be properly confined, leashed (10-foot maximum), or haltered and under owner control at all times.

Littering or dumping of garbage, refuse, sewage, debris, or other wastes or poisons is prohibited.

The use of a spotlight, automotive headlight, or other artificial light to spot, observe, locate, or take any animal is prohibited.

Taking, possessing, injuring, disturbing, damaging, destroying, or collecting any plant or animal (or attempting these actions) is prohibited.

Destroying, defacing, damaging, disturbing, or removing any private or public property, including any natural object or artifact, is prohibited. The use or possession of metal detectors or similar devices is prohibited.

Disturbing, molesting, or interfering with any person engaged in an authorized activity is prohibited. Engaging in any act of indecency or disorderly conduct (as defined by State or local laws) is prohibited.

Entering or remaining on the Refuge when under the influence of alcohol or a controlled substance is prohibited.

Begging or soliciting in any form or conducting a commercial enterprise on the Refuge is prohibited.

Refuge visitors are reminded that the Wildlife Drive (see map) is adjacent to several hunting areas. Please be aware that hunting is allowed during specific seasons, and be cautions and courteous when visiting areas shared with other refuge users.

Hunting/Trapping/Fishing/Weapons
Taking or possessing of bear, turkey, bobcat, any furbearer, or any part thereof, is prohibited, except when transporting same along an NC State road or U.S. highway.

Carrying, possessing, or discharging fireworks or explosives is prohibited.

Firearms may be discharged only by persons engaged in public hunting.

Possession of firearms is permitted in accordance with State law.

Hunting and fishing are subject to State and local regulations, seasons, and bag limits. A Refuge permit is required for hunting.

Vehicles/Roads/Trails
The speed limit on all Refuge roads, unless otherwise posted, is 35 miles per hour. State traffic laws that govern the use and operation of vehicles apply on the Refuge.

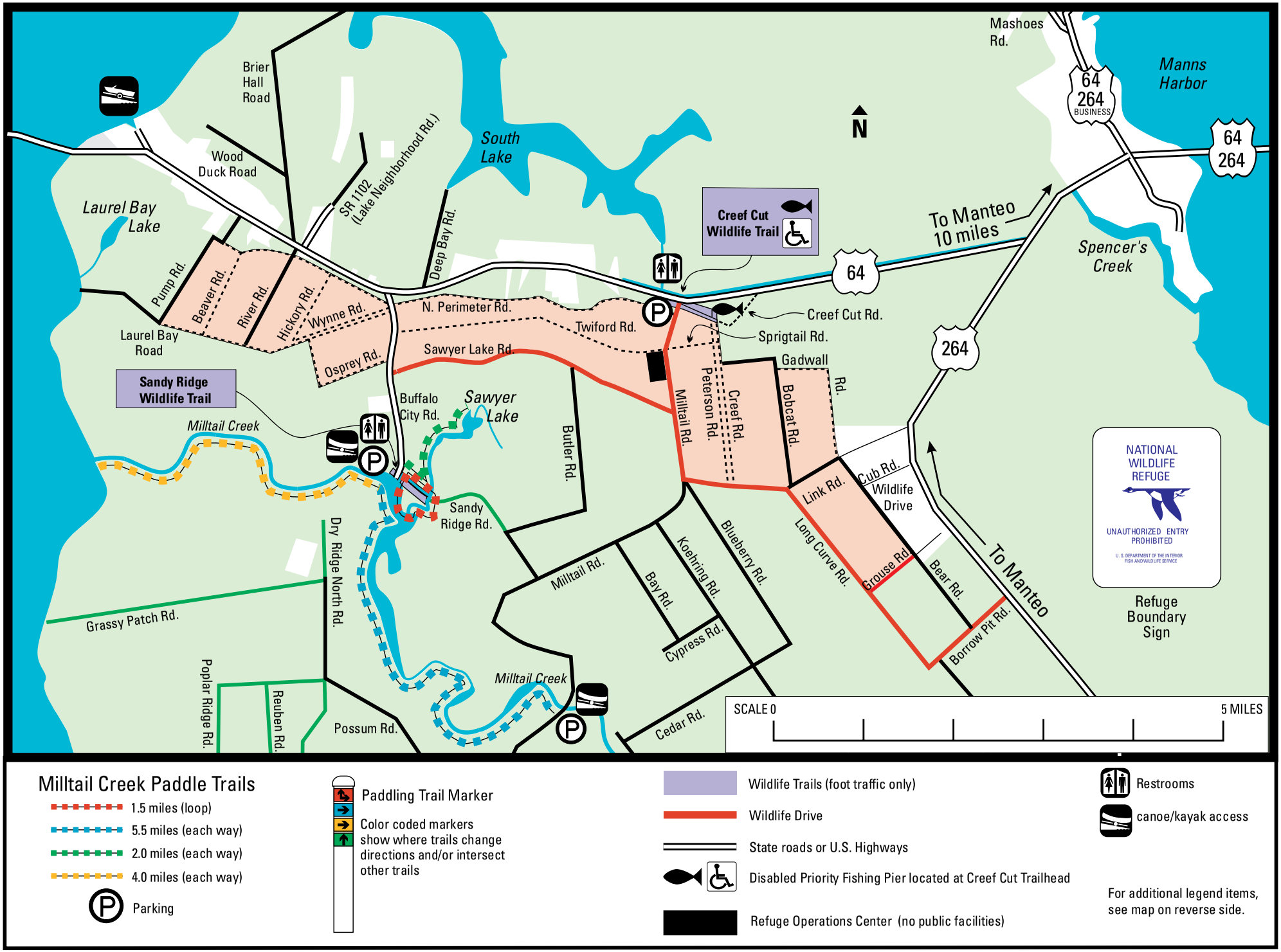
Motorized vehicles are allowed only on designated roads.

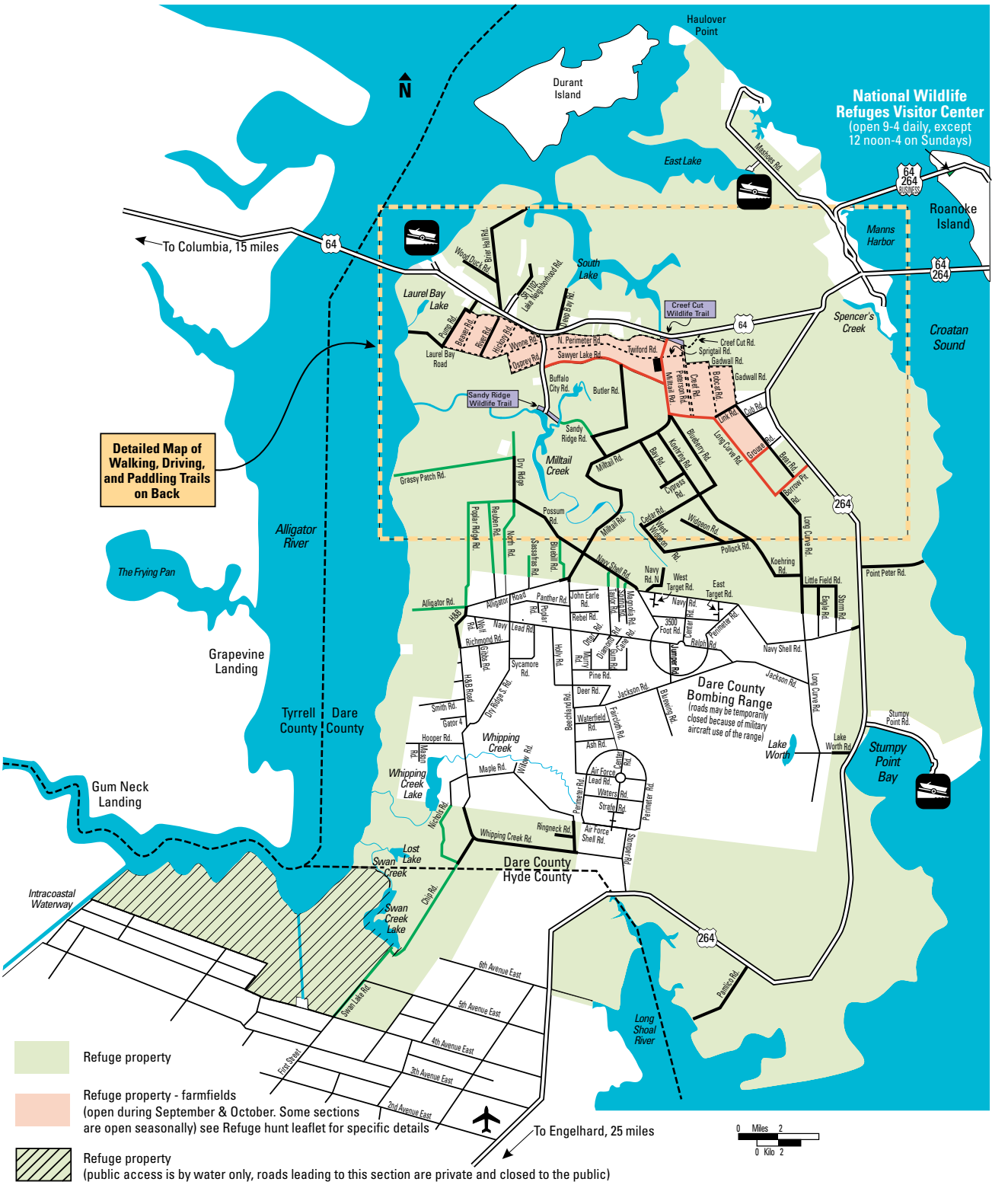
Refuge roads closed to motorized vehicles are open for walking and bicycle riding, unless posted as closed to all entry. Horseback riding is allowed only on roads open to motorized vehicles. Groups of 6 or more horses must have a Refuge Special Use Permit.

Operating any vehicle or boat that does not bear valid license plates or identification numbers and that is not properly lighted, certified, registered, or inspected according to State laws is prohibited. ATV's (3-wheelers, 4-wheelers, dirt bikes, etc.) are prohibited.

Stopping or parking a vehicle (either attended or unattended) on a road, trail, or firelane such that it blocks the free movement of other vehicles is prohibited.

For More Information
National Wildlife Refuges Visitor Center
100 Conservation Way, Manteo, NC 27954
phone: 252/473 1131
email: alligatorriver@fws.gov
http://www.fws.gov/alligatorriver
http://www.fws.gov/ncgatewayvc


Brier Hall Road
Wood Duck Road
SR 1102 (Lake Neighborhood Rd.)
South Lake
Deep Bay Rd.
Laurel Bay Lake
Pump Rd.
Beaver Rd.
River Rd.
Hickory Rd.
Wynne Rd.
Osprey Rd.
Laurel Bay Road
N. Perimeter Rd.
Twiford Rd.
Sawyer Lake Rd.
Creef Cut Wildlife Trail
Creef Cut Rd.
Sprigtail Rd.
Gadwall Rd.
Bobcat Rd.
Creef Rd.
Peterson Rd.
Milltail Rd.
Sandy Ridge Wildlife Trail
Buffalo City Rd.
Sawyer Lake
Milltail Creek
Butler Rd.
Sandy Ridge Rd.
Dry Ridge North Rd.
Grassy Patch Rd.
Poplar Ridge Rd.
Reuben Rd.
Possum Rd.
Milltail Creek
Milltail Rd.
Bay Rd.
Koehring Rd.
Blueberry Rd.
Cypress Rd.
Cedar Rd.
Link Rd.
Cub Rd.
Wildlife Drive
Long Curve Rd.
Grouse Rd.
Bear Rd.
Borrow Pit Rd.
To Manteo
Mashoes Rd.
Manns Harbor
64
264
BUSINESS
To Manteo 10 miles
Spencer's Creek
N
NATIONAL WILDLIFE REFUGE
UNAUTHORIZED ENTRY PROHIBITED
U. S. DEPARTMENT OF THE INTERIOR FISH AND WILDLIFE SERVICE
Refuge Boundary Sign
SCALE 0
5 MILES
Milltail Creek Paddle Trails
1.5 miles (loop)
5.5 miles (each way)
2.0 miles (each way)
4.0 miles (each way)
Parking
Paddling Trail Marker
Color coded markers show where trails change directions and/or intersect other trails
Wildlife Trails (foot traffic only)
Wildlife Drive
State roads or U.S. Highways
Disabled Priority Fishing Pier located at Creef Cut Trailhead
Refuge Operations Center (no public facilities)
Restrooms
canoe/kayak access
For additional legend items, see map on reverse side.



Refuge property

Refuge property - farmfields
(open during September & October. Some sections are open seasonally) see Refuge hunt leaflet for specific details

Refuge property
(public access is by water only, roads leading to this section are private and closed to the public)

Private property

Wildlife trails

Wildlife Drive (auto tour route)

Refuge roads (open to the public and motorized vehicles)

Refuge roads (closed to all motorized vehicles)

Refuge roads (seasonally open to the public)

Public or private roads (open to the public as indicated by signs)

State roads or U.S. Highways

NC Wildlife Resources Commission Boat Ramp

Refuge Roads!

- Refuge roads, including the Wildlife Drive, are unpaved.
- Refuge roads closed to motorized vehicles are open for walking and bicycle riding, unless posted as closed to all entry.
- Only roads open to motorized vehicles are open for horseback riding. Groups of more than 6 horses riding together must have a Refuge Special Use Permit.
- Road surface conditions may vary greatly due to weather conditions.
- Roads may become impassable at certain times,even for 4-wheel drive vehicles.
- Unless otherwise posted, the speed limit on all refuge roads is 35 mph.
- Please use good judgement and caution when driving on any refuge road.

Refuge is open only during daylight hours.

Special Use Permit
Wildlife Resources Commission

Brady Smith
[redacted]

Is authorized **access** under this Special Use Permit on the Commission-owned Land below:

LAND AUTHORIZED: J. Morgan Futch Game Land, Tyrrell County

Conditions of Permit:

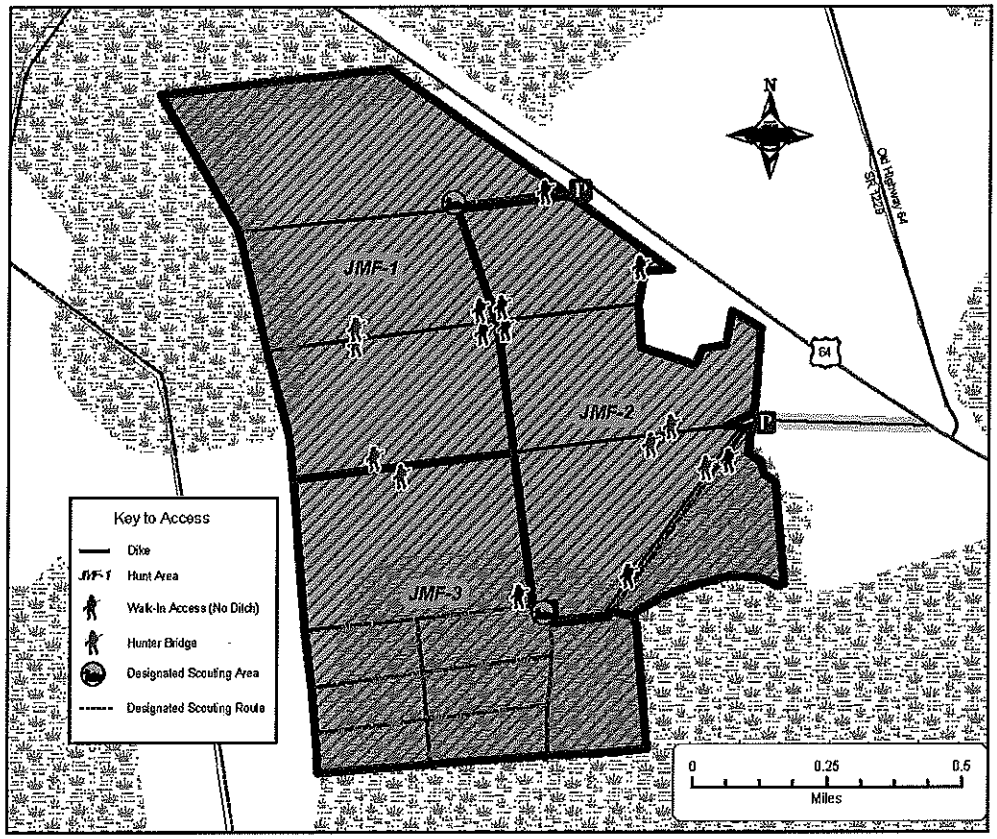
1. Brady Smith is authorized to use an ATV J. Morgan Futch Game Land for the purpose of utilizing Special Trapping Opportunity permit awarded to Brady Smith.
2. Mr. Smith must possess a copy of this Special Use Permit when on J. Morgan Futch Game Land.
3. The NCWRC will not be held responsible for any accidents or injuries that occur while using this permit.
4. The WRC reserves the right to terminate this agreement at anytime.
5. ATV access only will be through the northern most gate by a combination lock code **3102**.

DATE PERMIT ISSUED: February 12, 2018
DATE EFFECTIVE: February 12, 2018

DATE PERMIT EXPIRES: February 28, 2018

AUTHORIZED BY _____

J. MORGAN FUTCH GAME LAND
N.C. Wildlife Resources Commission,
Tyrrell County (600 acres)



Canid CAN-18-007M Release Map 9 March 2018

Legend

- CAN-18-007M_Release
- Roads
- County Boundary
- Hyde County Parcels

2870329 2871969 2873609 2875250

673811 672170 670530 668889

B. Glover's Parcel

HYDE

0 0.15 0.3 0.6 0.9 1.2

Kilometers

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Created by: Andrea J. Shipley
9 March 2018

On the afternoon of 12/4/2018 NCWRC agency staff were notified of a landowner in the possession of a collared canid that had been trapped in a foothold trap near Pinetown North Carolina, which is in Beaufort County north of highway 264 in between Washington and Belhaven. The captured individual had been placed in a kennel and transported to a private residence prior to our agency being notified. Via telephone conversation the trapper expressed a general interest in wildlife research, and verbally agreed to transfer the canid to our agency staff to determine the collar origin, and for either agency USFWS or NCWRC staff to proceed accordingly with further protocol steps regardless of whether the collar was that of the USFWS or the NCWRC.

Upon arrival Steven Nagy and myself were shown to the location of the kennel, which had been wrapped in burlap to protect from wind and reduce animal stress. The animal was removed from the trapper's kennel using a catch pole and physically restrained on a tarp laid on the ground, and eyes covered with a bandana. The foot was checked for trap injuries which were very minimal with no visible lacerations and some local swelling and was treated with rubbing alcohol. The individual was scanned for a pit tag which was not able to be detected. The collar was checked for presence of identifying information and the brass contact information plate used for NCWRC collars on this project was found mounted to the collar. The collar was then checked for any needed adjustments. It was discovered that the collar had become tight due to animal growth since the original collaring and release date. A visible raw area was also present on the side of the neck beneath the collar but whether this was a result of the collar being tight over time or an acute injury resulting from the recent capture event could not be determined. The raw area was treated with rubbing alcohol and an antiseptic blue lotion. The collar was loosened to the appropriate fitting, and the stop nuts were replaced with new ones to secure the collar in place. The canid was then transferred into a NCWRC kennel before leaving the residence.

After giving an update to USFWS RWRP staff the animal was transported and released at the original location of capture and collaring on 1/26/2018, north of Engelhard. The identity of the individual (CAN-18-003M) was confirmed using location data sent from the collar via satellite. The landowner of the original capture site (K. Davis) was notified before re-release.

Report Date	Report #	Kill Date	Kill Time	County	Permit #	CustomerID
2/5/19 5:27 PM	CKR-00065	2/5/2019	4:24 PM	Beaufort	19-chp03032	1540010
1/20/19 12:15 PM	CKR-00064	1/19/2019	4:00 PM	Beaufort	17-CHP02518	1934248
12/30/18 4:18 PM	CKR-00063	12/30/2018	08:30am	Washington	18-CHP04366	8180566
12/30/18 4:07 PM	CKR-00062	12/29/2018	4:30 PM	Washington	18-CHP04466	8441577
12/19/18 1:39 PM	CKR-00061	12/18/2018	3:40 PM	Tyrrell	CHP02960	7158860
11/29/18 12:20 PM	CKR-00060	11/29/2018	10:17 AM	Beaufort	18-chp03869	2000174
11/29/18 9:17 AM	CKR-00059	11/28/2018	5:13 PM	Tyrrell	18-chp04382	1371597
11/17/18 11:29 AM	CKR-00058	11/17/2018	8:45 AM	Beaufort	18-chp04424	2240178
10/13/18 8:01 PM	CKR-00057	10/13/2018	5:45 PM	Beaufort	18-CHP04114	1862691
10/8/18 1:11 PM	CKR-00056	10/8/2018	7:45 AM	Beaufort	18-CHP03869	2000174
10/6/18 12:33 PM	CKR-00055	10/6/2018	6:28 PM	Hyde		0
10/4/18 7:26 PM	CKR-00054	10/4/2018	8:03 AM	Hyde		0
10/3/18 5:07 AM	CKR-00053	10/2/2018	5:50 AM	Hyde		0
9/30/18 9:57 PM	CKR-00052	9/30/2018	3:30 PM	Washington	17-CHP03055	5259998
8/7/18 9:48 PM	CKR-00051	8/7/2018	9:01 AM	Tyrrell	17-chp02948	1371597
5/18/18 12:39 PM	CKR-00048	12/21/2017	12:37 PM	Washington	17-CHP02986	2348626
4/30/18 6:49 PM	CKR-00047	4/29/2018	7:30 PM	Beaufort	18-CHP03697	1779516
4/30/18 2:08 PM	CKR-00046	4/30/2018	8:30 AM	Beaufort	18-CHP03834	2576832
4/26/18 6:00 PM	CKR-00050	4/26/2018	11:40 AM	Hyde		0
4/26/18 5:59 PM	CKR-00049	4/26/2018	10:20 AM	Hyde		0
4/23/18 6:21 PM	CKR-00048	4/23/2018	8:30 AM	Hyde		0
4/22/18 5:56 PM	CKR-00047	4/22/2018	11:15 AM	Hyde		0
4/21/18 9:04 PM	CKR-00046	4/21/2018	9:30 AM	Hyde		0
4/21/18 9:00 PM	CKR-00045	4/21/2018	12:10 PM	Hyde		0
4/21/18 5:53 PM	CKR-00044	4/21/2018	9:40 AM	Hyde		0
4/20/18 8:06 PM	CKR-00043	4/19/2018	8:45 AM	Hyde		0
4/20/18 8:02 PM	CKR-00042	4/19/2018	8:45 AM	Hyde		0
4/19/18 7:39 PM	CKR-00041	4/18/2018	9:00 AM	Hyde		0
4/19/18 7:34 PM	CKR-00040	4/18/2018	6:30 PM	Hyde		0
4/19/18 7:30 PM	CKR-00039	4/18/2018	7:30 AM	Hyde		0
4/5/18 5:21 AM	CKR-00038	4/4/2018	9:20 AM	Beaufort	18-chp03582	1736410
2/20/18 8:19 PM	CKR-00037	2/19/2018	5:15 AM	Beaufort	17-CHP02518	1934248
2/19/18 7:25 PM	CKR-00036	2/18/2018	2:00 PM	Beaufort	18-chp03582	1736410

Eight pages withheld in part under exemption 6 PII

1/31/18 7:07 PM	CKR-00035	1/28/2018	07:06am	Beaufort	17-CHP02518	1934248
1/31/18 7:06 PM	CKR-00034	1/27/2018	9:00 AM	Beaufort	17-CHP02518	1934248
12/5/17 11:16 AM	CKR-00033	12/5/2017	10:34 AM	Beaufort	17-CHP03293	1892377
4/13/17 8:30 AM	CKR-00032	4/13/2017	7:00 AM	Tyrrell	16-chp01760	1371597
3/7/17 2:09 PM	CKR-00031	2/4/2017	12:00 PM	Beaufort	17-CHP02487	2212647
3/5/17 2:57 PM	CKR-00030	3/3/2017	2:00 PM	Beaufort	17-chp02518	1934248
2/11/17 3:17 PM	CKR-00029	2/11/2017	10:27 PM	Beaufort	17-CHP02523	1989641
1/29/17 2:56 PM	CKR-00028	1/29/2017	4:03 PM	Beaufort	17-chp02518	1934248
12/24/16 9:35 AM	CKR-00027	12/24/2016	6:50 AM	Hyde	16-CHP02107	1720651
12/7/16 10:04 AM	CKR-00026	12/7/2016	9:00 AM	Beaufort	16-CHP02237	1652185
11/12/16 5:31 PM	CKR-00025	11/12/2016	7:37 AM	Beaufort	16-CHP00926	2240178
10/16/16 2:57 PM	CKR-00023	10/15/2016	5:06 PM	Beaufort	16-CHP02023	2657621
10/16/16 2:56 PM	CKR-00022	10/15/2016	5:55 PM	Beaufort	16-CHP02023	2657621
10/10/16 9:16 AM	CKR-00021	10/9/2016	10:00 AM	Tyrrell	16-CHP01760	1371597
9/4/16 12:58 PM	CKR-00020	9/4/2016	7:05 AM	Dare	15-CHP00937	3990184
9/4/16 12:53 PM	CKR-00019	8/4/2016	7:00 AM	Dare	15-CHP00938	7596505
4/7/16 8:09 PM	CKR-00018	4/7/2016	1:07 PM	Hyde	15-CHP00989	1773996
3/9/16 3:40 PM	CKR-00017	3/9/2016	7:15 AM	Beaufort	16-CHP00217	1623209
1/30/16 4:02 PM	CKR-00016	1/30/2016	1:02 PM	Beaufort	16-CHP01368	1736410
1/19/16 8:32 PM	CKR-00015	1/19/2016	12:31 PM	Beaufort	16-CHP01368	1736410
1/19/16 2:27 PM	CKR-00014	1/19/2016	1:30 PM	Beaufort	CHP00135	1934248
12/28/15 11:52 AM	CKR-00013	12/28/2015	11:00 AM	Tyrrell	15-CHP00069	3218397
12/20/15 4:12 PM	CKR-00012	12/19/2015	5:09 PM	Washington	15-CHP01239	3173418
11/21/15 9:49 PM	CKR-00011	11/21/2015	11:00 AM	Beaufort	15-CHP01061	2407485
11/13/15 7:29 PM	CKR-00010	11/13/2015	7:30 AM	Washington	15-CHP00188	1744867
11/8/15 11:37 AM	CKR-00009	11/7/2015	7:20 AM	Hyde	15-chp00116	2234043
10/25/15 8:31 PM	CKR-00008	10/25/2015	2:30 PM	Beaufort	15-CHP01009	1637733
10/22/15 1:04 PM	CKR-00007	10/22/2015	8:05 AM	Beaufort	15-CHP00978	2570984
10/5/15 8:46 AM	CKR-00006	10/5/2015	7:41 AM	Hyde	15-CHP00141	2389259
5/20/15 7:13 PM	CKR-00005	5/20/2015	6:30 PM	Beaufort	15-chp00259	1136068
5/7/15 7:22 AM	CKR-00004	5/6/2015	7:30 AM	Hyde	15-chp00504	2155346
4/28/15 8:30 PM	CKR-00003	4/28/2015	7:50 PM	Hyde	15-CHP00141	2389259
4/9/15 10:20 AM	CKR-00002	4/8/2015	8:00 AM	Hyde	15-CHP00092	2347111
3/16/15 2:57 PM	CKR-00001	3/16/2015	2:56 PM	Dare		0

Kill Reason	Radio Collar	Hind Foot Length	Tail Length	Kill Address	Kill City
N/A	Yes	7	15	[redacted]	Washington
N/A	No	5	9		Terra ceia
N/A	No	4.5	14	[redacted]	Roper Nc
N/A	No	4.5	13.5	[redacted]	Roper nc
N/A	No	6.75	16	[redacted]	Columbia
N/A	No	8.5	16.5		Pantego
N/A	No	6.5	15.5	[redacted]	Columbia
N/A	No	6.75	14	[redacted]	belhaven
N/A	No	7	14		Washington
N/A	No	6.5	14		
Active Depredation	No	0	14	[redacted]	Fairfield, NC
Active Depredation	No	0	0	[redacted]	Edenton, NC
Active Depredation	No	0	0	[redacted]	Fairfield, NC
N/A	No	7	13	[redacted]	Plymouth
N/A	No	4	9	[redacted]	Columbia
N/A	No	6.6	14	[redacted]	Rpoer
N/A	No	8	14		
N/A	No	7.25	12.5	[redacted]	Bath NC
Active Depredation	No	4.5	12.25	See map with permit	
Active Depredation	No	5.5	13.5	See map with permit	
Active Depredation	No	4.5	12	See map with permit	
Active Depredation	No	5	14.75	See map with permit	
Active Depredation	No	4.75	12	See map with permit	
Active Depredation	No	5.25	14	See map with permit	
Active Depredation	No	5	13.75	See map with permit	
Active Depredation	No	5	15	See map with permit	
Active Depredation	No	5.5	15	See map with permit	
Active Depredation	No	5.25	14	See map with permit	
Active Depredation	No	5	13	See map with permit	
Active Depredation	No	5.5	14.5	See map with permit	
N/A	No	5	10		Pinetown
N/A	No	6	10		
N/A	No	5.5	12		

N/A	No	11	13	[redacted]	Pantego
N/A	No	10	13	[redacted]	Pantego
N/A	No	7.2	12.6		
N/A	No	7.5	17	[redacted]	Columbia
N/A	Yes	6	14	[redacted]	Washington
N/A	No	5	13	Not sure	Terra ceia
N/A	No	6	13	[redacted]	pantego
N/A	No	6	12		Terra ceia
N/A	No	7	16		ENGELHARD
N/A	No	2.75	14.5		
N/A	No	7	14		
N/A	No	4	14		
N/A	No	5	16		
N/A	No	7	12	[redacted]	Columbia
N/A	No	6	13	[redacted]	Manns Harbor
N/A	No	6	13	[redacted]	Manns Harbor
N/A	No	7	15		Fairfield
N/A	No	7.5	16		
N/A	No	9	18		
N/A	No	13	22	[redacted]	Pinetown
N/A	Yes	11	23		
N/A	No	10	20		
N/A	No	8	14		
N/A	No	3	12	[redacted]	Washington
N/A	No	7	13	[redacted]	Washington
N/A	No	7.5	11		
N/A	No	5	15		
N/A	No	8	13		
N/A	No	7.5	14	[redacted]	fairfield
N/A	No	7	12	[redacted]	chocowinity
N/A	No	7.5	17		
N/A	No	7.5	14	[redacted]	Fairfield
N/A	No	8	12.5		Fairfield
Protection of domestic animals or livestock	Yes	10	22		

Kill Zip	Kill Name Property	Kill Nearest Intersection	Kill Latitude	Kill Longitude	Program Interst	First Name
27889	[redacted]	[redacted]	35.35022	-7.706753		[redacted]
			0	0		[redacted]
			0	0		[redacted]
			0	0		[redacted]
27925	[redacted]		0	0		[redacted]
			0	0		[redacted]
27925	no name	[redacted]	0	0		[redacted]
			0	0		[redacted]
27889		5 points	0	0		[redacted]
			0	0		[redacted]
27826	[redacted]		35.19	-7.12	Yes, I'd lik	
27932	[redacted]		34.42	-3.54	Yes, I'd lik	
27826	[redacted]		35.2835	-9.54	Yes, I'd lik	
27962	[redacted]	[redacted] and [redacted]	0	0		[redacted]
27925	[redacted]	1229	0	0		[redacted]
			0	0		[redacted]
		[redacted] & [redacted]	0	0		[redacted]
27808			0	0		[redacted]
	[redacted]		35.353107	-76.03355	No, thank you.	
	[redacted]		35.36236	-76.032622	No, thank you.	
	[redacted]		36.36412	-76.32876	No, thank you.	
	[redacted]		35.353312	-76.09047	No, thank you.	
	[redacted]		35.3613	-76.31381	No, thank you.	
	[redacted]		35.344281	-76.035406	No, thank you.	
	[redacted]		35.353613	-76.031383	No, thank you.	
	[redacted]		35.3626	-76.0334	No, thank you.	
	[redacted]		0	0	No, thank you.	
		[redacted]	35.3538	-76.0416	No, thank you.	
	[redacted]		35.3831	-76.0742	No, thank you.	
	[redacted]		35.3626	-76.0334	No, thank you.	
			0	0		[redacted]
	[redacted]		0	0		[redacted]
			0	0		[redacted]

27860	[redacted]	[redacted]	0	0		[redacted]
27860	[redacted]	[redacted]	0	0		[redacted]
			0	0		[redacted]
27925	[redacted]	[redacted] and [redacted]	0	0		[redacted]
27889			35.5747	-76.766633		[redacted]
		Not sure	0	0		[redacted]
27860	[redacted]		0	0		[redacted]
	Not sure	Not sure	0	0		[redacted]
27824			0	0		[redacted]
			0	0		[redacted]
		[redacted] rd and [redacted] rd	35.29927	-76.38689		[redacted]
			0	0		[redacted]
			0	0		[redacted]
27925			0	0		[redacted]
27953	home owner		0	0		[redacted]
27953	Home owner		0	0		[redacted]
27826	[redacted]	boundary	0	0		[redacted]
			35.1946	-76.5454		[redacted]
			0	0		[redacted]
27865			0	0		[redacted]
			0	0		[redacted]
			0	0		[redacted]
			0	0		[redacted]
27889	[redacted]	264	0	0		[redacted]
27889	[redacted]	[redacted] & [redacted]	0	0		[redacted]
	[redacted]	[redacted] rd and [redacted] dr	0	0		[redacted]
			0	0		[redacted]
			0	0		[redacted]
27826			0	0		[redacted]
27817			0	0		[redacted]
			0	0		[redacted]
27826	NA	[redacted] and [redacted] Rd	0	0		[redacted]
		[redacted] Rd / [redacted] Rd	0	0		[redacted]
			0	0	No, thank you.	

Last Name	NC Resident	Address	City	State	Zip	Phone
[redacted]	Yes		WASHINGTON	North Carolina	27889	[redacted]
[redacted]	Yes		PANTEGO	North Carolina	27860	[redacted]
[redacted]	No		SUFFOLK	Virginia	23435	[redacted]
[redacted]	No		CHESAPEAKE	Virginia	23324	[redacted]
[redacted]	Yes		COLUMBIA	North Carolina	27925	[redacted]
[redacted]	Yes		WASHINGTON	North Carolina	27889	[redacted]
[redacted]	Yes		COLUMBIA	North Carolina	27925	[redacted]
[redacted]	Yes		BATH	North Carolina	27808	[redacted]
[redacted]	Yes		WASHINGTON	North Carolina	27889	[redacted]
[redacted]	Yes		WASHINGTON	North Carolina	27889	[redacted]
[redacted]	Yes	[redacted]	Edenton, NC	NC	27932	[redacted]
[redacted]	Yes	[redacted]	Edenton, NC	NC	27932	[redacted]
[redacted]	Yes	[redacted]	Edenton	NC	27932	[redacted]
[redacted]	Yes		PLYMOUTH	North Carolina	27962	[redacted]
[redacted]	Yes		COLUMBIA	North Carolina	27925	[redacted]
[redacted]	Yes		WILLIAMSTON	North Carolina	27892	[redacted]
[redacted]	Yes		AURORA	North Carolina	27806	[redacted]
[redacted]	Yes		WASHINGTON	North Carolina	27889	[redacted]
[redacted]	Yes	[redacted]	Edenton	NC	27932	[redacted]
[redacted]	Yes	[redacted]	Edenton	NC	27932	[redacted]
[redacted]	Yes	[redacted]	Edenton	NC	27932	[redacted]
[redacted]	Yes	[redacted]	Edenton	NC	27932	[redacted]
[redacted]	Yes	[redacted]	Edenton	NC	27932	[redacted]
[redacted]	Yes	[redacted]	Edenton	NC	27932	[redacted]
[redacted]	Yes	[redacted]	Edenton	NC	27932	[redacted]
[redacted]	Yes	[redacted]	Edenton	NC	27932	[redacted]
[redacted]	Yes	[redacted]	Edenton	NC	27932	[redacted]
[redacted]	Yes	[redacted]	Edenton	NC	27932	[redacted]
[redacted]	Yes	[redacted]	Edenton	NC	27932	[redacted]
[redacted]	Yes	[redacted]	Edenton	NC	27932	[redacted]
[redacted]	Yes		PINETOWN	North Carolina	27865	[redacted]
[redacted]	Yes		PANTEGO	North Carolina	27860	[redacted]
[redacted]	Yes		PINETOWN	North Carolina	27865	[redacted]

[redacted]	Yes		PANTEGO	North Carolina	27860	[redacted]
[redacted]	Yes		PANTEGO	North Carolina	27860	
[redacted]	Yes		WASHINGTON	North Carolina	27889	
[redacted]	Yes		COLUMBIA	North Carolina	27925	
[redacted]	Yes		WASHINGTON	North Carolina	27889	
[redacted]	Yes		PANTEGO	North Carolina	27860	
[redacted]	Yes		PANTEGO	North Carolina	27860	
[redacted]	Yes		PANTEGO	North Carolina	27860	
[redacted]	Yes		ENGELHARD	North Carolina	27824	
[redacted]	Yes		WASHINGTON	North Carolina	27889	
[redacted]	Yes		BATH	North Carolina	27808	
[redacted]	Yes		NEW BERN	North Carolina	28562	
[redacted]	Yes		NEW BERN	North Carolina	28562	
[redacted]	Yes		COLUMBIA	North Carolina	27925	
[redacted]	Yes		MANNS HARBOR	North Carolina	27953	
[redacted]	Yes		MANNS HARBOR	North Carolina	27953	
[redacted]	Yes		ENGELHARD	North Carolina	27824	
[redacted]	Yes		STONEWALL	North Carolina	28583	
[redacted]	Yes		PINETOWN	North Carolina	27865	
[redacted]	Yes		PINETOWN	North Carolina	27865	
[redacted]	Yes		PANTEGO	North Carolina	27860	
[redacted]	Yes		COLUMBIA	North Carolina	27925	
[redacted]	Yes		CRESWELL	North Carolina	27928	
[redacted]	Yes		GREENVILLE	North Carolina	27834	
[redacted]	Yes		WASHINGTON	North Carolina	27889	
[redacted]	Yes		BELHAVEN	North Carolina	27810	
[redacted]	Yes		WASHINGTON	North Carolina	27889	
[redacted]	Yes		PLYMOUTH	North Carolina	27962	
[redacted]	Yes		FAIRFIELD	North Carolina	27826	
[redacted]	Yes		CHOCOWINITY	North Carolina	27817	
[redacted]	Yes		PANTEGO	North Carolina	27860	
[redacted]	Yes		FAIRFIELD	North Carolina	27826	
[redacted]	Yes		FAIRFIELD	North Carolina	27826	
				NC		

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[redacted]@HOTMAIL.COM
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[redacted].COM
[redacted].COM
[redacted]@GMAIL.COM
[redacted]@GMAIL.COM
[redacted]@GMAIL.COM
[redacted]@GMAIL.COM
[redacted]@YAHOO.COM
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[redacted]@GMAIL.COM
[redacted]@SUDDENLINK.NET
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[redacted]@GMAIL.COM
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Species identification of individuals who are suspected to have red wolf ancestry
Final Report
2/6/19

Jennifer Adams, PhD and Lisette Waits, PhD
Laboratory for Ecological, Evolutionary and Conservation Genetics
University of Idaho

Objectives– 1) Determine the species composition of four hair samples collected from the Albemarle Peninsula provided by Andrea Shipley, Mammalogist, North Carolina Wildlife Resources Commission.

Methods

Laboratory Analysis

DNA was extracted from the hair samples using the DNeasy Blood and Tissue Kit (Qiagen, Inc.) in a laboratory dedicated to low quality DNA samples. One negative control was included in the extraction to monitor for contamination of reagents. Microsatellite genotypes were generated for each sample using 17 loci divided into two PCR multiplexes. Multiplex one contained the following loci, AHT103, AHT121, CXX20 CXX109, CXX172, CXX173, CXX200, CXX250 and CXX377 (Ostrander *et al.* 1993; Holmes *et al.* 1995; Mellersh *et al.* 1997). Multiplex two contained the following loci, CXX225, CXX403, FH2001, FH2004, FH2054, FH2062, FH2010, and FH2145 (Ostrander *et al.* 1993, 1995; Mellersh *et al.* 1997). Two to four replicate microsatellite PCRs were performed each hair sample. PCR products were visualized using a 3130xl DNA Sequencer (Applied Biosystems) and allele sizes were scored using Genemapper 5.0 (Applied Biosystems).

Statistical Analysis

The genetic ancestry of the samples was estimated using the Bayesian assignment test approach implemented in the software STRUCTURE 2.2 (Pritchard *et al.* 2000; Falush *et al.* 2003). The samples were combined with genotypes from 36 dogs, 62 coyotes from North Carolina and Virginia and 121 red wolves from the wild population in North Carolina. The number of populations (K) was set to 3 (ie. A red wolf population, coyote population and a dog population), and the percentage of ancestry (q) was estimated from each population. Program STRUCTURE 2.2 was run for 5 replicates with the admixed model of ancestry and the correlated allele frequency model with a burn-in length of 100,000 repetitions and 400,000 MCMC repetitions.

Results

DNA was successfully isolated for all 4 of the samples (Table 1 and Appendix 1, attached excel spreadsheet). Results of the STRUCTURE analysis indicate that two individuals shared ≥ 90% of their ancestry with coyotes (Table 1). Individual MV-18-015F shared 72% of its ancestry with the red wolf group, 16% of its ancestry with the dog group and 12% of its ancestry with the coyote group. Individual MV-18-017F shared 87% of its ancestry with the red wolf group and 12% of its ancestry with the

FEB 19 2019

coyote group. Both of these individuals could be classified as red wolf backcrossed individuals. Individual MV-18-017F is close to a 7/8^{ths} red wolf (where a 75% red wolf backcrosses to the red wolf population).

Regarding the presence of dog ancestry in one RWBC, we believe the dog ancestry is coming from admixed coyotes as evidenced by the presence of a coyote/dog F1 in the report from 101118.

Citations

Falush D, Stephens M, Pritchard JK (2003) Inference of population structure using multilocus genotype data: linked loci and correlated allele frequencies. *Genetics*, **164**, 1567–1587.

Holmes NG, Dickens HF, Parker HL *et al.* (1995) Eighteen canine microsatellites. *Animal Genetics*, **26**, 131–132.

Mellersh CS, Langston AA, Acland GM *et al.* (1997) A linkage map of the canine genome. *Genomics*, **46**, 326–336.

Ostrander EA, Mapa FA, Yee M, Rine J (1995) One hundried and one new simple sequence repeat-based markers for the canine genome. *Mammalian Genome*, **6**, 192–195.

Ostrander EA, Sprague GF, Rine J (1993) Identification and characterization of dinucleotide repeat (CA)n markers for genetic mapping in dog. *Genomics*, **16**, 207–213.

Pritchard JK, Stephens M, Donnelly P (2000) Inference of population structure using multilocus genotype data. *Genetics*, **155**, 945–959.

Table 1. Species identification results from microsatellite genotype data (Microsat Species).

Sample	Type	Microsat Species	Ancestry Red Wolf	Ancestry Dog	Ancestry Coyote
MV-18-015F	hair	RWBC*	72.1%	15.9%	11.9%
MV-18-016M	hair	coyote	0.30%	4.7%	95.1%
MV-18-017F	hair	RWBC°	86.8%	1.0%	12.2%
CC18003M	hair	coyote	0.20%	0.70%	99.1%

* 75% red wolf, 16% dog and 12% coyote

° 75% red wolf and 25% coyote

these "MV" samples are from the mitochondrial ventures depredation permit (Oct 2018). thought you'd be interested in seeing this. what's the RW spp. genetic threshold these days? just I know it was 87.5%. Thanks! Robin

DECISION MEMORANDUM FOR THE SECRETARY

DATE: January 9, 2018

FROM: Pete Benjamin, Project Leader, Raleigh Ecological Services Field Office

SUBJECT: Relocation of Juvenile Red Wolf

I. INTRODUCTION

As part of the Red Wolf Recovery Program, the Service has used Island National Wildlife Refuges to breed wolves. The role of these sites was to propagate pups in a somewhat controlled, but natural environment that will provide them "wild experience" as juveniles for the purpose of being strategically inserted into the North Carolina Experimental Populations (NENC NEP) on the mainland. Island breeding has been suspended, pending a revised 10j Rule for the NENC, however, 1 juvenile from 2016 remains on St. Vincent National Wildlife Refuge (NWR). The purpose of this memo is provide the alternatives to inform the decision whether or not to capture and move juvenile male offspring (M2192) from the Island of St. Vincent to pre-empt the predicted dispersal and if so where to place him.

II. BACKGROUND

In 1990, the Service implemented an island propagation site on St. Vincent NWR, an island off the Gulf Coast of Florida, to aid in red wolf recovery. There are currently three red wolves on St. Vincent NWR, two adults (M1804 and F2050) and their juvenile male offspring (M2192), who is a few months shy of two years old. Within the NENC NEP, male juvenile red wolves typically disperse from their family group at around the age of two years old. In the past, offspring on St. Vincent NWR were captured at around 18 months of age and relocated within the NENC NEP before they naturally dispersed. Based on the age of the juvenile currently residing on St. Vincent and typical dispersal age, it is expected that in the relative short-term he will either disperse on his own or be pushed out by the adult red wolves.

III. ANALYSIS AND POSITIONS OF INTERESTED PARTIES

Ecological Services staff charged with managing the Red Wolf NENC NEP and Refuge staff from both St. Vincent NWR and Alligator River NWR along with our partners managing the captive population have coordinated to explore the following alternatives.

1. Status Quo: Under this alternative the juvenile male offspring (M2192) would be left at St. Vincent NWR until another alternative can be identified or the wolf attempt leaves the island forcing the need to attempt to capture that red wolf and then hold him in captivity until another alternative is identified. The obvious short coming of this alternative is that

it merely delays the inevitable choice of one of the other alternatives and is likely to drain resources with a predicable dispersal off the island.

2. SSP / Alternate Captive Facility: Under this alternative M2192 would become part of the captive breeding program. Moving a wild adult male into a captive facility has not been done since the original founders were collected from the wild. So this would be an unprecedented use of the Island animals. Nevertheless, Will Waddell was contacted to see if there was space within an SSP facility to take in the juvenile male. His response indicated that they were still working on trying to place several wolves within the SSP population so there is currently no space available for this red wolf at a SSP facility (see attached email). While we are working to encourage other non-SSP facilities to take on holding Red Wolves, at this time only the SSP facilities are holding animals. At this time that leaves our Service Sandy Ridge Facility. While this facility does have space it is not designed for long term holding of wild wolves and without repair and investment is not capable of containing a wild wolf for more than a short term as illustrated by escapes in 2016 of wild wolves being held there temporarily. In fact, efforts are being made to transfer the remaining wolves held at Sandy Ridge to facilities better equipped to care for their needs, although as discussed previously there is currently no other space available. However, this is the only captive alternative and depending on holding time may make the animal no longer releasable as wild.

3. Relocation of M2192 into the NENC NEP onto Alligator National Wildlife Refuge: This alternative is consistent with what has been done in the past with red wolf offspring from St. Vincent NWR, and with the original intent of the island propagation sites. Further there is a female red wolf residing on Alligator River NWR currently paired with a sterilized coyote that is need of a mate. With the decline in the wild red wolf population in the NENC NEP, the availability of suitable red wolf mates has declined. In fact, due to the location of her home range on the northern portion of Alligator River NWR peninsula, she is related to the vast majority of male red wolves in that area since she originated as a Milltail Pack pup. There was a young male red wolf originally captured on Ventures that had traveled north within her home range and in close proximity to her periodically throughout the summer and fall. We had hoped he would pair with her, but unfortunately he was hit and killed by a vehicle in November. Alligator River NWR Refuge Management have indicated they have no objections to the release and do not foresee any compatibility issues with what is being proposed (see attached email).

IV. RECOMMENDATION

Alternative 3: Relocate of M2192 into the NENC NEP onto Alligator National Wildlife Refuge

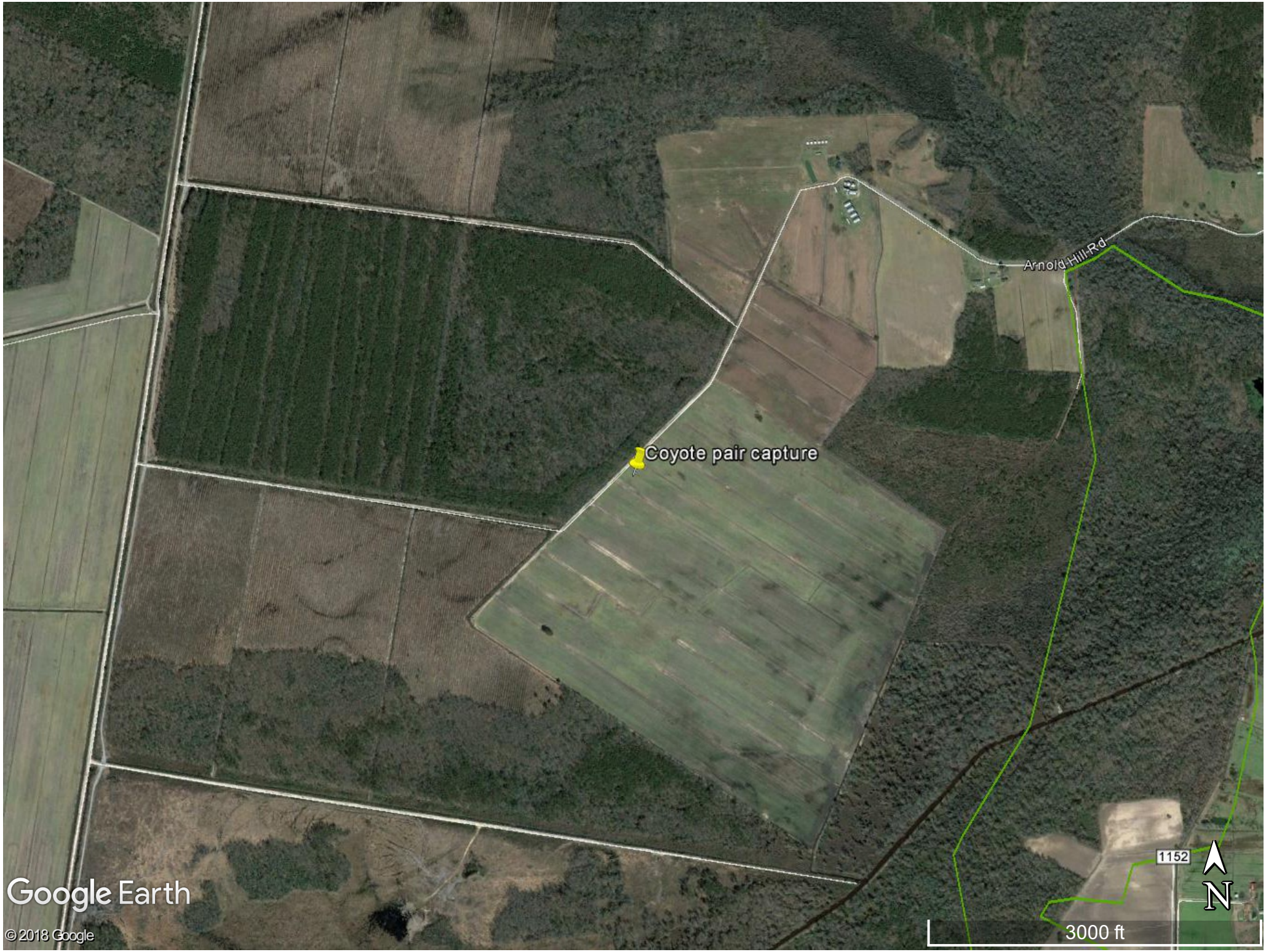
Because of the availability of the juvenile male red wolf on St. Vincent that will need to be relocated at some point relatively soon and the benefit to red wolf recovery to have another red wolf/red wolf breeding pair on Alligator River NWR, we would like to relocate the juvenile male to within close proximity of the existing female on Alligator River NWR. If the pairing is successful it seems most likely that this new pair would continue to inhabit the established territory within the Refuge. As such, we would in essence be moving this individual from one NWR to another NWR. With breeding season very quickly approaching there is a degree of urgency to accomplish this transfer soon to have the greatest chance for success. This position is supported by the Managers of the NCNEP and the Refuge Managers at St. Vincent and Alligator River.

Decision:

Status Quo _____

Move male red wolf (M2192) to Alligator River NWR _____

Other: _____ (Explanation Attached)


Arnold Hill Rd
Coyote pair capture
1152
N
3000 ft
Google Earth
© 2018 Google

MEMORANDUM

November 20, 2013

TO: All Interested Parties

FROM: "for" Cynthia K. Dohner, Director, Southeast Region, U.S. Fish and Wildlife Service
Gordon S. Myers, Executive Director, N.C. Wildlife Resources Commission

SUBJECT: Collaborative Conservation of Red Wolves and Other Canids on North Carolina's Albemarle Peninsula

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Recovery of the federally-listed red wolf has been a priority for the U.S. Fish and Wildlife Service (FWS) for more than 20 years and is focused in North Carolina on the Albemarle Peninsula (AP; i.e., Hyde, Tyrrell, Washington, Beaufort, and Dare counties). Comprehensive stakeholder involvement and collaboration with other management agencies is critical to successful recovery of any at-risk species. The North Carolina Wildlife Resources Commission (WRC) is a key collaborator in this regard, as it has jurisdiction over all state-trust wildlife resources in N.C.

Since 2009, the FWS and WRC have worked to broaden our collaboration in the conservation and management of all canid species (including red wolves) on the AP. As these efforts have solidified, specific actions have been jointly identified by our two agencies that will improve conservation outcomes. These actions are categorized into five areas; collaboration, research, outreach, regulatory, and enforcement. Specific action items are outlined and prioritized within each of these categories in Attachment A.

This memo establishes the FWS's and WRC's commitment to initiate, or to continue, the efforts outlined in Attachment A. The common goal in this effort is to establish clear expectations and accountability for collaboration regarding the action items on Attachment A, thus resulting in enhanced and seamless canid conservation and management on the AP. This approach provides the best opportunity to achieve recovery goals for red wolves, while at the same time managing other canids to balance biological variables with social expectations. The dynamics of these canid species are complex and offer unique opportunities for innovation. Appropriate staff from each agency is hereby tasked with immediately developing a timeline to implement these actions. Through this commitment, we will continue to advance our collective conservation goals.

Attachment A

Action Items for Collaborative Conservation of Canids on North Carolina's Albemarle Peninsula (AP)

(*Note: Action Items are prioritized within category.*)

Collaboration

1. The N.C. Wildlife Resources Commission (WRC) and U.S. Fish and Wildlife Service (FWS) will formalize in writing the collaborative management of canids on the AP. This agreement should:
    a. include a clear mission statement, goals, objectives, and implementation strategies (ask and answer the "Why?");
    b. set a goal to define success regarding canid management on the AP;
    c. espouse a philosophy of canid management operating within the context of a three-legged stool (i.e., federal and state governments and stakeholders);
    d. as available, commit funding and staffing resources for field personnel to contribute to the conservation of the red wolf and management of coyotes;
    e. as available, commit funding to conduct research pertinent to canid management on the AP;
    f. establish polices and goals for developing a collaborative genetic archive for AP canids, a data sharing portal accessible by staff in both agencies, and reciprocal sharing of all historical data (including phenotypic and genotypic data and literature) of the red wolf;
    g. establish a foundation for developing and implementing an adaptive approach to canid management on private lands on the AP;
    h. initiate development of a collaborative canid research program;
    i. describe plans to conduct the next five year Red Wolf Program review;
    j. outline options for holding annual workshops with federal and state enforcement staff;
    k. outline plans to hold semi-annual coordination meetings regarding canid management on the AP; and
    l. develop milestones for future development of a management plan for all canids in the AP.

2. The FWS will initiate a review of the current Red Wolf Recovery Plan to determine if the state-of-our-knowledge or field conditions have changed such as to warrant its revision. Review and comments from the WRC will be considered in this evaluation.

3. The WRC, with support and participation of the FWS, will establish a "Canid Forum" (similar to that established for manatees in Florida) to facilitate communication and discussion regarding canid management and citizen science opportunities on the AP.

Research

1. The FWS and WRC will provide funding and logistical support for research identified by the Red Wolf Recovery Implementation Team, Red Wolf Program staff, other FWS staff, or the WRC that promote the conservation and recovery of the red wolf and other canids on the AP. Studies could include:
    a. tests of the "placeholder theory" on the AP, including behavior of sympatric canids,
    b. determining carrying capacity of canids on the AP,
    c. determining genetic profiles of canid species on the AP,
    d. evaluating predator-prey dynamics,
    e. studies of canid habitat use,
    f. epidemiology of diseases impacting canids on the AP,
    g. development of stochastic simulation models of sympatric canid population dynamics and habitat use, and
    h. canid dispersal dynamics

2. The FWS and WRC will conduct jointly-supported research to determine the attitudes and opinions of N.C. private landowners and other citizens concerning canids on the AP (i.e., human dimensions studies).

Outreach

1. The FWS and WRC will collaborate with other partners to design and implement broad-based outreach and marketing programs with clear goals, objectives, strategies, and measurable outcomes, including development of consistent agency messages and educating the public about canids on the AP.

Regulatory

1. The FWS and WRC will initiate a review and, if needed, subsequent rule-making to clarify concepts or rectify conflicts in current federal or state rules (including the current 10(J) rule).

2. The WRC will review and evaluate statutory requirements for listing red wolves as state threatened in the five AP counties.

3. As data demonstrating a relationship between coyote hunting and red wolf mortality become available, the FWS and WRC will evaluate, and if appropriate implement, adaptive approaches to regulate of take of coyotes that may result in incidental take of red wolves.

4. The WRC will evaluate the status, management, and regulation of Controlled Fox Hunting Preserves.

5. The WRC will develop BMPs (due care provisions) for coyote hunting, trapping, and live sale.

6. The WRC will compile, compare, and contrast canid hunting and trapping regulations and programs in other states, including, but not limited to, other states with other species of wolves.

Enforcement

1. The FWS and WRC will develop coordination strategies to improve enforcement of federal regulations protecting red wolves.

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Cross-fostering as a conservation tool to augment endangered carnivore populations

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Cross-fostering offspring with nonbiological parents could prove useful to augment populations of endangered carnivores. We used cross-fostering to augment captive-born and wild-born litters for the endangered red wolf (*Canis rufus*). Between 1987 and 2016, 23 cross-fostering events occurred involving captive-born pups fostered into captive litters (n = 8 events) and captive-born pups fostered into wild recipient litters (n = 15 events). Percentage of pups surviving 3 and 12 months was 91.7% for captive-born pups fostered into captive recipient litters. For pups fostered into wild litters, percentage of pups surviving 5 months was > 94% among fostered pups (pups fostered into a wild red wolf litter or replaced a hybrid litter), pups in recipient litters (wild-born litters receiving fostered pups), and pups in control litters (wild-born litters not in a fostering event) when using pups with known fates. Including pups with unknown fates as deaths, percentage of pups surviving 5 months was > 54% among fostered pups, pups in recipient litters, and pups in control litters. Among wild litters, percentage of pups surviving 12 months was > 82% among fostered pups, pups in recipient litters, and pups in control litters when using pups with known fates. Including pups with unknown fates as deaths, percentage of pups surviving 12 months was > 48% among fostered pups, pups in recipient litters, and pups in control litters. Although survival to 12 months was similar among the groups, average life span was different with pups in control litters living 3.3 years, pups in recipient litters living 4.6 years, and fostered pups living 5.6 years. Of fostered pups surviving > 12 months in the wild, 9 animals whelped or sired 26 litters. Cross-fostering was successful at augmenting litter size for red wolves without any deleterious effects on recipient litters, illustrating fostering as a tool for increasing populations of endangered carnivores.

Key words: augmentation, *Canis rufus*, cross-fostering, population, red wolf, survival

Maintaining or increasing population size is often the key conservation objective for threatened and endangered species. However, many rare or threatened mammalian species may have low birth rates, and low survival and recruitment of young (e.g., Laurenson 1994; Fuller et al. 2003; Groom et al. 2017). Increasing survival rates of young carnivores born into wild populations involves many variables (i.e., sufficient food of high quality, protection from intra- and interspecific predation, disease, human-caused mortality, or extreme weather) that may act independently or in concert with each other (e.g., Mech and Goyal 1995; Fuller et al. 2003; Angerbjörn et al. 2004; Bohling and Waits 2015; Hinton et al. 2017). Although increased survival is essential for population growth, fundamentally a population must produce new individuals to grow.

The red wolf (*Canis rufus*) was declared extinct in the wild in 1980 (U.S. Fish and Wildlife Service 1989) and is currently listed as critically endangered (IUCN 2017). To mitigate the decline of red wolf population numbers, a breeding program was established in 1973 at the Point Defiance Zoo and Aquarium, Tacoma, Washington (Phillips et al. 2004). This managed

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breeding program, operated under the Species Survival Plan of the Association of Zoos and Aquariums, was developed as a cooperative breeding program to enhance long-term population management for approved species (Hutchins and Wiese 1991). The red wolf Species Survival Plan was designed to function as a source population for initial and ongoing red wolf restoration efforts (U.S. Fish and Wildlife Service 1989). Only 14 individuals were considered "pure" red wolves and were the founders for the red wolf breeding program, with descendants of 12 founders serving as source individuals for reintroduction into the Alligator River National Wildlife Refuge, North Carolina (Phillips et al. 2003).

Low genetic diversity, increased genetic drift, and inbreeding depression can be significant issues whenever low numbers of breeding animals are involved, such as captive breeding programs (Rabon and Waddell 2010) or some wild populations (Brzeski et al. 2014), which can result in reduced litter sizes (Lockyear et al. 2009; Rabon and Waddell 2010). In addition, the expansion of coyotes (*Canis latrans*) into the northeastern North Carolina experimental population area and the risk of hybridization represented another threat to red wolf restoration (Kelly et al. 1999; Stoskopf et al. 2005; Fredrickson and Hedrick 2006; Bohling and Waits 2015). To mitigate introgression of coyote genes into the red wolf population, an adaptive management plan was implemented that 1) sterilized and released coyotes to serve as nonbreeding placeholders (Gese and Terletzky 2015), 2) removed coyotes from the area, 3) translocated red wolves (McLellan and Rabon 2006), and 4) cross-fostered captive-born pups into wild litters (Stoskopf et al. 2005). Combined with intensive field management (Gese et al. 2015) and genomic testing protocols (Miller et al. 2003), wild-born pups could be identified as red wolf, red wolf-coyote hybrid, or coyote, leading to the option of replacing hybrid individuals with red wolf pups from the captive breeding population.

Cross-fostering, the raising of young by nonbiologically related individuals, has the potential to increase population sizes of threatened or endangered species (Kitchen and Knowlton 2006; Stoskopf 2012). Fostering of offspring from natal to surrogate parents has been conducted with Columbian ground squirrels (*Spermophilus columbianus*—Murie et al. 1998), captive coyotes (Kitchen and Knowlton 2006), many bird species (Powell and Cuthbert 1993; Drewien et al. 1997; Oswald et al. 2013), and has been observed without human facilitation in black bears (*Ursus americanus*—Benson and Chamberlain 2006). Fostered young that were raised successfully have been both captive-born (Kitchen and Knowlton 2006) and orphaned in the wild (McNutt et al. 2008). Most research on cross-fostering of canid species has been limited to small sample sizes (< 4 litters) or anecdotal records, although fostering in African wild dogs (*Lycaon pictus*—McNutt et al. 2008), coyotes (Kitchen and Knowlton 2006), and wolves (*Canis lupus*—Schultz et al. 2007; Jansson et al. 2015; Scharis and Amundin 2015) has greatly advanced our understanding of factors required for successful cross-fostering. Kitchen and Knowlton (2006) reported that the age at which captive-born fostered pups were introduced to captive recipient litters influenced survival rates and that fostered pups > 6 weeks old did not survive. Survival of fostered gray wolf pups has been ambiguous. Some pups > 4–5 months old survived into adulthood while other pups, of the same litter, did not survive (Bradley et al. 2005; Schultz et al. 2007). Fostering young pups increases the probability of survival and success. For example, captive-born gray wolf pups that were only 4–6 days old were fostered into captive recipient litters, were readily accepted by the foster female, and had high survival (Scharis and Amundin 2015). The Mexican wolf (*Canis lupus baileyi*) population in the southwestern United States was founded by 7 individuals resulting in a highly inbred population (Harding et al. 2016). Cross-fostering of 2 wild pups (1 female and 1 male) to a wild recipient litter of 3 pups resulted in the survival of all 5 pups for at least 8 months, suggesting that cross-fostering has the potential to increase litter size and subsequently population size of this endangered canid (Harding et al. 2016).

The potential benefits associated with fostering nonmaternal offspring include improved genetic fitness for a population and reduced inbreeding depression (Jansson et al. 2015), in addition to the numerous advantages associated with living in groups (Kokko et al. 2001; Ausband et al. 2016; Lehtonen and Jaatinen 2016). The gray wolf in Sweden is descended from 5 individuals and is highly inbred, but Jansson et al. (2015) suggested that augmentation of wild recipient litters from captive fostered litters should potentially reduce the inbreeding coefficient.

We summarized data on age, litter size, sex ratio, and survival to 3 and 12 months of age for captive-born pups fostered into captive recipient litters, and survival to 5 and 12 months of age for captive-born pups fostered into wild recipient litters. To successfully augment a wild population, fostering should not be deleterious to the recipient litter; therefore, we examined the same parameters for pups within the recipient litter in the wild. In addition, as a "control," we documented the same metrics for an equal number of litters of wild-born red wolf pups not involved in a fostering event (i.e., control litters). These parameters were used to evaluate the success and utility of cross-fostering red wolf pups that were captive-born into litters of captive-born and wild-born red wolves.

Materials and Methods

Red wolf pups involved in fostering events were born and fostered at 11 facilities across the United States: Beardsley Zoo, Connecticut; Brevard Zoo, Florida; Cape Romain National Wildlife Refuge, South Carolina; Dan Nicholas Nature Center, North Carolina; Great Smoky Mountains National Park, Tennessee; Lincoln Park Zoo, Illinois; Miller Park Zoo, Illinois; North Carolina Zoo, North Carolina; Oglebay Zoo, West Virginia; Point Defiance Zoo and Aquarium, Washington; and the Red Wolf Recovery Area, North Carolina. Pups fostered into wild wolf litters were released into 2 locations: 1 fostering event in the Great Smoky Mountains National Park, Tennessee, and 14 fostering events augmenting wild red wolf litters in the Red Wolf Recovery Area located on the Albemarle Peninsula in northeastern North Carolina. For descriptions of

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the study areas and history of recovery efforts in these 2 sites, see Lucash et al. (1998) for Great Smoky Mountains National Park, Tennessee, and Bohling and Waits (2015) and Gese et al. (2015) for the Red Wolf Recovery Area, North Carolina.

We considered the location of source and recipient litters, litter sizes, and age of the pups as initial factors before fostering attempts; age of captive-born pups was known from birth date. We introduced captive-born fostered pups only to captive recipient litters that had successfully raised at least 1 litter to adulthood (Green et al. 2002). History of successfully raising litters of wild recipient parents was not available. We attempted to match as closely as possible the ages of foster pups and pups in recipient litters and in all fostering events; the eyes of fostered and recipient litter pups were closed or had just opened (i.e., pups were 10–14 days old—Kreeger 2003). Fostered pups transferred to captive recipient litters did not have their scents masked nor did animal care staff; however, fostered pups transferred to wild recipient litters were handled by personnel wearing latex gloves.

Captive-born pups fostered into captive recipient litters.—We housed wolves as mated pairs in outdoor enclosures (450–900 m^2) containing natural substrate, foliage, and artificial dens. Half (4 of 8) of the sires and half (4 of 8) of the dams of fostered pups had at least 1 litter before the fostering event. The time between removing a fostered pup from a natal litter to placement into a recipient litter ranged from several minutes to approximately 6 h. Short-duration fostering events required a simple transfer of a fostered pup(s) from one enclosure to another enclosure within the same facility. The event with the longest interval (6 h) required animal care staff from the Brevard Zoo (Florida) accompanying 2 female pups on a commercial airline to a recipient litter at the Beardsley Zoo (Connecticut).

Identification of fostered pups following placement in a recipient litter was possible based on sex (e.g., 1 male pup fostered to recipient den with 3 females) or by a small patch of pelage marked with animal tattoo ink (Ketchum Mfg. Co. Inc., Lake Luzerne, New York). We observed the activity level of all pups daily for 5–7 days following placement in a recipient litter. To assess development, we obtained weights for all pups in recipient litters to ensure neonate growth was consistent among litter mates. Before fostering, we determined that if a fostered pup was isolated from the litter by recipient parents or if consistent weight loss was recorded, the pup would be removed. No fostered pups were rejected other than a single pup that disappeared the day following placement. The percentage of fostered pups surviving to 3 and 12 months of age was the measure of success for the captive fostering events.

Captive-born pups fostered into wild recipient litters.—Reproductive female red wolves in the wild were foot-hold trapped, fitted with a very high frequency (VHF) radiocollar (Telonics, Inc., Mesa, Arizona) and monitored daily from late March to May to identify den sites; fostering events occurred in April and May. Females that were not radiocollared but occupied known den site locations that had previously raised pups, or that were in breeding pairs with stable territories and had an adult female with proven rearing success, were also monitored. All female and male wolves involved with fostering captive pups were born in the wild with the exception of 1 female and 3 males. Additionally, most adults receiving fostered pups in the northeastern North Carolina population had at least 1 litter before the fostering event with the exception of 1 female and 2 males (but were paired with experienced mates). Only the pair involved with the fostering event in the Great Smokey National Park had not raised a prior litter. If a wild litter was genetically determined to be red wolf-coyote hybrids, the hybrid litter was removed and captive-born red wolf pups were placed in the den site (i.e., litter replacement). If a wild litter was considered small in number (but not a hybrid litter), captive-born pups were fostered into the wild litter (i.e., litter augmentation). To avoid facilitating a competitive advantage to either captive or wild pups, we matched the sex ratio and age of the fostered pups as close as possible to the age of the wild-born litter of pups (Kitchen and Knowlton 2006); age of wild-born pups was estimated from body measurements and estimated whelping date. We moved captive-born pups to the den location of the recipient wild litter as soon as possible to promote acceptance of the fostered pups into the litter. We implanted each captive pup with a passive integrated transponder (PIT) tag (Eidap, Inc., Sherwood Park, Alberta, Canada) inserted subcutaneously between the shoulders prior to placement in the den. All capture and handling procedures were in accordance with guidelines endorsed by the American Society of Mammalogists (Sikes et al. 2016).

After placing pups into a den, the wild dam was monitored daily by radiotelemetry for 3–5 days to confirm her return to the den site. Although it is common for wild red wolves to move their pups at this age, we continued to observe the movements of the dam remotely and only attempted to verify the survival of the fostered pups during the fall trapping season approximately 5 months following the fostering event. At this time, juvenile wolves were large enough to be safely trapped and equipped with radiocollars. The outcome of captive-born to wild fostering events was considered successful only when a fostered individual was trapped, equipped with a radiocollar, and released at the capture location. If the pups were not captured in the fall, the fate of the pup was classified as "unknown fate." We estimated the number of pups surviving to 5 and 12 months of age for both the fostered pups and the pups in the recipient litter as a measure of success of the fostering event, as well as a measure that cross-fostering is not deleterious to the pups in the recipient litter. Recapturing, radiocollaring, and telemetry flights of fostered and recipient pups continued as part of the overall red wolf monitoring program to assess survival, causes of death, timing and distance of dispersal movements, and reproduction, mainly litter size (Gese et al. 2015). Radiocollared wolves were monitored 2–3 times/week, allowing for the early detection of a mortality signal and facilitating recovery of the carcass to determine the cause of death. If applicable, a field necropsy was conducted, or if the cause of death was not apparent, the carcass was examined by a veterinary pathologist.

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Wild-born red wolf pups as "control" litters.—As a comparison to fostered pups and pups in the recipient litters, we evaluated the fate of the pups from an equal number (n = 15 litters) of wild-born red wolf litters not involved in a cross-fostering event (i.e., control pups). We then compared the percentage of pups surviving to 5 and 12 months of age, and the life span of pups surviving > 1 year among the 3 categories: fostered, recipient, and control pups. For clarity, fostered pups were pups that were captive-born and placed into a wild red wolf den (either complete replacement of a hybrid litter, or augmentation of an existing red wolf litter). Pups in recipient litters were wild-born pups in which fostered pups were placed. Control pups were wild-born pups that were not involved in a fostering event. The control litters from the Red Wolf Recovery Area were randomly chosen from the entire data set of red wolf litters, but stratified to match the number of fostered litters within each year and management zone (Gese et al. 2015) to reduce the influence of annual and geographical variation in survival rates. Similar to the fostered and recipient pups, the surviving control pups were recaptured, radiocollared, and relocated as part of the overall red wolf monitoring program to assess survival, causes of death, timing and distance of dispersal movements, and reproduction, mainly litter size (Gese et al. 2015). Radiocollared wolves were monitored 2–3 times/week allowing for the early detection of a mortality signal and facilitating recovery of the carcass to determine the cause of death. If applicable, a field necropsy was conducted, or if the cause of death was not apparent, the carcass was examined by a veterinary pathologist.

Statistical analyses.—For captive-born pups fostered into wild litters, we examined differences in the percentage of pups from the 3 treatment groups (i.e., fostered pups, pups in recipient litters, pups in control litters) surviving to 5 and 12 months of age with contingency tables and chi-square tests (Zar 1996). This comparison was performed for pups with known fates (i.e., complete fates), as well as adding pups with unknown fates that were assumed to be deaths. Chi-square tests also were used to examine where dens, in terms of landownership (federal, state, private), of fostered and control litters were located; the proportion of fostered and control pups that dispersed; the proportion of different causes of death between fostered and control pups; and the proportion of landownership (federal, state, private) between fostered and control pups in relation to where they died. We determined landownership using state GIS databases (Gese and Terletzky 2015). Differences in litter size, age at the time of dispersal, and distance of dispersal movements between fostered and control pups were determined with a Student's t-test (Zar 1996).

Results

Captive-born pups fostered into captive recipient litters.—There were 8 events involving 12 fostered pups between captive-born red wolf pups and captive-born red wolf recipient litters (Table 1). The mean age of fostered pups was 10.7 ± 2.7 days (*SD*) with the youngest pups 8 days old and the oldest pups 16 days old. Single pups were the most common (62.5%) number of pups fostered, followed by 2 fostering events with 2 pups (25.0%), and a single fostering event involving 3 pups. There was an equal sex ratio (6 F:6 M) among the 12 fostered pups. The mean age of pups in captive recipient litters was 8.9 ± 5.6 (*SD*) with the youngest litters 4 days old and the oldest litter at 19 days old. Recipient litters, before fostering pups, consisted of 3 litters of a single pup, 3 litters of 3 pups, 1 litter of 2 pups, and 1 litter of 4 pups. The sex ratio of the 18 pups in recipient litters was 7 females to 11 males (Table 1). The largest age difference between fostered pups and recipient litter pups was 7 days with the fostered pups being older. Including the fostered pups, the sex ratio of the 30 pups in recipient litters was 13 females to 17 males.

The overall percentage of fostered pups surviving in the recipient litters to 3 months of age was high (91.7%; 11 of 12 pups). This single unaccounted pup may have been eaten by the recipient litter dam, although 1 of the 2 siblings from this individual's natal litter was stillborn and the other disappeared 8 days postpartum. Thus, this pup may have been medically compromised; however, the cause of mortality could not be verified because of the disappearance of the body 1 day following insertion into the recipient den. The percentage of fostered pups surviving to 12 months of age remained 91.7% (Table 1).

Captive-born pups fostered into wild recipient litters.—There was a total of 15 events involving 31 captive-born pups fostered into wild recipient litters (Table 2). Four recipient litters were

Table 1.—Age, litter size, and sex ratio of fostered pups and pups in recipient litters, and percent surviving of captive red wolf (*Canis rufus*) pups fostered into captive recipient litters.

Fostered pups			Pups in recipient litter			Combined litter			% fostered pups surviving	
# fostered	Sex ratio (F:M)	Age (days)	# prior to event	Sex ratio (F:M)	Age (days)	Final # pups	Final sex ratio (F:M)	Age difference (days)[a]	@ 3 months old	@ 12 months old
1	1:0	11	3	0:3	11	4	1:3	0	100	100
3	1:2	8	1	0:1	7	4	1:3	+1	100	100
1	0:1	8	2	2:0	10	3	2:1	−2	100	100
1	1:0	16	3	0:3	19	4	1:3	−3	100	100
2	1:1	11	3	2:1	4	5	3:2	+7	100	100
2	2:0	14	1	0:1	11	3	2:1	+3	100	100
1	0:1	9	4	3:1	4	5	3:2	+5	0	0
1	0:1	11	1	0:1	7	2	0:2	+4	100	100

[a] Age difference is the number of days older or younger the fostered pups were as compared to pups in the recipient litter.

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Table 2.—Age, litter size, sex ratio, and percent pups surviving of fostered pups and pups in recipient litters for events involving captive red wolf (*Canis rufus*) pups fostered into wild recipient litters. NA: not applicable, as this was a hybrid litter and all pups were removed.

Fostered pups					Pups in recipient litter					Combined litter		
# pups	Sex ratio (F:M)	Age (days)	% survive to 5 months	% survive to 12 months	# pups	Sex ratio (F:M)	Age (days)	% survive to 5 months	% survive to 12 months	Final # pups	Final sex ratio (F:M)	Age difference (days)[a]
2	0:2	5	50	50	3	1:2	9	100	100	5	1:4	−4
5	2:3	11	100[b]	100[b]	NA	NA	NA	NA	NA	5	2:3	NA
2	1:1	14	100	100	2	0:2	15	100	100	4	1:3	−1
1	1:0	17	100	100	4	0:4	18	100[c]	50[c]	5	1:4	−1
1	1:0	18	100	100	2	1:1	4	100	100	3	2:1	+14
4	3:1	15	100	75	NA	NA	NA	NA	NA	4	3:1	NA
1	1:0	7	100	100	1	0:1	6	Unk	Unk	2	1:1	+1
2	2:0	7	100[d]	100[d]	1	0:1	6	Unk	Unk	3	2:1	+1
2	2:0	7	Unk	Unk	3	1:2	11	100[e]	100[e]	5	3:2	−4
2	1:1	7	100	100	2	1:1	11	100[d]	100[d]	4	2:2	−4
2	1:1	13	Unk	Unk	2	2:0	14	100[d]	100[d]	4	3:1	−1
2	2:0	13	Unk	Unk	NA	NA	NA	NA	NA	2	2:0	NA
2	1:1	7	Unk	Unk	3	2:1	7	100[f]	100[f]	5	3:2	0
1	1:0	10	100	100	2	2:0	11	100[d]	100[d]	3	3:0	−1
2	2:0	10	Unk	Unk	NA	NA	NA	NA	NA	2	2:0	NA

[a] Age difference is the number of days older or younger the fostered pups were as compared to pups in the recipient litter.
[b] Known fate of 3 out of 5 pups.
[c] Known fate of 2 out of 4 pups.
[d] Known fate of 1 out of 2 pups.
[e] Known fate of 2 out of 3 pups.
[f] Known fate of 1 out of 3 pups.

determined to be hybrids and these pups were removed. Thus, the fostered pups were considered litter replacements. The other 11 events involved litter augmentation (i.e., adding fostered pups to an existing red wolf litter). The mean age of fostered pups was 10.8 ± 3.7 days with the youngest pups at 5 days old and the oldest pups at 18 days old. Pairs of pups were the most common (56.2%) number of pups fostered, followed by a single pup being fostered (31.2%), 3 pups in 1 event, and 5 pups in another event (Table 2). The number of captive-born pups fostered had more females than males (21 F:10 M). The mean age of pups in wild recipient litters was 10.9 ± 4.2 days with the youngest litter at 4 days old and the oldest litter at 18 days old. The largest age difference between the fostered pups and the wild recipient litter pups occurred when the fostered pups were 14 days older. Before having the hybrid pups removed and the fostered pups added, the mean size of wild recipient litters was 3.4 (± 2.1 *SD*) pups and ranged from litters with a single pup to a litter with 9 pups. However, after removing the 4 recipient litters determined to be hybrids, the mean litter size was 2.4 (± 0.8) pups at the time of fostering. For the wild recipient litters, the sex ratio was 10 females to 15 males (Table 2). The resulting litter size containing fostered and recipient pups ranged from 2 to 5 pups, well within the range of litter sizes for red wolves (Lockyear et al. 2009).

The fate of 8 pups fostered into the 15 wild litters was unknown at 5 and 12 months of age (Table 2). Overall, the percentage of "known fate" pups fostered into wild red wolf litters, or replacing hybrid litters, surviving to both age 5 and 12 months was high (Table 3). However, if pups with unknown fates are considered deceased, then the percentage of fostered pups surviving to 5 and 12 months was lower (Table 3). Unfortunately, the fate of some pups remained unknown as they were never recaptured in the recovery area. One litter with complete survival information had 1 fostered pup die before 3 months of age, but a second fostered pup survived to at least 12 months. Both pups were handled 28 days after placement in a recipient den; however, 1 pup disappeared after movement of the litter by the recipient parents (Table 2). Notably, of 16 fostered pups known to survive > 12 months of age, these individuals lived to an average age of 5.6 years, and 9 animals whelped or sired a total of 26 litters in the wild.

Table 3.—Percentage of fostered, recipient, and control red wolf (*Canis rufus*) pups with known fates and unknown fates assumed to be deaths surviving to 5 and 12 months of age.

Fate Treatment group	*n* pups	% surviving to 5 months	% surviving to 12 months
Known fate			
Fostered	18	94.4	88.9
Recipient	15	100	93.3
Control	35	100	82.0
Known fate and unknown fate assumed dead			
Fostered	31	54.8	51.6
Recipient	25	60.0	56.0
Control	66	59.1	48.5

Since cross-fostering is meant to assist population recovery of this endangered carnivore, we examined whether augmenting existing litters could be deleterious to the recipient litter. For pups of known fate in the recipient litters, the percentage

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of pups surviving to 5 months (100%) and 12 months (93.3%) was similarly high as the fostered pups (Table 3). When considering the pups with unknown fates as deaths, the percentage of pups in the recipient litters surviving to 5 months (60%) and 12 months (56%) was similar to the percent survival of the fostered pups. Of 15 recipient pups known to survive > 12 months of age, these individuals lived to an average of 4.6 years of age.

Why some fostered individuals survived far into adulthood, while others did not live to 12 months of age is not readily apparent (Table 2). The percentage of fostered pups surviving to 12 months of age within the 4 litters that were replacements for the hybrid litters that were removed (i.e., no competition from a recipient litter) was 85.7% (6 of 7 pups) for pups with known fates, and 46.1% (6 of 13 pups) when including pups with unknown fates. For 8 litters of fostered pups that were equal to (0 age difference), greater than (> 1 day age difference), or only 1 day different (−1 day age difference) from the pups in the recipient litter, survival to 12 months was 100% (7 of 7 pups) for pups with known fates and 58.3% (7 of 12 pups) when including pups with unknown fates. For the 3 litters in which the fostered pups were much younger than the recipient litter (i.e., −4 days age difference), the number of known fate pups surviving to 12 months of age was 75% (3 of 4 pups) and when including pups with unknown fates as deaths, the percent survival was 50% (3 of 6 pups).

Comparison of fostered, recipient, and control litters.—We analyzed data from 15 litters containing 66 wild-born red wolf pups as the "control" group for comparison to the fostered pups and pups in recipient litters. The percentage of pups surviving to 5 months of age was similar among fostered pups, pups in recipient litters, and pups in control litters when using pups with known fates ($\chi^2_2 = 3.042$, $P = 0.218$; Table 3) and was similar across groups when including pups with unknown fates as deaths ($\chi^2_2 = 0.199$, $P = 0.905$; Table 3). The percentage of pups surviving to 12 months of age also was similar among fostered pups, pups in recipient litters, and pups in control litters when using pups with known fates ($\chi^2_2 = 1.308$, $P = 0.520$; Table 3) and was similar across groups when including pups with unknown fates as deaths ($\chi^2_2 = 0.420$, $P = 0.810$; Table 3). Even though the percent of pups surviving to 12 months of age was similar among the 3 groups, life span differed ($F_{2,58} = 4.49$, $P = 0.015$) with pups from the control litters living an average 3.3 years (± 1.97 *SD*; $n = 32$ pups), recipient pups living to a mean of 4.6 years (± 2.62; $n = 14$ pups), and fostered pups living to an average of 5.6 years (± 3.16; $n = 15$ pups).

The greatest difference among the groups was the fostered pups living 2.3 years longer than the control pups. We examined several factors that may explain this disparity. First, we examined where dens were located as differences in landownership could create more risky landscapes. Results showed similar use of federal, state, and private lands between the 2 cohorts (Table 4). Second, we examined if smaller litter sizes could give pups a competitive advantage later in life, and found that the fostered litters were slightly smaller than the control litters (Table 4). Third, we examined the possible influence of dispersal since dispersal into unfamiliar areas carries a decrease in survival. We had anticipated that the control pups would have a higher dispersal rate, but found the percentage of pups dispersing was dissimilar with more fostered pups dispersing from their natal home range (Table 4). The age at which the pups dispersed and the distance they dispersed was similar (Table 4). Last, we examined aspects of mortality and found the causes of mortality were similar between fostered and control pups (Table 4), suggesting that different life spans were not related to agents of mortality. Human-caused sources of mortality included gunshot, foul play, poisoning, trapping, and vehicle collisions. The type of landownership where pups were killed also was similar between fostered and control pups (Table 4), suggesting equal exposure to risk on the landscape.

Discussion

The survival of captive-born red wolf pups fostered into captive and wild recipient litters was high for animals of known fate. When we considered red wolf pups with unknown fates as having perished, then the percentage of pups surviving to

Table 4.—Landownership at the den, litter size, dispersal rate, age at dispersal, distance of dispersal, causes of mortality, and landownership at death site for fostered and control red wolf (*Canis rufus*) pups, with test statistic and *P*-value.

Metric	Fostered pups	Control pups	Test statistic	*P*-value
Landownership at den (%)				
Federal	43	60	$\chi^2_2 = 1.64$	0.44
State	7	0		
Private	50	40		
Litter size (*n* pups)	3.7 ± 1.2	4.4 ± 1.5	$t = 1.36$	0.09
Dispersal rate (%)	75	45	$\chi^2_1 = 4.13$	0.042
Age of dispersal (months)	17.6 ± 5.3	20.9 ± 11.7	$t = -0.91$	0.18
Distance of dispersal (km)	29.5 ± 17.0	30.9 ± 15.2	$t = 0.05$	0.48
Causes of mortality (%)				
Human	71.2	67.7	$\chi^2_2 = 0.09$	0.95
Natural	14.4	14.7		
Unknown	14.4	17.6		
Landownership at death site (%)				
Federal	7.1	2.9	$\chi^2_2 = 0.48$	0.79
State	7.1	5.9		
Private	85.7	91.1		

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12 months of age declined, but was still greater than 50% survival. Stoskopf (2012) surmised that 30–35% survival to maturity among a cross-fostered litter was a positive contribution to a population. Most individuals fostered from captivity into wild red wolf litters were known to have survived past weaning, remained with their surrogate pack, and several demonstrated movement and dispersal behaviors comparable to wild-born red wolves. For example, following dispersal from her natal home range, 1 fostered female red wolf died at 23 months of age from complications associated with pregnancy. This individual's fostered male sibling also dispersed from his natal range and sired a litter of 8 pups.

Overall, of the fostered red wolf pups known to have survived a year in the wild, these individuals lived to an average age of 5.6 years, and several of these animals produced or sired litters in the wild as adults. The several fostered pups growing to adulthood, successfully mating, and producing wild red wolf litters indicate the utility of cross-fostering, as these individuals learned the behavioral skills necessary to survive and reproduce, thereby contributing to the red wolf population. Equally important to the recovery of any endangered species was the finding of similar survival rates among the pups in the recipient litters, further demonstrating that fostering was not deleterious to the existing wild litter that received the fostered pups.

Why the control pups had a lower life span compared to the fostered and recipient pups remains unclear. Where the pups were placed, when they dispersed, how far they dispersed, what they died from, and where they died did not appear to be factors determining the observed difference in life span between fostered and control pups. Whether the slight difference in litter size among the fostered litters translated to longer life span remains a possibility. Therefore, we concluded that while survival up to 12 months of age was similar between the cohorts, why fostered animals lived on average 2 years longer than the control animals requires further investigation.

The release of adult red wolves from the captive program to initiate new packs or supplement the wild population has had mixed success (van Manen et al. 2000; Phillips et al. 2003; Gese et al. 2015). Furthermore, acclimation to humans and human-related activates may have resulted in increased mortality risk (e.g., vehicle collision, gunshot—Hinton et al. 2017). Regardless of the age when captive-born individuals were introduced into a wild population, mortality risks were unavoidable for free-ranging animals. Introducing pups from captivity into wild red wolf litters can provide fostered individuals the benefit of learning survival and social skills from wild parents and other pack members, can be used as replacements for hybrid (red wolf-coyote) litters, and can augment population size in the recovery area and potentially facilitate increased genetic diversity in an inbred population. The recovery program also successfully fostered a litter of pups from one wild litter following the death of the breeding female into another wild litter, thereby keeping that litter alive and integrated into the wild population.

Kitchen and Knowlton (2006) recommended cross-fostered coyote pups be placed in recipient litters as young as possible (< 1 week) to facilitate acceptance by the pack. In our study, the pups that did not survive to 5 months were not older than 9 days, nor was the age difference between the fostered pups and the recipient litter pups more than 9 days. Conversely, we recorded a 16-day-old pup was successfully accepted into a captive recipient litter and an 18-day-old pup was successfully accepted into a wild recipient litter. The fostering success of pups older than a week but younger than 3 weeks suggests that the age of fostering is more plastic than previously thought. We did not attempt cross-fostering with pups older than 18 days, so we were not able to assess the oldest day at which fostering could be successful. However, Kitchen and Knowlton (2006) reported that fostered coyote pups > 6 weeks old did not survive in their recipient litter.

Stoskopf (2012) made several recommendations to reduce den disturbance (e.g., scent transfer, timing insertions when adults are away from the den, minimizing the number of personnel involved on-site) and thereby increase the success of fostering pups into wild litters. We further recommend the fostered pups be well fed (i.e., bottle fed) before insertion as they cry when hungry and could potentially attract predators while the recipient female is away from the den. We also recommend minimizing the time spent at the den to avoid overly disturbing the parents and risk abandonment of the litter, and consider the weather conditions at the time of fostering (e.g., dry conditions if the pups are in a day bed exposed to the elements, rather than in an excavated den). To ensure success and survival of cross-fostered pups, we recommend that pups be fostered between the ages of 4 to 21 days (but urge using pups < 14 days old, if possible), and that fostered pups be of similar age to the recipient litter (Kitchen and Knowlton 2006; Stoskopf 2012). The similar survival rates among the fostered pups that varied in age relative to the recipient litter, or had no competition from a recipient litter, indicated there was no competitive advantage when the fostered pups were similar in age or older. However, the numbers of litters were small, thereby inference was limited, and future investigations among other canid species are warranted.

We concluded that cross-fostering was successful at augmenting litter size for red wolves without any deleterious effects on recipient litters, illustrating cross-fostering as a potential management tool for increasing populations of other endangered carnivores. Most research on cross-fostering of canid species has been limited to small sample sizes or anecdotal records, although fostering in African wild dogs (McNutt et al. 2008), coyotes (Kitchen and Knowlton 2006), and gray wolves (Schultz et al. 2007; Jansson et al. 2015; Scharis and Amundin 2015) has advanced our understanding of the factors required for successful cross-fostering within these canid species. We demonstrated that cross-fostering red wolf pups was an effective rearing technique that has assisted captive and wild population management and could complement other management strategies (Stoskopf et al. 2005; Gese et al. 2015; Gese and Terletzky 2015) when supplementing endangered canid populations is required. Cross-fostering pups also could provide a simple process for maintaining genetic diversity of both captive and wild populations where units are disjunct from one another.

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RED WOLF (*CANIS RUFUS*) AND COYOTE (*CANIS LATRANS*) ECOLOGY AND INTERACTIONS IN NORTHEASTERN NORTH CAROLINA

by

JOSEPH WILLIAM HINTON

(Under the Direction of Michael J. Chamberlain)

ABSTRACT

In recent decades, red wolf (*Canis rufus*) hybridization with coyotes (*Canis latrans*) has posed a serious threat to red wolf recovery efforts. Preventing hybridization has become a primary objective requiring intensive management efforts to prevent introgression. As the red wolf population increases, long-term recovery requires general understanding of red wolf and coyote ecology to develop appropriate management strategies for addressing hybridization. The primary objective of this study was to understand the underlying mechanisms that influence red wolf and coyote interactions by examining morphology, diet, and spatial ecology of both species. We examined external morphological characters of red wolves, coyotes, and their hybrids to determine if morphology could be an accurate discriminator among the 3 canid taxa. Using hind foot length, weight, width of head, and tail length, we were able to correctly identify 86% of canids to their *a priori* species groups as identified via genetic analysis. We also assessed factors affecting prey selection of red wolf packs, coyote pairs, and congeneric pairs of red wolves and coyotes and found that all three had similar and overlapping diets. Nevertheless, we detected differential use of prey; difference in diet was associated with body size. Larger individuals within and among different breeding pairs consumed more white-tailed deer, and less rabbits and small mammals. We observed red wolf and coyote preferences for agricultural habitats over forested habitats and space use patterns to be influenced by body size. Coyote home-ranges had an upper limit of approximately 50 km^2, whereas an upper limit for red wolves was

approximately 180 km^2. Home-ranges of congeneric pairs did not exceed 50 km^2 and we suggest the smaller coyote may constrain and limit space use patterns of congeneric pairs. We suggest that similarities in body size of individual red wolves and coyotes may contribute to successful congeneric pairing and hybridization via similar use of space, habitat, and prey. Therefore, lowering hybridization rates between red wolves and coyotes may require increasing the average body size of the red wolf population to facilitate differential use of limiting resources.

INDEX WORDS: coyote, *Canis latrans*, *Canis rufus*, body size, diet, ecology, habitat selection, hybridization, interactions, space use

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DOCTOR OF PHILOSOPHY

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DEDICATION

Dedications are often only offerings from interested baseness to disdainful vanity. – Voltaire in *Dictionnaire Philosophique*

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CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

In recent decades, red wolf (*Canis rufus*) hybridization with coyotes (*Canis latrans*) has become a serious threat to red wolf recovery efforts. During the 1970s, the last remaining red wolves were removed from the wild because the last remnant population began hybridizing with an expanding coyote population. Shortly after reintroducing red wolves onto Alligator River National Wildlife Refuge in northeastern North Carolina, coyotes began expanding their range throughout North Carolina. The current red wolf population co-exists with coyotes and hybridization between the two species occurs. Red Wolf Recovery Team biologists and Red Wolf Recovery Implementation Team scientists identify red wolf-coyote interactions, related resource partitioning, and prevention of coyote gene introgression into the wild red wolf gene pool as critical factors vital to long-term recovery, management, and planning (USFWS 2007). Therefore, preventing hybridization has become a primary management goal (Kelly *et al*. 1999; Stoskopf *et al.* 2005; Rabon *et al.* 2013).

To prevent coyote introgression into the red wolf population, coyotes captured by United States Fish and Wildlife Service (USFWS) personnel within the Red Wolf Recovery Area (Recovery Area) are reproductively sterilized and used as space holders until red wolves move in and occupy those areas. This tactic provides a reproductive advantage to red wolves by reducing coyote reproduction within the Recovery Area (USFWS 2007; Stoskopf *et al*. 2005). More importantly, in the event that a red wolf forms a breeding pair with a sterilized coyote, this prevents introgression because the pair is incapable of successfully breeding. Despite intensive management efforts, red wolf/coyote hybrids are still captured within the Recovery Area indicating that canid management is not ubiquitous. To achieve long-term recovery of red wolves, it is imperative that the Red Wolf Recovery Program improves its general knowledge of red wolf

and coyote ecology to understand mechanisms facilitating red wolf-coyote hybridization. The primary objective of this research is to understand the underlying mechanisms that influence red wolf and coyote interactions in northeastern North Carolina by examining red wolf and coyote morphology, diet, and spatial ecology. Currently, a full understanding of red wolf ecology is lacking, which is fundamental to ensuring recovery and persistence of the species. Furthermore, most research conducted on coyotes has been done in the western United States and Canada and the few studies on coyote behavior in the southeastern United States have been conducted at small scales (Holzman *et al*. 1992; Chamberlain *et al*. 2000; Constible *et al*. 2006).

Among phylogenetically related species that coexist, body size is the most distinguishing feature among those animals (LaBarbera 1989). Within canid communities, competition is strongly asymmetrical with larger species displacing smaller competitors (Paquet 1992; White *et al*. 1994; Arjo and Pletscher 1999; Constible *et al*. 2006; Berger and Gese 2007). Red wolves and coyotes exhibit morphological and niche overlaps, in which red wolves are the larger species. Although competition for space and food resources is common among coexisting species with similar body sizes and ecological needs, competition between red wolves and coyotes extends beyond space and food because both species can use each other as a resource for reproduction when within-species mating opportunities are exhausted. As a result, interactions between the two species are complex because the outcome of red wolf-coyote interactions can range from lethal antagonism to congeneric pair-bonding resulting in hybridization. The functional significance of body size within these interactions remains unclear and the relationship between hybridization and body size is worth examination.

In this dissertation, I propose to examine the influence of body size on red wolf and coyote space and resource use, habitat selection, and interactions. Space use is thought to reflect the ecological requirements of a species and body size is known to have pervasive influence on spatial ecology through consumer-resource interactions (Yodzis and Innes 1992; Basset and DeAngelis 2007). It has been demonstrated that home range sizes of carnivores scales

allometrically with individual body size (McNabb 1963; Gittleman and Harvey 1982; Mace and Harvey 1983; Swihart *et al*. 1988) in which larger carnivores have larger home ranges relative to smaller carnivores because larger home ranges provide more food resources for greater energetic demands. Additionally, there is a positive relationship between body size and prey size among carnivores (Gittleman 1985; Radloff and Du Toit 2004). Differing in body size, red wolves (20-38kg) and coyotes (11-18kg) in northeastern North Carolina should have differential energy requirements and different capacities for searching for and processing food resources. This difference in body size may be the primary trait that promotes differential use of space, resources, and habitat between the two species. Therefore, it is likely that selection forces may act on morphological variation in which body size differences create niche partitioning and reduce competitive interactions between red wolves and coyotes.

If body size drives the outcome of competitive interactions between red wolves and coyotes, it is plausible to hypothesize that size may influence the rates of hybridization between the two species. Coyotes are capable of consorting with red wolves that result in the successful formation of congeneric breeding-pairs that are maintained for several years. The over-arching goal of this project is to understand the conditions that facilitate red wolf-coyote hybridization. Red wolf-coyote interactions indicate that both populations in northeastern North Carolina may be limited by the availability of mates and not space and food resources in which congeneric pair-bonding demonstrates weak reproductive barriers between red wolves and coyotes. In the same manner that body size may influence resource partitioning between red wolves and coyotes through differential use of resources, body size may influence reproductive partitioning through assortative mating (Pfennig and Pfennig 2010; Schemske 2010).

If red wolf and coyote mate selection is non-random, there should be a pattern of behavior in which individuals preferentially mate with certain members of the opposite sex. Benefits derived by choosing certain mates rather than others can be difficult to quantify because those benefits can be subtle (Halliday 1983). Successful production of offspring doesn't appear to

influence partner fidelity because sterilized coyotes are capable of maintaining pair-bonds with other coyotes and red wolves for multiple years (USFWS, unpublished data). However, red wolf and coyote mate choice and continued fidelity may result from behavioral mechanisms that result in similar use of space, habitat, and prey in order for both individuals to complement one another. In other words, differences in ecological requirements may serve as barrier to conspecific pair-bonding between red wolves and coyotes. If this hypothesis is correct, body size may create reproductive partitioning, along with resource partitioning, between red wolves and coyotes. For example, if coyotes have a much lower ceiling for home-range sizes then red wolves because of lower energy demands associated with smaller body sizes, then red wolves that exceed those spatial demands are likely to be reproductively isolated from the coyote population. The differences in space use and resource demands will not allow for successful maintenance of monogamous breeding pairs. However, red wolves that are below that ceiling are susceptible to consorting and breeding with coyotes because they can complement the spatial and resource needs of their coyote mates. Therefore, morphological traits, such as body size, that promote dissimilarity in space use and resource needs may create reproductive barriers between red wolves and coyotes.

Chapter 2 summarizes the history of red wolf recovery efforts, provides a synopsis of challenges to red wolf restoration, and suggests future research needed for to pursue full recovery of red wolves.

Chapter 3 examines external morphological characters of red wolves, coyotes, and their hybrids to determine if morphology could be an accurate discriminator among the 3 canid taxa. This would allow us to verify if red wolves and coyotes differed in morphology. To accomplish this we collected mean body measurements from 171 red wolves, 134 coyotes, and 47 hybrids for identifying canid taxa in the wild. We then used polytomous logistic regression analysis of 7 morphometric variables to allocate canids to their *a priori* species groups predetermined via genetic analysis.

Chapter 4 assesses factors affecting prey selection of red wolf packs, coyote pairs, and congeneric pairs. To accomplish this, my team and I collected and analyzed the prey remains in 1754 scats from 13 red wolf packs, 17 coyote pairs, and 8 congeneric pairs. We used several variables (i.e., body weight, social structure, age, etc.) that have not been traditionally used in analyses of scat remains to account for variation in diet. Furthermore, this study is the first to assess dietary behaviors of congeneric canid breeding units that are the source of hybridization. Additionally, this study represents the most comprehensive assessment of canid diet in the eastern United States.

Chapters 6 and 7 assess space use and habitat selection of red wolves and coyotes. Accomplishing this objective required capturing and fitting global positioning system (GPS) radio-collars to red wolves and coyotes. This permitted us to monitor resident and transient animals and assess ways in which both species move, interact, and use several primary habitats in northeastern North Carolina. This study represented the 1st broad scale study (> 5000 km^2) of coyote space use and habitat selection in the southeastern United States. We also provide for the 1st assessment of body weight influence on coyote and red wolf home-range size.

Finally, Chapter 8 examines whether body size is a reproductive barrier between red wolves and coyotes. To accomplish this, we used linear regression to evaluate the influence of body weight on ecological parameters such as home-range size and diet composition. Observed patterns are then used to discuss the effects of energetics on red wolf and coyote hybridization.

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CHAPTER 2

RED WOLF (*CANIS RUFUS*) RECOVERY: A REVIEW WITH SUGGESTIONS FOR FUTURE RESEARCH

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Abstract

By the 1970s, government-supported eradication campaigns reduced red wolves to a remnant population of less than 100 individuals on the southern border of Texas and Louisiana. Restoration efforts in the region were deemed unpromising because of predator-control programs and hybridization with coyotes. The U.S. Fish and Wildlife Service (USFWS) removed the last remaining red wolves from the wild and placed them in a captive-breeding program. In 1980, the USFWS declared red wolves extinct in the wild. During 1987, the USFWS, through the Red Wolf Recovery Program, reintroduced red wolves into northeastern North Carolina. Although restoration efforts have established a population of approximately 70-80 red wolves in the wild, issues of hybridization with coyotes, inbreeding, and human-caused mortality continue to hamper red wolf recovery. We explore these three challenges and, within each challenge, we illustrate how research can be used to resolve problems associated with red wolf-coyote interactions, effects of inbreeding, and demographic responses to human-caused mortality. We hope this illustrates the utility of research to advance restoration of red wolves.

Introduction

Perceived threats to human enterprise have historically motivated efforts to exterminate large carnivores such as wolves, bears, and lions. In particular, wolves have been extirpated from much of their historical ranges in North America by government-supported eradication campaigns protecting agricultural and livestock interests. However, changes in American societal beliefs have resulted in profound changes to how wolves are perceived. The passage of the Endangered Species Act of 1973 (ESA) paved the way for restoration of wolf populations that were severely reduced or extirpated during the 19th and early 20th centuries. When the ESA was legislated, gray wolves (*Canis lupus*) and red wolves (*Canis rufus*) existed as declining remnant populations in the contiguous United States. Although gray wolf populations in Alaska and Canada were stable and the species was not threatened with extinction, red wolves were afforded no refuge. Red wolves were likely the first New World wolf species to come in contact with

Europeans and, consequently, the first to be persecuted. Prior to European colonization, red wolves were common in the eastern United States and they inhabited an area from the Atlantic coast west to central Texas, with the Ohio River Valley, northern Pennsylvania, and southern New York being its northernmost range and their distribution extending south to the Gulf of Mexico (Figure 1; Nowak 2002, 2003). At the turn of the 20th century, red wolves were extirpated throughout most of their range and approximately 100 individuals occupied coastal habitats of eastern Texas and western Louisiana (McCarley 1959, 1962). Declining because of aggressive predator-control programs and surrounded by an expanding coyote (*Canis latrans*) population, red wolves were incapable of maintaining self-sustaining populations. They began hybridizing with coyotes when they were unable to find conspecific mates and canid populations in the region gradually became genetically admixed (McCarley 1959; Paradiso and Nowak 1972; Carley 1975). This generated concerns that the last remaining red wolves would be genetically assimilated into the coyote genome through hybridization, so the southeast Texas and southwest Louisiana populations were targeted for restoration efforts (Carley 1975).

After the passage of the ESA, the United States Fish & Wildlife Services (USFWS) established the Red Wolf Recovery Program (Recovery Program) with the task of locating and preserving populations of red wolves in southeast Texas and southwest Louisiana (USFWS 1989). However, with rapidly declining red wolf populations and extensive hybridization, the USFWS decided to remove the last red wolves from the wild and place them in captivity. The Recovery Program's objectives soon changed to capture as many red wolves as possible for propagation in captivity, and to re-establish red wolf populations within the species' historic range in the near future (USFWS 1989). To find pure red wolves for the captive-breeding program, the Recovery Program captured as many wild red wolf-like canids as possible in southeast Texas and southwest Louisiana. From 1973 through 1980, approximately 400 canids were captured and 43 met the morphological standards to be considered red wolves. Breeding experiments were then conducted with those 43 individuals and, eventually, 14 individuals met the criteria established to

define the species. These individuals were used as the founders to begin the captive-breeding program (USFWS 1989). The red wolf was declared extinct in the wild in 1980, becoming the first species to be purposely extirpated in the wild to save it from extinction.

The captive-breeding program safeguarded the last remaining red wolves and served as the last repository of the red wolf genome. The primary objectives of the captive-breeding program were to certify the genetic purity of wild-caught red wolves, increase the number of red wolves in captivity, and maintain a captive red wolf population for re-establishment of the species in the wild (USFWS 1989). Red wolves readily reproduced in captivity with the first captive-born litters produced during 1977. Early efforts in the captive-breeding program then focused on developing procedures and protocols to ship, handle, and breed red wolves within a network of zoo facilities (Carley 2000). To maintain integrity within the captive-breeding program, the USFWS developed a Species Survival Plan® (SSP) that was accepted by the Association of Zoos & Aquariums (AZA; USFWS 1989). This ensured that the species would be preserved in captivity until a strategy was developed for reintroducing red wolves in the wild. To acclimate captive red wolves to wild conditions, the Recovery Program began conducting experimental releases of captive-born red wolves on island propagation sites such as Bulls Island of the Cape Romain National Wildlife Refuge in South Carolina. Bulls Island became one of three island propagation sites that allowed the Recovery Program to develop restoration techniques.

During 1984, Alligator River National Wildlife Refuge (ARNWR) was established on the Albemarle Peninsula of northeastern North Carolina (NENC) when the Prudential Insurance Company donated approximately 480 km² (48,000 ha) of land to the federal government (USFWS 1989). This area was identified as the future reintroduction site for red wolves because the refuge contained suitable prey for red wolves, coyotes were absent on the landscape, no livestock were present, and the presence of humans was low. In 1987, the USFWS released eight captive-born red wolves (four male-female pairs) onto ARNWR to begin reintroduction efforts. Initially, mortality rates were high as captive-born wolves were hit by cars, drowned, succumbed

to disease, or were attracted to townships (Phillips et al. 2003). As a result, early attempts to established red wolves on ARNWR were aggressive and resulted in the release of more than 60 red wolves from 1987 through 1994 (Phillips et al. 2003). Eventually, the NENC population transitioned from captive-born individuals to wild-born individuals and the release of captive-born adult wolves to augment the NENC population ceased. Currently, almost all red wolves in NENC are wild born. Periodically, island-born juveniles and captive-born pups fostered into wild litters are used to maintain genetic diversity and health of the wild population. By the mid-1990s, red wolves in the wild formed packs, maintained territories, and successfully bred, and the reintroduction marked the first successful reintroduction of a wolf species. It also marked the first successful attempt to reintroduce a large predator that was completely extirpated from the wild.

The USFWS initiated a second reintroduction in the Great Smoky Mountains National Park (GSMNP) of the southern Appalachians (USFWS 1990). During 1991, the initial stage of the GSMNP reintroduction was implemented to gather information on interactions of red wolves and coyotes, livestock, and humans (Lucash et al. 1998). Initial efforts appeared successful when a mated adult pair and two pups established a territory in Cades Cove of the GSMNP, so the USFWS proceeded with a full-scale reintroduction. However, most of the 37 red wolves released were unable to establish and maintain territories within the park boundaries and left for better habitat on surrounding lower-elevation agricultural land (Henry 1998). Additionally, red wolves that maintained territories on GSMNP had low pup survival as a result of Parvovirus, malnutrition, and parasites (Henry 1998). After repeated introduction attempts and low pup survival, it was determined that the red wolf population on GSMNP would have to be perpetually managed within the park and the GSMNP red wolf reintroduction was terminated in 1998. Red wolves that remained in the park were subsequently captured and relocated to ARNWR.

Although nearly 25 years have elapsed since red wolves were reintroduced into the wild, more than half of the red wolf population still exists in captivity. The captive-breeding program safeguards approximately 200 red wolves in more than 40 captive facilities around the United

States while the reintroduced red wolf population has expanded throughout the Albemarle Peninsula to about 70-80 animals in approximately 15 packs (USFWS 2013). Since 1987, the Recovery Area has expanded to accommodate the growing population from approximately 480 km^2 to approximately 6800 km^2 of federal, state, and private lands (Figure 2). Although red wolf restoration has experienced success in many ways, efforts to maintain the NENC population and to find future reintroduction sites continually face challenges. For instance, the red wolf species continues to be plagued by taxonomic controversy regarding its origin and arguments against the systematic validity of the red wolf have been used to oppose red wolf restoration (Phillips and Henry 1992; Nowak and Federoff 1998). Red wolves still remain a remnant population and experience a series of ecological threats such as hybridization with coyotes and inbreeding (Kelly et al. 1999; Stoskopf et al. 2005; USFWS 2007). Without management of coyotes in the Recovery Area, it is likely that the red wolf population would be genetically assimilated into the eastern coyote population (Kelly et al. 1999). Additionally, the small number of red wolves makes the population in NENC susceptible to genetic drift and inbreeding depression (Rabon and Waddell 2010). To prevent inbreeding and maintain genetic diversity in the wild population, captive-born and island-born individuals are periodically released into the Recovery Area. Additionally, quixotic fervor within the hunting community to suppress predators continues to hamper red wolf population growth in NENC. Increased mortality by gunshot during the hunting season has reduced the number of red wolf packs, lowered red wolf survival, and has facilitated coyote expansion into the Recovery Area (USFWS 2007).

In the progress of overcoming these challenges to restoring red wolves to the wild, there is a need to consolidate knowledge and contemplate those experiences as recovery efforts move forward. Therefore, our objective is to provide a synopsis of the challenges to restoration of the red wolf and suggest future research needed to pursue full recovery of the species.

Red Wolf Taxonomy

Currently, scientists find themselves in a contentious debate regarding the taxonomy of New World wolves and its implications on the evolution, ecology, and conservation of *Canis* species in eastern North America (Chambers et al. 2012). The origin of the red wolf is central to this debate (Nowak 1979, 2002; Wayne and Jenks 1991; Wilson et al. 2000). Although scientific synthesis has led to new insights into the evolution and ecology of New World wolves, massive loss of historic and geographic genetic data and recent genetic introgression by coyotes continues to hinder consensus on red wolf origin (Chambers et al. 2012). Despite significant voids in data to adequately characterize the historic red wolf populations in the Southeast, limited and anecdotal data does exist to indicate the existence of a large canid in the southeastern United States.

The unique presence of a southeastern wolf was noted during the 18th century (Bartram 1791; Harper 1942; Nowak 1992) and, by 1851, the red wolf was given a valid scientific name (Audubon and Bachman 1851). During the turn of the 20th century, several authors recognized structural differences between gray and red wolves and initiated revisions of the red wolf's taxonomic status (Bangs 1898; Baily 1905; Miller 1912). Eventually, Goldman (1937, 1944) described red wolves as distinct from gray wolves and coyotes based on cranial and dental characters and consigned all wolves of the Southeast to one species, *C. rufus*. By the 1960s, federal and state agencies generally assumed that viable populations of red wolves existed in the Southeast despite a great deal of confusion about the species status. McCarley's (1962) taxonomic study of red wolves concluded that red wolves had been replaced by coyotes and red wolf/coyote hybrids in most areas of eastern Texas, Arkansas, Louisiana, and Oklahoma. His work indicated that a few red wolf populations still existed in parts of Louisiana. After examining a number of *Canis* specimens from the Southeast, Paradiso (1965, 1968) and Pimlott and Joslin (1968) confirmed McCarley's (1962) findings and brought attention to what were believed to be the last surviving red wolf populations on the Gulf Coast in southeast Texas and southwest Louisiana (Carley 2000).

Nowak (Nowak 1979, 2002) investigated the taxonomy of *Canis* species of eastern North America using discriminant function analysis to evaluate the characteristics of modern and paleontological *Canis* skulls (Nowak 1979, 2002) and dentition (Nowak 2002). In doing so, he was able to differentiate gray wolves, red wolves, coyotes, and domestic dogs (*Canis familiaris*) into separate groups and postulated that red wolves evolved from a transitional form (i.e., *Canis mosbachensis*) between a wolf-like coyote ancestor and the gray wolf. Nowak (1979) found no evidence that gray wolves existed in the southeastern United States. Despite widespread occurrence of domestic dog in the Southeast, Nowak (1979) found no evidence of introgression from domestic dogs into the red wolf and coyote populations. The earliest red wolf specimens showed no statistical overlap with gray wolves, coyotes, or domestic dogs and had similar multivariate distribution as the red wolf specimens from the Pleistocene era. Specimens collected before 1930 indicated hybridization between red wolves and coyotes was uncommon where their ranges approached. However, specimens from the 1930s until the 1950s indicated hybridization with coyotes was occurring over large areas of the red wolf's southern range where coyotes were replacing red wolves. Nowak (1979, 2002) suggested that hybridization between red wolves and coyotes began at the turn of the 20th century when anthropogenic factors destroyed ecological and behavioral isolation. Despite coyote introgression into the red wolf genome during the 20th century, Nowak (2002) reported that the morphology of modern red wolves is predominately like *C. rufus* that persisted in the eastern United States 10,000 years ago.

Although it had been suggested that red wolves were the result of coyote and gray wolf hybridization (Mech 1970), the hypothesis of a hybrid origin did not receive much attention until applied molecular techniques became the primary means of evaluating red wolf taxonomy. Analyzing mitochondrial DNA (mtDNA), Wayne and Jenks (1991) evaluated the genetic integrity of red wolves in the captive-breeding program and reported no unique genetic markers in red wolves that were distinct from gray wolves and coyotes. Therefore, they concluded that the red wolf is a hybrid form derived from gray wolves and coyotes. Similar conclusions were

reached by a series of genetic papers examining red wolf mtDNA and nuclear DNA (nDNA) that accepted the premise that red wolves originated from hybridization events occurring between 250 to 13,000 years ago (Roy et al. 1996; Reich et al. 1999; vonHoldt et al. 2011). However, these conclusions have been contested in morphological (Nowak and Federoff 1996; Nowak 2002, 2003) and molecular (Bertorelle and Excoffier 1998; Wilson et al. 2000; Hedrick et al. 2002; Adams et al. 2003; Wilson et al. 2003; Kyle et al. 2006; Hailer et al. 2008; Chambers et al. 2012; Rutledge et al. 2012) studies.

Examining the origin and taxonomy of wolves in eastern Canada, Wilson et al. (2000, 2003) reported that captive red wolves and eastern wolves (*Canis lycaon*) have mtDNA control sequences more closely related with coyotes, while exhibiting unique haplotypes not found in gray wolves and coyotes. Although these mtDNA sequences don't occur in western coyotes, they cluster among western coyote populations and Wilson et al. (2000) attributed this as evidence that red wolves, eastern wolves, and coyotes share a recent common ancestor in the New World independent of gray wolves. Other studies have supported these conclusions (Wilson et al. 2003; Wheeldon et al. 2010; Chambers et al. 2012) and these results appear to reconcile early observations that red wolves and coyotes approached one another in morphology (Nowak 1979; Goldman 1937). Although the results of these studies indicate that red wolves are not of hybrid origin, Wilson et al. 2000 proposed that the red wolf and eastern wolf are genetically close enough to be considered a single species under *C. lycaon*. The disagreement among these genetic studies stems in part from differing assumptions about the nature of the coyote-like mtDNA found in eastern and red wolves. Those that support a hybrid origin interpret the coyote-like mtDNA as being from coyotes, whereas those that support the hypothesis that red wolves, eastern wolves, and coyotes share a common ancestry interpret the coyote-like mtDNA as being eastern wolf in origin and a result of incomplete lineage sorting.

Significant gaps in the historic and geographic genetic data and recent hybridization makes it difficult to sort out the evolutionary history of red wolves. As a result, the taxonomy of

North American wolves is complex and not without debate. Prior to and during European colonization of the Southeast, there appears to have been a small wolf species present and its modern equivalent may be the red wolf. It is also possible that red wolves are morphologically and genetically similar to coyotes because they fall within the species limits of the coyote clade (Chambers et al. 20012). Although the door is open for future taxonomic revision, the hybrid origin of red wolves is difficult to reconcile because gray wolves have historically been absent from the southeastern United States and, until the mid-20th century, coyotes were absent from the region for over 10,000 years (Nowak 2002). Additionally, there is no evidence of ongoing hybridization between gray wolves and coyotes that are currently sympatric (Kyle et al. 2006; Wheeldon et al. 2010; Rutledge et al. 2012). Modern hybridization among *Canis* species in the East makes it difficult to sort out the evolutionary history of red wolves. Recent and developing studies demonstrate that the taxonomy of red wolves is complex and morphological and molecular studies of fossilized wolves from the southeast are essential to settling the debate over red wolf origin.

Ecological Challenges

Red Wolf and Coyote Hybridization

Red wolves and coyotes exist as a panmictic population in NENC and hybridization provides an exceptionally tough set of problems for red wolf recovery. Understanding how red wolves interact with coyotes is an important issue which could dictate the success of the reintroduction project. During 1999, the USFWS re-evaluated the red wolf recovery effort by organizing a Population and Habitat Viability Assessment workshop (PHVA; Kelly et al. 1999). Introgression of coyote genes into the red wolf population was considered the principal threat to recovery efforts when it was discovered that hybridization could render the wild red wolf population unrecognizable within several generations (Kelly et al. 2006; Stoskopf et al. 2005). As a result, priorities were identified and the PHVA called for approaches that would prevent hybridization and promote the growth of a self-sustaining population of red wolves in NENC. An

adaptive management plan (Rabon et al. 2013) was designed during the PHVA with the intent to provide the Recovery Program flexibility to modify management schemes and scientific studies as conditions and threats to red wolf recovery change.

As history has proven, coyote populations are too resilient to state and federal eradication programs and clearing the Albemarle Peninsula of coyotes poses an overwhelming challenge. Two management techniques were developed during the PHVA to prevent hybridization. Coyotes and hybrids captured by USFWS personnel within the Recovery Area are reproductively sterilized (hereafter sterilized) and used as space holders until red wolves move in and occupy those areas. Coyotes and hybrids are taken to a local veterinary clinic in which females and males are sterilized by tubal ligation and vasectomy, respectively. This process keeps the hormonal system intact and avoids disrupting breeding and territorial behavior. Sterilized animals are fitted with mortality-sensitive radio-collars, released, and monitored for the duration of their life. This allows the Recovery Program to collect relevant information on coyote space use, habitat selection, and interaction with red wolves while suppressing coyote reproduction. In the event that a red wolf pairs with a sterilized coyote, the pair cannot produce hybrid litters. Additionally, sterilized coyotes that maintain territories keep those spaces occupied and prevent fertile coyotes from establishing breeding pairs on the landscape.

As recommended during the PHVA, the Recovery Area was divided into three management zones in which management efforts varied in intensity to minimize hybridization on the landscape (Figure 2). The ultimate management goal is to ensure that all *Canis* breeding pairs within the Recovery Area are red wolves. To implement this, Recovery Program biologists began eradicating coyotes and hybrids from Zone 1 while selectively using sterilized coyotes as space holders in Zone 2. When objectives in Zone 1 were completed, management efforts shifted west to Zone 2 in which sterilized space holders were removed to create space for red wolves. Once coyotes and hybrids were removed from Zone 1 and 2, management efforts would be undertaken in Zone 3. Implementing management goals in order of priority allowed the Recovery Program to

minimize hybridization by monitoring red wolf and coyote packs throughout the Recovery Area and replacing coyotes and hybrids with red wolves when opportunities arose.

Prior to the PHVA, the Recovery Program assumed all canids captured within the Recovery Area were wolves unless animals were unusually small and coyote-like in appearance (Stoskopf et al. 2005). Once hybridization was considered the primary threat to recovery efforts, molecular techniques were developed to identify coyotes and hybrids and quantify introgression into the red wolf population. Using microsatellite markers from the 14 founding individuals and other captive red wolves to generate allele frequencies, a pedigree of the red wolf population was developed (Miller et al. 2003; Adams 2006). Animals are now blood sampled upon capture and identified as red wolves, coyotes, or hybrids using 17 microsatellite markers. As these methods were developed, a hybridization event that occurred during 1993 between a female red wolf and a male coyote was detected (Adams 2006; USFWS 2007). Individuals in the wild population considered red wolves were then correctly identified as 2^{nd} and 3^{rd} generation backcrosses from the male hybrid offspring of the 1993 hybridization event. When it was realized that removing all red wolves with introgression would essentially extirpate the wild red wolf population, the Recovery Program opted to allow wild reproduction among red wolves to slowly breed the coyote genetics out. To accelerate purging of coyote genetics, the Recovery Program selectively culled animals they thought were not red wolves. Over time, selective management of backcrosses and minimizing hybridization has been successful in limiting coyote introgression in the wild red wolf population to less than 5% in 2006 (Adams 2006) and has continue to facilitate a decrease since then (USFWS unpublished).

Scientific research is essential to understanding hybridization and the interplay between research and management offers an interesting opportunity to examine this process over the long-term. Initial scientific inquiries after the PHVA were to establish studies to measure, monitor, and manage hybridization in the Recovery Area. In doing so, a complete reconstruction of a red wolf pedigree has been established and this most likely represents the most complete database for any

wild population. It's now understood that hybridization between red wolves and coyotes is not directional in terms of the wolves' sex and hybrids backcross with both species (Adams 2006; Rabon 2009; Bohling 2011). Furthermore, current research has identified young, inexperienced red wolves with coyote ancestry to be more likely to breed with coyotes (Bohling 2011). Despite these successes in measuring and monitoring hybridization, ecological explanations for hybridization have been lacking. In other words, little quantitative information exists on mate selection and possible reproductive barriers between red wolves and coyotes (Bohling 2006; Rabon 2009), and future research efforts should focus on discovering possible reproductive isolating mechanisms that exist between red wolves and coyotes.

Hybridization between red wolves and coyotes implies the obvious break down of reproductive barriers and the two species consort and breed with one another when situations favor opportunities to mate with congenerics. Currently, no extrinsic reproductive barriers (i.e., geographic barriers) exist between red wolves and coyotes because coyotes are ubiquitous throughout the red wolf's historic range. Hybridization occurs between the two species when a red wolf and a coyote form a breeding pair that will defend a territory together until the death or displacement of a mate. Consequently, the red wolf-coyote pair will produce hybrid offspring and maintain pack dynamics similar to gray wolves (Jordan et al. 1967; Mech 1970, 1999), red wolves (Phillips et al. 2003; Hinton and Chamberlain 2010; Sparkman et al. 2011), and coyotes (Gese et al. 1996a, 1996b; Bekoff and Gese 2003). This should be expected because monogamous breeding appears to be a phylogenetic component that operates at the family level and group living is common within *Canis* (Gittleman 1989; Geffen et al. 1996). Therefore, if an isolating mechanism exists, it's most likely to be an intrinsic isolating factor (i.e., behavior) that would prevent pair formation between red wolves and coyotes. Understanding the ecology of red wolf-coyote interactions is crucial to define species traits that serve as isolating mechanisms, describe how these traits prevent hybridization, and identify what selection forces in nature favor the maintenance of red wolves and coyotes as separate species.

If intrinsic isolating factors do exist between red wolves and coyotes, then behaviors that promote sexual isolation of individual red wolves and coyotes should be associated with phenotypes that promote divergence in behavior and genetic discontinuity between the two species. Red wolves and coyotes share the same body plan but do not overlap in body size in which red wolves are the larger species (Hinton et al. In review). As a result, body size is the primary trait that distinguishes red wolves from coyotes and it most likely facilitates differential use of resources between the two species. It is well established that body size has a major effect on inter- and intraspecific interactions of mammalian carnivore species in which competitive interactions are strongly asymmetrical with larger species displacing smaller competitors (Rosenzweig 1966, 1968; Gittleman 1985; Palomares and Caro 1999). Furthermore, body size is a key predictor of life history traits, population growth rates, density, space use, and predator-prey dynamics (Huxley 1936; McNab 1963; Gittleman 1985; Brown and Nicoletto 1991; Brown et al. 2004; White et al. 2007). It is logical that red wolves and coyotes are not exempt from the broad influences that body-size allometries have at individual-, population-, and community-level processes. Understanding how body size differences lead to differences in red wolf and coyote resource demands, demographics, diet, and space use will lead to more comprehensive understanding of red wolf-coyote interactions and identify what behaviors facilitate genetic discontinuity between the two species.

Recent research has allowed the Recovery Program to measure, monitor, and manage hybridization in NENC. However, preventing hybridization using reproductive sterilization techniques is heavy handed and a short-term strategy to jump start red wolf colonization. There are other important biological considerations to be addressed and research objectives regarding hybridization should shift in the direction of studying the relationship between phenotypic traits and hybridization. For instance, when choosing a mate, do red wolves and coyotes use a criterion of mate quality as a predictor of benefits that potential mates offer and, if so, how does choosing for mate complementarity effect partner fidelity and breeding pair stability? These types of

research objectives could associate specific traits with hybridization and breeding success and, eventually, allow biologists to detect selection processes within the red wolf and eastern coyote populations. Reproductive barriers are maintained through ecological, demographic, and developmental conditions (Mayr 1941) and understanding how sexual isolation operates is crucial to the restoration of red wolves.

Inbreeding Effects

Inbreeding can increase the risk of extinction for small populations by decreasing reproductive rates and increasing susceptibility to environmental change and disease (Charlesworth and Charlesworth 1987; Crnokrak and Roff 1999; Hedrick and Kalinowski 2000; Charlesworth and Willis 2009). A primary goal of many conservation programs is to minimize inbreeding depression, the deleterious effects of inbreeding, because of the link between increased inbreeding and loss of population viability (Lande 1988; Allendorf et al. 2010; Frankham 2010). As a small population pushed to the brink of extinction, the red wolf suffered considerable loss of genetic diversity and obviating the potential effects of inbreeding depression and further loss of genetic diversity on red wolf fitness is a conservation goal (USFWS 1989). Given inbreeding depression may occur when red wolves mate with closely related kin, and as a population founded by few individuals, managing the overall relatedness of captive and wild populations poses challenges for restoration efforts.

Captive breeding of red wolves began three decades ago to preserve the species and provide demographic security. Preservation of genetic diversity in captivity requires using a red wolf Population Analysis and Breeding and Transfer Plan to select sires and dams for artificial breeding (Waddell and Long 2010). The long-term goal is to preserve 80-90% of the genetic diversity for 150 years (USFWS 1989) and, currently, the captive red wolf population has retained 89.5% of the genetic diversity that existed in the 14 founders (USFWS 2007; Waddell and Long 2010). Although heritable defects, such as progressive retinal atrophy, malocclusion, and undescended testicles, were observed in a small number of captive red wolves, early studies

that examined juvenile survival and litter size reported no observable inbreeding depression in the red wolf captive program (Kalinowski et al. 1999; USFWS 2007; Hedrick and Fredrickson 2008). Subsequent studies found increased levels of inbreeding in the captive population were correlated with decreased litter size, but overall, inbreeding depression was minimal (Rabon and Waddell 2010). Rabon and Waddell (2010) concluded that improvements in husbandry, veterinary care, and nutrition positively contribute to pup survival and offset the negative effects of inbreeding in the captive population. However, these services are not extended to red wolves in the wild and understanding the effects of inbreeding in the wild population requires further study.

Red wolves are social carnivores in which intraspecific aggression and delayed dispersal play an important role in pack dynamics. The small size of the wild population and the high level of relatedness among individuals increase the risk for incestuous mating to occur. The influence of mate choice and inbreeding avoidance behavior on population dynamics remains poorly understood. It's been shown that dispersal is an important inbreeding avoidance behavior in other canid species that results in few inbred matings (Smith et al. 1997; Jankovic et al. 2010; Geffen et al. 2011). Similarly, Sparkman et al. (2012) found few instances of breeding between 1st degree relatives in wild red wolves and concluded that dispersal behaviors reduced the risk of inbreeding. Red wolf behaviors associated with inbreeding avoidance suggest that inbreeding has a negative effect on fitness and may influence population dynamics.

Inbreeding levels of wild red wolf populations may be high and the effect of inbreeding avoidance on hybridization with coyotes remains unknown. Inbreeding avoidance may cause red wolves to outbreed with a closely related species, such as coyotes, when inbreeding leads to severe fitness consequences. During the mid-2000s, Recovery Program biologists observed dispersing red wolves passing through territories of potentially available red wolf mates and pair-bonding with coyotes. They speculated inbreeding avoidance may influence red wolf mate choice and facilitate hybridization. The premise behind this observation is a hypothesis that assumes when red wolves cannot locate red wolf mates unrelated to them they will opt to breed with

unrelated coyotes to avoid incest (Beyer and Lucash personal communication). Therefore, understanding how inbreeding depression influences hybridization between red wolves and coyotes has become a concern for managing the wild red wolf population.

Research on the effects of inbreeding should involve both ecological and genetic analyses to investigate red wolf and coyote pair formation and how inbreeding avoidance influences hybridization and red wolf fitness. One particular area of promise is sequencing major histocompatibility complex (MHC) genes to examine red wolf kin recognition and mate choice. MHC genes were originally identified in inbred mice during skin graft experiments in which MHC molecules of the host recognized graft tissue as foreign antigens and attacked them (Snell and Higgins 1951). Since then, MHC genes have been discovered to play a critical role in cellular immune response and correlations between MHC alleles, haplotypes, or heterozygosity and pathogen resistance have been shown for a number of species (Apanius et al 1997; Sommer 2005). Given that MHC variation affects disease resistance, there may be an advantage to avoid kin and other mates with similar MHC alleles or haplotypes (Milinski 2006; Huchard et al. 2010). Studies have found MHC-dependent mate choice in both captive and wild species where individuals preferred MHC dissimilar mates (Piertney and Oliver 2006). Cooperative group living is a primary adaptive characteristic of red wolves and individuals are likely to recognize kin. How MHC variation influences kin recognition and, subsequently, inbreeding avoidance and hybridization in red wolves is unknown. Red wolves are known to have fewer MHC alleles than other wild canid populations (Hedrick et al. 2002) and future research should evaluate how MHC variation may influence mate selection, and hybridization.

Red Wolf Demographics

It's well established that variation in survival and reproduction are responsible for the dynamics of populations (Leslie 1945; Ginzburg 1986; Gotelli 2001; Watts et al. 2009; Stahler et al. 2013). Accurate estimates of survival and reproductive rates are essential for conservation programs to minimize extinction risks and promote conditions enhancing the persistence of small,

vulnerable populations (Willams et al. 2002; Norris 2004). Population viability analysis (PVA) has traditionally been used to project population trajectories into the future based on ecological and demographic parameters (Akçakaya 2000a, 2000b). The red wolf population currently exists as a small, vulnerable population with a high risk of extinction to demographic and environmental stochasticity. Understanding how the red wolf population is expected to change in response to environmental conditions is dependent on accurate estimates of vital rates and realistic population estimates from quantitative models.

A primary goal of red wolf recovery is to establish and maintain a red wolf population of 220 individuals in three disjunct populations within the species' historical range (USFWS 1989). To evaluate the red wolf population and its viability in the presence of a ubiquitous coyote population, a PVA model was developed at the PHVA to predict population trends and the effect of hybridization on red wolf persistence (Kelly et al. 1999). The 1999 PVA predicted that red wolves would increase 20% each year for about 10 years before reaching a carrying capacity limit of 140 individuals. Low mortality for wild wolves was assumed to drive the rate of population growth and, despite not reaching 220 individuals, no immediate risk of extinction was suspected given this scenario. When hybridization was incorporated into the 1999 PVA, increased loss of female red wolf breeders to coyote encroachment was predicted to suppress reproductive rates of red wolves to a level too low to offset natural and human-mediated mortality. Therefore, increasing levels of hybridization increases the risk of extinction not only through red wolf assimilation into the coyote population but, also through an inability to replace red wolves lost to mortality.

The 2007 5-year status review (hereafter 2007 Review) of red wolves indicated the NENC population had fluctuated between 80-130 individuals per year since 1999 (USFWS 2007). With an estimated carrying capacity (*K*) of 140 individuals that was reached in 2001, it was assumed that the red wolf population would continue to expand in subsequent years because red wolves occupied approximately 60% or less of the Albermarle Peninsula land area (USFWS

2007). However, the red wolf population did not expand but, rather, gradually declined to approximately 100 individuals since peaking in 2001 (see Red Wolf Recovery Program Quarterly Reports). Preliminary analysis of red wolf demographics from 1999 until 2007 indicated overall annual red wolf survival rate was 78.2% and anthropogenic sources of mortality (e.g. gunshots, trapping, and vehicle strikes) accounted for 58% of red wolf deaths (USFWS 2007). The 2007 Review reported the high proportion of red wolf deaths by anthropogenic factors was additive to other mortality sources and that red wolf fatalities resulting from gunshots remains the most problematic to red wolf persistence.

Red wolves were seven times more likely to be killed during the North Carolina white-tailed deer (*Odocoileus virginianus*) hunting season (October 15 – December 15) than during the non-hunting season (USFWS 2007; Bohling 2011). Illegal take of red wolves is believed to hamper red wolf population growth because it disrupts natural behavioral dynamics that effect demographic processes (Packer et al. 2009; Rutledge et al. 2012b). Furthermore, reduction of red wolves increases coyote presence in the Recovery Area by breaking up packs and destabilizing social dynamics, which reduces the red wolf's ability to hold and defend territories against coyotes. The breeding season for red wolves occurs during white-tailed deer and American black bear (*Ursus americanus*) hunting seasons and increased mortality rates during this time forces red wolf breeders to quickly replace lost mates. When red wolves lost mates to gunshots during the hunting seasons they were more likely to pair with coyotes or fail to replace their mates than to pair with red wolves (USFWS 2007). Evaluating the breeding records and individual histories of red wolves involved in hybridization events, Bohling (2011) found most hybridization events occurred after red wolves lost mates to gunshots and suggested that social structure and stability play a critical role in preventing hybridization. Similarly, Rutledge et al. (2012b) found intense harvest of eastern wolves around Algonquin Provincial Park (APP) during the 1960s to have exacerbated hybridization with coyotes. Therefore, it is prudent for red wolf conservation that managers better understand how high mortality caused by illegal killing of red wolves during the

hunting season may disrupt social structures, influence population dynamics, and promote hybridization with coyotes.

The PHVA warned that human-caused mortality that is additive would facilitate hybridization and increase the risk of extinction for red wolves. Therefore, research on red wolf demographics should focus on elucidating mechanisms that influence persistence of wolves on the landscape. This requires use of the Recovery Program's long-term monitoring data of the NENC red wolf population. Long-term monitoring involves annual trapping of red wolves during the fall to radio-tag juvenile and adult red wolves and inspection of dens during the spring to count and transponder pups (Rabon et al. 2013). These efforts allow the Recovery Program to identify individual red wolves at birth and monitor them until death to collect baseline data on survival and reproduction. Demographic parameters such as survival and population size can be estimated from capture-recapture data (Nichols et al. 1994; Burnham et al. 1995; Ivan et al. 2013) and research efforts should incorporate red wolf monitoring data to develop accurate parameters. Research objectives should estimate annual rates of population change and age-specific survival and reproductive rates of the red wolf population. Additionally, effects of natural and anthropogenic sources of mortality on red wolf persistence should be examined to understand how environmental conditions affect population dynamics over the short- and long-term. This type of research would provide accurate estimates of population parameters for PVAs and assist in developing a valuable framework to evaluate important ecological questions related to red wolf population dynamics.

Conclusions

Created in the wake of new societal values, the Red Wolf Recovery Program was tasked by the USFWS with the responsibility of restoring red wolves within their historic range. Along the road to saving the red wolf from extinction, the Recovery Program extirpated the species from the wild to prevent its genetic assimilation into the expanding coyote population. The Recovery Program established a captive-breeding program, and despite starting with 14 founders, grew a

captive population of red wolves used for future reintroductions into the wild. During fall of 1987, the red wolf became the first carnivore completely extirpated from the wild to be successfully reintroduced back into its historic range. Today, the Recovery Program manages the only wild population of red wolves on the Albemarle Peninsula of North Carolina. However one views the merits of this effort to restore red wolves, it is a story with challenges and one worth contemplation.

Disagreements about the nature of coyote-like DNA found in red wolves have created controversy in red wolf taxonomy and conservation. The initial discovery of coyote-like haplotypes in red wolves spurred conclusions that the species originated through modern hybridization between gray wolves and coyotes (Wayne and Jenks 1991; Roy et al. 1996). As a result, academic debates during the 1990s focused on the role of modern hybridization in red wolves and its implications for red wolf conservation (Gittleman and Pimm 1991; Nowak 1992; Wayne and Gittleman 1995; Nowak and Federoff 1998). However, later research reported the coyote-like DNA found in red wolves indicated a shared ancestry with eastern wolves and coyotes, and concluded that all three species evolved in a New World canid lineage independent of gray wolves (Wilson et al. 2000; Wheeldon et al 2010; Chambers et al. 2012). Predictably, the academic debate has begun shifting towards resolving whether eastern and red wolves are conspecific (Murray and Waits 2007; Kyle et al. 2008; Wheeldon et al. 2010; Chambers et al. 2012). Taxonomy is fluid because species evolve and competing concepts over species statuses are not uncommon. In the case of the red wolf, the lack of historic and geographic specimens coupled with modern hybridization between red wolves and coyotes facilitate conflicting conclusions with regards to the species origin. Therefore, it's realistic to expect scientific debate over the taxonomic status of red wolves and, as future studies provide new information, revisions to competing hypotheses regarding species origin should be expected.

Any discussion of red wolf recovery must occur against the backdrop of current ecological and anthropogenic challenges. Although hybridization, inbreeding, and demographics

were discussed separately earlier, these three issues are intrinsically related because they are influenced by the presence and management of coyotes. Therefore, these issues are complex and controversial causing management plans to promote recovery efforts to be more difficult than planned. Prior to the mid-1990s, coyotes were rare but increasing in NENC and Recovery Program biologists anticipated eventual colonization of the Peninsula by coyotes. The use of sterilized coyotes as space holders allowed the Recovery Program to saturate the Recovery Area with territories of red wolf packs and sterile coyote pairs. During the early 2000s, most coyotes captured, sterilized, and released with radio-collars failed to establish territories or pair with a space holder. In other words, the Recovery Program effectively saturated the Peninsula with canid territories and coyotes dispersing into the Recovery Area failed to find available space or mates and eventually left. However, legislation (NCGS § 113 273) passed by the NC General Assembly allowing owners of fox pens to buy live coyotes from licensed trappers and hunt them within their fox pens (NCWRC 2013) may negatively affect these efforts by disrupting red wolf packs and sterilized coyote space holders. Fox pens are enclosures averaging 250 ha in which gray foxes (*Urocyon cinereoargenteus*), red foxes (*Vulpes vulpes*), and coyotes are hunted with hound dogs for sport in approximately 20 states (Davidson et al. 1992; Baker 1993; Lee et al. 1993). Fox pen operations create legal and illegal markets for the importation and release of coyotes for hunting opportunities, and those markets may supplement local coyote populations through accidental or intentional releases of coyotes into the wild. The number of coyotes trapped in the Recovery Area increased each year after legal trafficking of live coyotes was permitted in 2003 (USFWS unpublished data). Although the number of red wolves captured and hunted in fox pens is unknown, disappearance and illegal take of red wolves has increased since the passage of the law. Increased efforts by trappers to capture coyotes and increased vigilance of deer hunters to shoot coyotes have stagnated red wolf population growth by breaking up red wolf packs and removing sterilized coyote space holders from the landscape through accidental and purposeful killing of red wolves and sterilized coyotes (USFWS unpublished data).

Evident by the widespread persistence and range expansion of coyotes, current policies to control their populations are ineffective and have failed to significantly reduce coyote populations. Laws promoting trafficking and nighttime hunting of coyotes increase the chances that red wolves will be accidentally or purposefully killed by hunters, and attempts to remove these hunting laws are constrained by organized hunting and trapping groups. Increased killing of red wolves by predator-control programs during the early 20th century facilitated the decline of red wolves and promoted their hybridization with expanding coyotes. Recent research showed intense harvest of eastern wolves also facilitated hybridization with coyotes by disrupting the population's social structure (Rutledge et al. 2012b). Today, increased killing of red wolves by humans appears to be disrupting red wolf packs and facilitating hybridization with coyotes (Bohling 2011). Increased relatedness of red wolves through discriminant killing opportunities will eventually lead to inbreeding depression in the wild population. Use of MHC genes to evaluate red wolf mate choice could lead to insights of how red wolves respond reproductively to anthropogenic changes and how MHC variation affects resistance to potential diseases that can be introduced through trafficking coyotes. Therefore, controlling hybridization and inbreeding requires understanding how anthropogenic sources of mortality facilitate conditions favorable to hybridization.

Increased mortality rates of red wolves and coyotes promote high turn-over rates of territories and erode the effectiveness of sterilization methods. Despite this, continued use of sterilization and efforts to increase the number of red wolves on the landscape will likely fail to prevent hybridization if reproductive barriers do not exist in the first place (Fredrickson and Hedrick 2006). Key to developing effective management that prevents the hybridization of sympatric red wolf and coyote populations is to identify unique traits of both species that promote sexual isolation. Within the Recovery Area, some individual red wolves and sterile coyotes appear to always prefer conspecifics as mates while others show random preferences, and assortative mating within both populations may indicate an intrinsic reproductive barrier. In the

hybridization section of this paper, we discussed evaluating the effects of body size on mate complementarity between red wolves and coyotes because body size is the most characteristically distinct trait between the two species. Life history traits (i.e., rates of individuals growth, reproduction, and mortality), population-level processes (i.e., abundance and space use), and community-level interactions (i.e., predator-prey dynamics and interspecific interactions) are known to correlate with body-size allometries regardless of taxonomic status (LaBarbera 1989; Brown et al. 1993, 2004; Capellini et al. 2010). Therefore, there are compelling reasons to study how phenotypes facilitate the outcomes of red wolf-coyote interactions because phenotypes are the direct interface between the two species. Selection acts directly on phenotypes with genetic change occurring as an indirect consequence and phenotypes have ecological effects on population dynamics and community structure (Agrawal 2001; Schluter 2001; Price et al. 2003; Kingsolver and Pfennig 2008; Siepielski et al. 2009; Crispo et al. 2010). If certain phenotypes serve as reproductive barriers between red wolves and coyotes, management can manipulate selection to achieve desired demographic effects and reduce hybridization.

A major impediment to red wolf restoration is the limited knowledge about traits that facilitate behavioral and ecological differences between red wolves and coyotes. This is critical to red wolf restoration because expanding our knowledge about mechanisms that facilitate stable and reproductively isolated red wolf populations will allow us to recognize responses of red wolves to changing environments. This knowledge guides research to make accurate inferences and predictions about the future and promotes implementation of appropriate management. The reality of incomplete reproductive isolation may present challenges to red wolf restoration but evolution is ongoing and management efforts should promote conditions that allow for the gradual evolution of reproductive barriers. Although much work remains to be done, information and experiences gained from more than 25 years of restoration efforts have made crucial contributions to the future of the red wolf. They also allow us to formulate areas of investigation that are of direct relevance to the restoration of red wolves.

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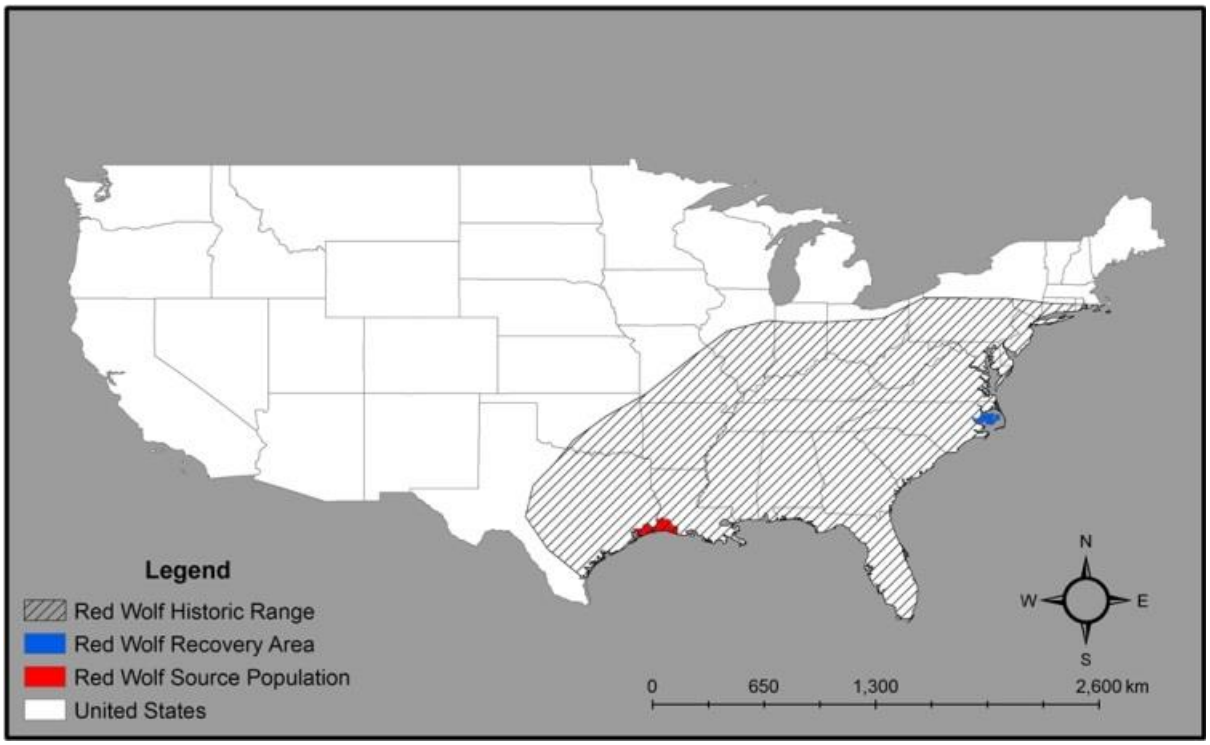


Figure 2.1: Historic and current range of red wolves (*Canis rufus*) in North America.

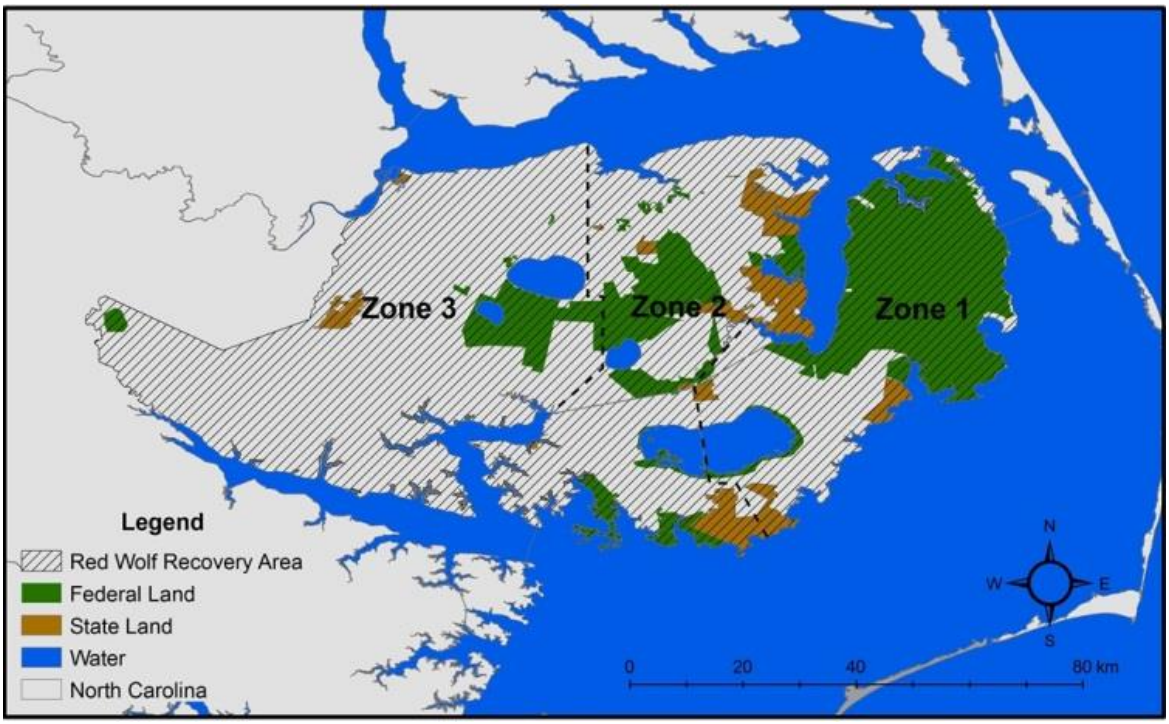


Figure 2.2: Management zone boundaries with the Red Wolf Recovery Area of northeastern North Carolina.

CHAPTER 3

MORPHOMETRICS OF *CANIS* TAXA IN EASTERN NORTH CAROLINA

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Abstract

We describe the external morphological characters of red wolves, coyotes, and their hybrids from North Carolina and assess if morphology could be an accurate discriminator among the 3 canid taxa. We used body measurements from 171 red wolves (*Canis rufus*), 134 coyotes (*Canis latrans*), and 47 hybrids in a polytomous logistic regression analysis to assess if they could be used to identify canids as red wolves, coyotes, or hybrids. Polytomous logistic regression analysis of 7 morphometric variables was able to correctly allocate 86% of canids to their a priori taxa groups. Using Akaike's information criterion, we judged hind foot length, weight, width of head, and tail length as variables to best separate taxa. Among the 3 sympatric *Canis* taxa in eastern North Carolina, red wolves are clearly the larger canid with hybrids intermediate to coyotes and red wolves in body size. Our results suggest that red wolves represent a unique *Canis* phenotype in the southeastern United States.

Introduction

Recent advances in science and technology have promoted molecular genetics as the primary tool for inferring the evolutionary and demographic past of North American wolves. In particular, the role of hybridization has become a predominant and contentious issue in the evolution and conservation of wolf populations in eastern North America. For example, the use of molecular markers bolstered the possible role coyotes (*Canis latrans*) played in the ancestry of wolves in Eastern North America (Chambers et al. 2012; Wayne and Jenks 1991; Wilson et al. 2000). Despite leading to controversies surrounding the taxonomy of New World wolves, genetic markers have proven invaluable for conservation efforts by providing new insights into the evolution and ecology of *Canis* species (Chambers et al. 2012). Nevertheless, morphology is a fundamental component of biology (MacLoed 2004; Nelson 1989) and phylogenetic analysis is not possible without some method of describing the morphological variation between individuals, populations, and species (MacLeod and Forey 2004). Therefore, a complete synthesis of *Canis* species in eastern North America that leads to successful conservation requires studies from

multiple disciplines involving ecological, evolutionary, molecular, and morphological analyses (Rutledge et al. 2012).

The Red Wolf Recovery Program (Recovery Program) of the United States Fish and Wildlife Service (USFWS) oversees the recovery of endangered red wolves (*Canis rufus*) and it currently manages the only wild population of red wolves on the Albemarle Peninsula in eastern North Carolina (Hinton et al. 2013). Since its inception during 1973, the Recovery Program has considered hybridization between red wolves and coyotes to be a primary threat to red wolf recovery efforts because hybridization can render the wild red wolf population unrecognizable within several generations (Kelly et al. 1999; Rabon et al. 2013; USFWS 1989). During the initial stages of red wolf recovery efforts, morphometric data were used to identify individual red wolves captured from hybrid swarms in eastern Texas and western Louisiana, and these individuals were later used as founders for the captive and eastern North Carolina populations (USFWS 1989). Additionally, the use of morphometric measurements alluded to issues of hybridization and coyote introgression into red wolf genetics before modern molecular approaches were developed (Nowak 1979). Therefore, morphometric data provide another method to differentiate among red wolves, coyotes, and red wolf/coyote hybrids (hereafter hybrids) that is essential to determine whether hybridization is occurring. Red wolves and coyotes are sympatric in eastern North Carolina and developing morphometric profiles for red wolves, coyotes, and hybrids in this region is necessary to develop practical approaches to address hybridization and enhance conservation.

An assessment of morphometric data for *Canis* taxa in eastern North Carolina can improve important areas necessary for red wolf recovery efforts. First, it allows tests to determine if morphometric measurements can be used to discriminate among red wolves, coyotes, and hybrids in the absence of molecular markers. If successful, this will permit an evaluation of which measurements are most useful to discriminate among the 3 *Canis* taxa. Such data can be extended to ecological studies to determine the limits of potential resource use and the relative efficiency of

red wolves and coyotes to exploit resources within those limits (Wainwright 1996). Second, assessing morphometric measurements will allow the description of phenotypes of the 3 *Canis* taxa. Nowak (2002) observed the morphology of modern red wolves to be consistent with fossilized remains of small wolves in the eastern United States dating back to the Pleistocene. If this is true, regardless of the modern red wolf's evolutionary origins, the eastern North Carolina population may represent a *Canis* phenotype unique to the southeastern United States. Here we provide a systematic analysis of morphometric measurements currently collected by Recovery Program biologists from red wolves, coyotes, and hybrids and assess their reliability to describe and discriminate among the 3 taxa.

Study Area

The Red Wolf Recovery Area (Recovery Area) was established on the Albemarle Peninsula in northeastern North Carolina during 1987. The area included 5 counties (Beaufort, Dare, Hyde, Tyrrell, and Washington) and consisted of approximately 6800 km^2 of federal, state, and private lands (Figure 1). The Albemarle Peninsula was comprised of an intensively farmed agricultural-hardwood bottomland matrix in which approximately 30% of the landscape was driven by agricultural activity.

Methods

Red wolves, coyotes, and hybrids used in this study were captured by the Recovery Program during annual trapping within the designated Recovery Area from 1987 until 2011 (Rabon et al. 2013). Canids were captured using padded foot-hold traps (Victor no.3 Softcatch, Lititz, Pennsylvania, USA) and were sexed, measured, weighed, and aged by tooth wear (Gier 1968), and a blood sample was collected for genetic analysis. Ages of most red wolves were known and tooth wear estimates mostly applied to coyotes and hybrids (Rabon et al. 2013). For this study, only animals captured between the months of November through March were used. This ensured that all pups used in the analysis were at or near full potential body size for the taxa. We aged individuals > 2 years old as adults, < 2 but > 1 years old as juveniles, and > 6 months

but < 12 months old as pups. Microsatellite markers and other genetic information from the 14 founding individuals and other predefined red wolves were used to generate allele frequencies to reconstruct the pedigree of the red wolf population. Individuals used in this study were genotyped at 17 microsatellites and genetic analyses of blood samples followed the methods outlined in Adams (2006), Bohling et al. (2013), and Miller et al. (2003). Individuals were assigned to a species or hybrid group using the methods developed by Miller et al. (2003) to specifically identify red wolves, coyotes, and hybrids. During our study, these were the molecular methods used by the United States Fish and Wildlife Service for monitoring red wolf genetic ancestry (Bohling et al. 2013).

Morphometric measurements were taken from live animals and measurements were followed as closely to standard anatomical reference points as possible. Body traits measured included body weight, ear length (edge of the external auditory canal to the tip of the ear), tail length (tip of the fleshy part of the tail to the tail base), body length (anterior tip of the nose pad to the tail base), hind foot length (hock to the tip of the digital pads), shoulder height (tip of the scapula to the tip of the digital pads), front and hind paw width (width across the cushiony pads at the widest points), front and hind paw length (base of the metacarpal pad to the tip of the digital pads), length of head (edge of the premaxillary to the most posterior point of the occipital bone), and width of head (widest points across the zygomata). All animals measured were later identified as red wolves, coyotes, and hybrids by the Recovery Program using molecular methods.

We analyzed measurements of canids using univariate and multivariate statistical methods in Program R, version 3.0.2 (R Development Core Team 2013). We present statistics of measurements as the mean ± standard error. To evaluate similarities between pairs of measurements, we used a correlation analysis. Individuals were included in the analysis only once to maintain independence. To remove redundancy, we used only one measurement from a set of strongly correlated measurements to represent that taxon in further analysis.

We used analysis of variance (ANOVA) and *t*-tests to evaluate differences of measurements among and within taxa groups. We then used measurements in a polytomous logistic regression analysis to assess the reliability of morphometrics to identify canid taxa. Polytomous logistical regression is a logical extension of binary logistic regression that allows more than 2 categories of the dependent variable (Hosmer and Lemeshow 2000). The ability of the polytomous logistical regression to identify red wolves, coyotes, and hybrids using morphometric measurements was revealed as the percentage of individuals correctly reallocated to each taxon. The number of misclassified individuals indicated the degree of overlap between the groups. We used the Akaike information criterion (AIC) to compare models of morphometric measurements by calculating the AIC_c for each model and using ΔAIC_c and Akaike weights (*w*i) to select the measurements which best delineated different canid categories (Burnham and Anderson 2002). We performed polytomous logistical regression and model selection using the polytomous and AIC functions from the polytomous and MuIN packages for Program R.

Sample sizes among measurements varied because it was not always possible to measure every variable for each individual. Only individual canids with all measurements were included in the polytomous logistical regression analysis. We used a Kolmogorov-Smirnov one-sample test for each measurement to determine whether measurements for the subset of individuals used in the polytomous logistical regression analysis were biased when compared to the larger sample from which they were drawn.

Results

From 1987 to 2011, 951 canids were captured and measured. These included 528 red wolves (56%), 264 coyotes (28%), and 159 hybrids (17%) that were genetically identified. Measurements differed among red wolves, coyotes, and hybrids (Table 1) and hybrids were intermediate to red wolves and coyotes in all morphometric measurements.

The correlation coefficients of the measurements in the original dataset were strongly correlated with one another ($r = 0.75 – 0.90$). To reduce the number of variables, we used only 7

univariate estimates (body weight, ear length, tail length, body weight, hind foot length, shoulder height, and width of head) to characterize overall size because this subset most completely represented the various aspects of canid anatomy needed for analysis. Among red wolves all 7 measurement means increased ($F_{2, 453} \geq 6.79$, $P < 0.001$) with age. Additionally, all 7 measurement means were greater ($t_{528} \geq 6.07$, $P < 0.001$) for males than females. Among coyotes, weight, ear length, body length, hind foot length, shoulder height, and width of head were greater ($t_{264} \geq 2.98$, $P \leq 0.003$) for males than females, but there was no difference in tail length ($t_{264} = 1.60$, $P = 0.11$). Ear length and tail length ($F_{2, 159} \leq 1.72$, $P \geq 0.181$) did not differ among ages, but weight, body length, hind foot length, shoulder height, and width of head ($F_{2, 163} \geq 5.61$, $P \leq 0.004$) increased with age. Among hybrids, tail length and body length ($t_{159} \leq 1.78$, $P \geq 0.077$) did not differ between males and females, whereas weight, ear length, hind foot length, shoulder height, and width of head were larger for males than females ($t_{159} \geq 2.06$, $P \leq 0.041$). Weight, tail length, and shoulder height ($F_{2, 56} \leq 4.77$, $P \geq 0.012$) increased with age, but ear length, body length, hind foot length, and width of head ($F_{2, 56} = 2.95$, $P = 0.060$) did not differ with age.

Included in the polytomous logistical regression analysis were 352 (171 red wolves, 134 coyotes, and 47 hybrids) canids for which all 7 measurements were completed. The subset used in the polytomous logistical regression analysis was not biased when compared to the larger samples of red wolves ($D = 0.10$, $P = 0.094$), coyotes ($D = 0.06$, $P = 0.925$), and hybrids ($D = 0.2$, $P = 0.110$). The polytomous logistical regression model correctly classified 86% of the canids. Coyotes and red wolves were correctly classified 99% and 98% of the time, respectively. Hybrids were correctly classified 13% of the time. Hybrids were more likely to be misclassified as coyotes than red wolves (61% vs. 35%).

When red wolves were separated as pups (> 6 but < 12 months old) and non-pups (adults and juveniles), all non-pups were correctly identified as red wolves and only 2 pups (1.8%) were misclassified as a coyote and a hybrid (Table 2). Only 2 coyotes (1.5%) were misclassified as red wolf pups and none were misclassified as hybrids. Most hybrids were misclassified as coyotes

(53%) and red wolf pups (30%). Hybrids were 29% more likely to be misclassified as red wolf pups than non-pups. This is likely because as red wolf pups, born in the spring, overlap in body size with hybrids during summer and autumn as they approach adult body sizes in the winter.

The most useful measurements for separating red wolves, coyotes, and hybrids were hind foot length, weight, width of head, and tail length (Table 3). Hind foot length was the single most useful measurement. Our findings (Tables 4) suggest a reliable threshold that canids with hind foot lengths > 21.5cm, weights > 21.5kg, width of heads > 10.5cm, and tail lengths > 35cm were most likely to be red wolves. Coyotes typically had hind foot lengths < 19.5cm, weights < 19.5kg, width of heads < 10.5cm, and tail lengths < 35cm. Hybrid values for these 4 measurements would most likely overlap the minimum values for red wolves and maximum values for coyotes.

Discussion

Our results show that body size measurements of red wolves and coyotes are distinct from one another with hybrids representing an ambiguous intermediate size. Using measurements of hind foot length, body weight, width of head, and tail length in a polytomous logistic regression analysis, we were able to correctly classify 86% of 352 canids into their correct taxa category with moderately high (80% to 90%) accuracy. Red wolves and coyotes were correctly classified 98% and 99%, respectfully. On the other hand, hybrids were more difficult to re-assign and only 13% were correctly classified. Hybrids were more likely to be misclassified as either coyotes or red wolf pups. Despite the issue of morphological ambiguity, Recovery Program biologists still correctly classify canids as hybrids prior to genetic confirmation by identifying the morphological ambiguity and breeding status of hybrids. In other words, canids intermediate in size to red wolves and coyotes that have fully developed and active reproductive systems (e.g., males with enlarged testicles and females in estrus) are obviously adult hybrids, whereas those with underdeveloped and inactive reproductive systems are considered red wolf pups and confirmed with genetic analysis.

Of the 153 hybrids measured, only 2% (3 adult males) attained measurements above the minimum threshold values used by the Recovery Program to assign canids as red wolves. Nevertheless, the minimum values for red wolves reported in this study were estimated from the smallest adult females. Adult male red wolves are significantly larger than the minimum threshold reported. Interestingly, 20 of the 25 largest hybrids were captured and measured during 1998 through 2001. Since 2001, hybrids have been more coyote-like in their morphology and rarely exceed 20 kg in body weight. Coyotes did not fully colonize the Albemarle Peninsula until the mid-2000s (USFWS 2007), so hybrids prior to this period may have been more red wolf-like because backcrosses were occurring within the smaller red wolf population. Once introgression was identified and management actions were used to reduce hybridization during the early 2000s (Hinton et al. 2013, Kelly et al. 1999, Rabon et al. 2013), hybrid backcrosses began to occur more often within the larger coyote population.

The Recovery Program uses sterilization of coyotes and hybrids as the primary management tool to prevent coyote introgression into the red wolf genome (Hinton et al. 2013, Rabon et al. 2013). After capture, sterilized canids are released back into the Recovery Area fitted with mortality-sensitive radio-collars and monitored for the duration of their life. In the event that a red wolf pairs with a sterilized canid, the pair cannot produce hybrid litters. Although molecular markers ultimately confirm the taxa of canids captured, Recovery Program biologists routinely use morphometric measurements to pre-screen, process, and re-release individual canids into the wild before receiving genetic confirmation. Morphometric measurements are used to reduce holding times because this lowers the risk that captured canids would lose breeding mates and territories because of absence. Therefore, quick identification during the canid breeding season allows Recovery Program biologists to minimize disruptions to canid packs with excessive holding times while waiting for genetic confirmation. The accuracy of using morphometric measurements we observed confirms that morphological measurements could be used to pre-screen canids for management decisions, while awaiting genetic confirmation. Ultimately, genetic

assessments are necessary to effectively monitor, measure, and manage coyote introgression in the red wolf population.

Regardless of the ambiguity of hybrid measurements, our findings concerning morphometric measurements of red wolves and coyotes are consistent with the results of Nowak (1979, 2002) who demonstrated little to no overlap in red wolf and coyote cranial and dental measurements. Throughout North America, average coyote weights reported in studies rarely exceed 18 kg (Bekoff and Gese 2003; Leopold and Chamberlain 2001; Way 2007). Additionally, our date indicates that F1 and F2 hybrids are incapable of reaching body sizes of adult red wolves. This suggests that the red wolf represents a unique *Canis* phenotype in the southeastern United States. Differences in body size measurements are highly suggestive of differences in ecological requirements, as this is particularly true for carnivores regarding diet (Carbone et al. 2007; Donadio and Buskirk 2006; Gittleman 1985), space use (Gittleman and Harvey 1982; Gompper and Gittleman 1991), and interspecific interactions (Donadio and Buskirk 2006; Palomares and Caro 1999; Rosenzweig 1966). The general relationship between morphology and ecology is well known (Arnold 1983; Hutchinson 1959; Kishida et al. 2010; Wainwright 1996), but effects of body size on the relative ability of red wolves and coyotes to successively hunt prey, acquire mates, and defend territories is not well known.

Among the 3 sympatric *Canis* taxa in eastern North Carolina, red wolves are clearly the larger canid with hybrids intermediate to coyotes and red wolves in body size. Although this is a commonly held opinion, there is no significant literature comparing the morphometrics of red wolves, coyotes, and hyrbrids. Nowak (1979, 2002) assessed measurements from skulls of prehistoric and 20th century red wolves, gray wolves (*Canis lupus*), and coyote specimens and concluded red wolves to be a species intermediate in size to gray wolves and coyotes. USFWS (1989) reported only minimum measurements used to distinguish male and female red wolves from non-red wolf canids in southeastern Texas and southwestern Louisiana during the 1970s. The 1999 Population Habitat and Viability Assessment for red wolves stated the need to develop

a morphological profile for red wolves, coyotes, and hybrids for quick identification in the field (Kelly et al. 1999). Therefore, this study represents the first morphometric comparison of sympatric red wolves, coyotes, and their hybrids. Our analysis has shown morphometrics to be valuable in exploring morphological variation among closely related and sympatric *Canis* taxa. Further examination of morphological characters between red wolves and coyotes could detect patterns of phenotypic discreteness that may highlight opportunities for analysis of traits that may have genetic, evolutionary, and ecological importance. Therefore, we recommend examining the effects of morphology on red wolf and coyote ecology and interactions that may facilitate hybridization between the 2 species.

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Table 3.1. Means (± SE) and results of analysis of variance (ANOVA) for the morphological characters of red wolves, coyotes, and their hybrids in northeastern North Carolina, USA, 1987-2011.

Traits	Red Wolf		Coyote		Hybrid		ANOVA	
	N	Mean ± SE	N	Mean ± SE	N	Mean ± SE	F Ratio	P Value
Weight (kg)	509	23.2 ± 0.23 (7.9 – 38.6)[a]	240	13.4 ± 0.12 (6.9 – 19.1)	147	17.0 ± 0.34 (6.4 – 27.5)	438.97	<0.0001
Ear Length (cm)	458	11.0 ± 0.03 (9.0 – 12.9)	254	9.9 ± 0.04 (8.0 – 12.8)	153	10.5 ± 0.05 (8.5 – 12.5)	236.55	<0.0001
Tail Length (cm)	456	36.4 ± 0.15 (25.8 – 48)	241	33.9 ± 0.20 (20.5 – 44.7)	151	35.7 ± 0.25 (24.5 – 43.5)	48.53	<0.0001
Body Length (cm)	454	106.4 ± 0.33 (75.0 – 125.0)	246	90.0 ± 0.30 (64.0 – 105.0)	136	97.7 ± 0.60 (78.0 – 122.0)	497.72	<0.0001
Hind Foot Length (cm)	460	22.3 ± 0.06 (17.0 – 27.0)	256	18.7 ± 0.06 (16.4 – 22.5)	153	20.4 ± 0.11 (17.0 -25.1)	813.38	<0.0001
Shoulder Height (cm)	455	66.9 ± 0.18 (52.3 – 77.2)	249	57.3 ± 0.02 (47.1 – 68.7)	140	62.2 ± 0.36 (50.3 – 79.9)	563.23	<0.0001
Front Paw Length (cm)	407	7.1 ± 0.02 (5.0 – 8.7)	238	6.0 ± 0.03 (4.44 – 7.73)	148	6.5 ± 0.05 (4.3 – 7.8)	432.24	<0.0001
Front Paw Width (cm)	406	5.0 ± 0.02 (3.4 -6.3)	238	4.1 ± 0.02 (3.0 – 5.5)	148	4.6 ± 0.04 (3.3 – 6.3)	292.59	<0.0001
Hind Paw Length (cm)	381	6.5 ± 0.02 (5.0 – 8.2)	227	5.5 ± 0.03 (4.2 – 6.6)	146	6.0 ± 0.04 (4.9 – 7.5)	364.41	<0.0001
Hind Paw Width (cm)	380	4.5 ± 0.02 (3.0 – 5.9)	227	3.7 ± 0.02 (2.8 – 4.9)	146	4.1 ± 0.03 (3.2 – 5.1)	350.72	<0.0001
Length of Head (cm)	183	22.2 ± 0.11 (19.0 – 26.0)	146	19.9 ± 0.08 (17.5 – 24.0)	50	21.0 ± 0.24 (17.5 – 24.5)	146.91	<0.0001
Width of Head (cm)	182	11.9 ± 0.08 (9.5 – 14.5)	146	10.4 ± 0.05 (9.0 – 12.5)	51	11.1 ± 0.11 (9.5 – 12.5)	108.38	<0.0001

[a] Ranges for trait measurements

Table 3.2. Classification tables obtained from polytomous logistic regression (PLR) for red wolves, coyotes, and hybrids in northeastern North Carolina, USA, 1987-2011.

	Predicted Species				
Actual Species	Red Wolf Pup	Red Wolf Non-Pup	Coyote	Hybrid	Error
Red Wolf Pup (N=112)	94	16	1	1	0.16
Red Wolf Non-Pup (N=59)	23	36	0	0	0.39
Coyote (N=134)	2	0	132	0	0.01
Hybrid (N=47)	14	2	25	6	0.87

Table 3.3. Results of the 10 best models for stepwise analysis of morphological characters for red wolves, coyotes, and hybrids in northeastern North Carolina, USA, 1987-2011.

Model	k[a]	AIC_c	ΔAIC_c	w_i
Species ~ HF + WT + WH + TA	6	278.41	0	0.38
Species ~ HF + WT + TA	5	279.91	1.50	0.18
Species ~ HF + WT + BO + TA	7	280.07	1.66	0.17
Species ~ HF + WT + BO + SH + TA	8	281.88	3.47	0.07
Species ~ HF + WT + WH	5	282.20	3.79	0.06
Species ~ HF + WT + BO + WH	5	282.23	3.82	0.05
Species ~ HF + WT + WH + SH	6	283.92	5.51	0.02
Species ~ HF + WT+ BO + SH + WH + TA	9	283.94	5.53	0.02
Species ~ HF + WT + BO + WH	6	284.06	5.65	0.02
Species ~ HF + WT + WH + EA	6	284.20	5.79	0.02

[a] k represents number of parameters for each model

Table 3.4. Means (± SE) and ranges for 4 morphological characters of red wolves, coyotes, and hybrids in northeastern North Carolina, USA, 1987-2011.

Species	Hind Foot Length (cm)			Weight (kg)			Width of Head (cm)			Tail Length (cm)		
	N	Mean	Range	N	Mean	Range	N	Mean	Range	N	Mean	Range
Red Wolf	460	22.3±0.1	17.0 – 27.0	509	23.2±0.2	7.9 – 38.6	182	11.9±0.1	9.5 – 14.5	456	36.4±0.2	25.8 – 48.0
Male	238	22.9±0.1	19.6 – 27.0	260	25.1±0.3	10.2 – 38.6	89	12.3±0.1	10.0 – 14.5	234	37.3±0.2	25.8 – 48.0
Pup	122	22.6±0.1	19.6 – 26.0	128	22.2±0.4	10.2 – 34.0	54	11.9±0.1	12.0 – 14.5	120	36.9±0.3	29.4 – 46.0
Juvenile	47	22.9±0.2	21.0 – 25.4	52	25.9±0.5	18.6 – 31.8	20	12.6±0.2	11.0 – 14.5	46	36.9±0.5	29.0 – 48.0
Adult	69	23.4±0.1	20.7 – 27.0	80	29.1±0.4	21.4 – 38.6	15	13.4±0.2	12.0 – 14.5	68	38.1±0.5	25.8 – 46.0
Female	222	21.7±0.1	17.0 – 24.5	249	21.2±0.3	7.9 – 34.7	93	11.5±0.1	9.5 – 14.4	222	35.4±0.2	28.0 – 44.0
Pup	119	21.5±0.1	18.0 – 24.0	124	18.3±0.4	7.9 – 28.6	63	11.1±0.1	9.5 – 12.8	120	35.1±0.2	28.0 – 43.0
Juvenile	48	21.8±0.2	19.7 – 24.0	54	22.7±0.4	18.2 – 30.0	21	12.2±0.2	11.0 – 14.4	48	35.6±0.3	31.0 – 43.0
Adult	55	22.1±0.2	17.0 – 24.5	71	25.1±0.3	19.9 – 34.7	9	12.1±0.3	11.0 – 13.5	54	36.2±0.4	29.0 – 44.0
Coyote	256	18.7±0.1	16.4 – 22.5	240	13.4±0.1	6.9 – 19.1	146	10.5±0.1	9.0 – 12.5	241	33.9±0.2	20.5 – 44.7
Male	127	19.0±0.1	16.5 – 22.0	122	14.0±0.2	9.0 – 19.1	73	10.7±0.1	9.5 – 12.5	118	34.3±0.3	20.5 – 43.0
Pup	17	18.5±0.2	17.0 – 20.1	15	12.4±0.7	6.9 – 17.0	8	10.3±0.2	10.0 – 11.0	16	34.0±0.9	29.0 – 43.0
Juvenile	28	18.6±0.1	17.3 – 19.9	27	13.7±0.3	11.4 – 18.2	24	10.6±0.1	9.5 – 11.5	28	33.5±0.7	20.5 – 40.0
Adult	36	19.1±0.2	16.5 – 20.5	34	14.5±0.3	10.5 – 18.2	21	10.8±0.2	9.5 – 12.0	34	35.3±0.4	31.0 – 42.5
Unknown*	46	19.2±0.1	17.5 – 22.0	46	14.2±0.2	11.5 – 19.1	20	10.7±0.1	9.5 – 12.5	40	34.0±0.5	25.0 – 38.0
Female	129	18.4±0.1	16.4 – 22.5	118	12.8±0.1	8.9 – 16.5	73	10.2±0.1	9.0 – 11.5	123	33.6±0.3	27.0 – 44.7
Pup	23	17.9±0.2	16.4 – 20.0	23	11.6±0.3	8.9 – 15.0	13	10.0±0.2	9.0 – 11.0	23	34.5±0.8	28.0 – 44.7
Juvenile	35	18.3±0.2	17.2 – 21.5	32	12.8±0.2	10.0 – 15.4	26	10.1±0.1	9.5 – 11.0	35	33.4±0.5	27.0 – 41.2
Adult	27	18.4±0.2	16.8 – 22.5	25	13.1±0.3	9.7 – 16.3	15	10.4±0.1	10.0 – 11.0	26	33.3±0.5	29.4 – 43.0
Unknown*	44	18.6±0.1	17.0 – 21.9	38	13.3±0.2	11.4 – 16.5	19	10.4±0.1	9.5 – 11.5	39	33.5±0.5	28.5 – 40.1

*Age class unknown

Table 3.4. Continued

	Hind Foot Length (cm)			Weight (kg)			Width of Head (cm)			Tail Length (cm)		
Species	N	Mean	Range	N	Mean	Range	N	Mean	Range	N	Mean	Range
Hybrid	153	20.4±0.1	16.4 – 25.1	147	17.0±0.3	6.4 – 27.5	51	11.1±0.1	9.5 – 12.5	151	35.7±0.25	24.5 – 43.5
Male	85	20.6±0.2	17.3 – 25.1	83	17.6±0.5	6.4 – 27.5	32	11.3±0.1	9.5 – 12.5	83	36.0±0.36	24.5 – 43.5
Pup	4	19.5±0.5	18.5 – 21.0	6	9.9±1.2	6.4 – 14.5	1	10.8±N/A	N/A	3	31.5±1.80	29.0 – 35.0
Juvenile	12	19.9±0.3	17.3 – 21.6	10	15.9±1.5	10.1 – 22.4	9	11.3±0.2	10.5 – 12.5	12	35.6±0.72	32.5 – 41.4
Adult	18	21.2±0.2	18.8 – 21.5	18	17.8±0.9	10.2 – 25.9	12	11.4±0.2	9.5 – 12.0	18	36.4±0.54	32.3 – 40.5
Unknown*	51	21.0±0.2	17.8 – 25.1	49	18.9±0.6	12.0 – 27.5	10	11.2±0.2	10.5 – 12.0	50	36.3±0.51	24.5 – 43.5
Female	68	20.2±0.2	17.0 – 22.5	64	16.1±0.4	7.3 – 23.2	19	10.8±0.2	9.5 – 12.5	68	35.2±0.34	27.0 – 41.5
Pup	5	19.3±0.6	16.4 – 20.0	5	13.0±1.9	7.3 – 17.3	13	10.8±1.3	9.5 – 12.0	5	33.1±1.52	29.5 – 37.0
Juvenile	14	19.6±0.4	17.0 – 21.9	13	15.1±0.9	10.2 – 20.9	26	10.8±0.3	9.5 – 12.0	14	35.4±0.93	31.2 – 41.5
Adult	6	19.7±0.5	18.3 – 21.7	6	14.9±0.5	11.8 – 23.2	15	10.0±0.5	9.5 – 11.0	6	35.4±0.89	32.0 – 38.0
Unknown*	43	20.5±0.2	17.8 – 22.5	40	17.0±0.5	11.8 – 23.2	3	11.5±0.6	10.5 – 12.5	43	35.4±0.38	27.0 – 41.0

*Age class unknown

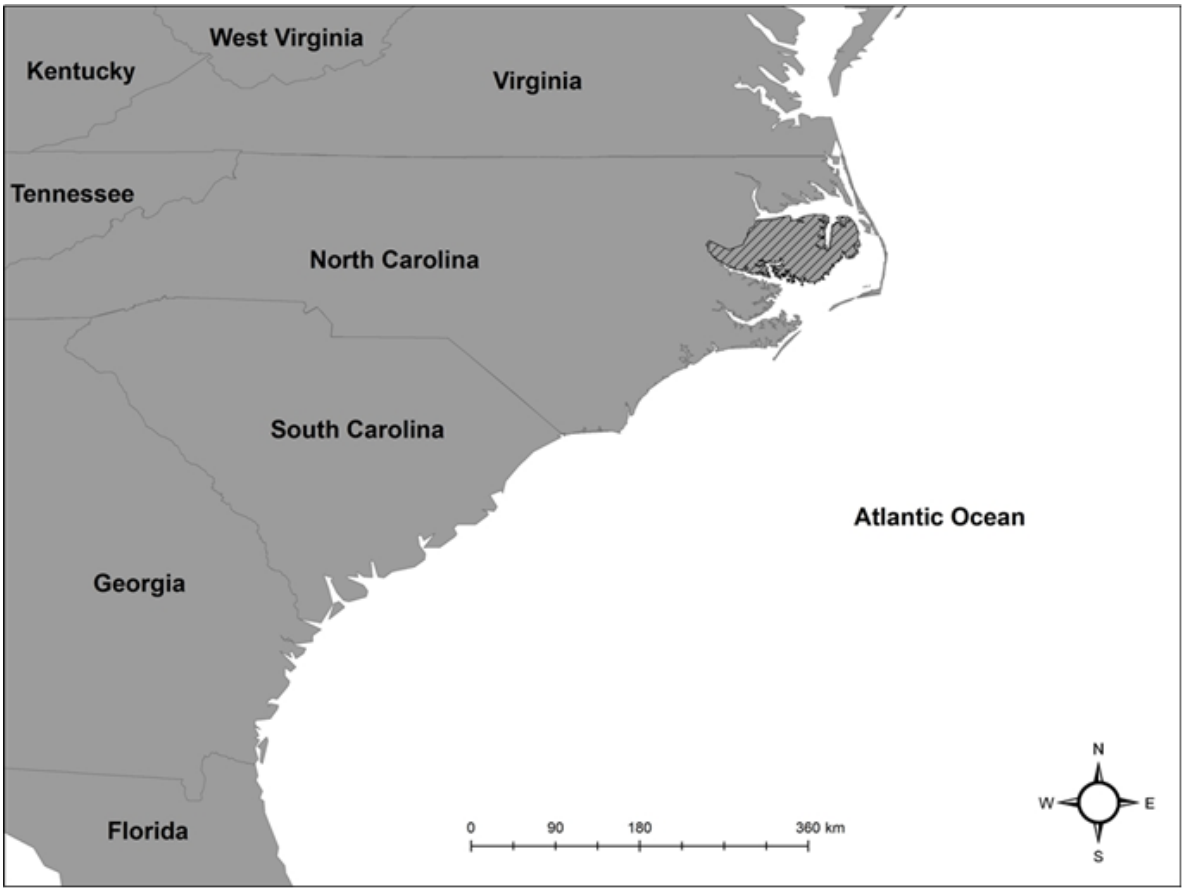


Figure 3.1. Outline map of North Carolina showing the location of the Red Wolf Recovery Area (hatched area) in the northeastern portion of the state.

CHAPTER 4

FACTORS AFFECTING DIETS OF RED WOLVES AND COYOTES

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Abstract

Foraging behaviors of red wolves and coyotes are complex and their ability to form congeneric breeding pairs and hybridize adds additional difficulties into understanding factors affecting prey selection. We assessed factors affecting prey selection of red wolf packs, coyote pairs, and congeneric pairs form by red wolves and coyotes and found that all three had similar and overlapping diets. Nevertheless, we detected differential use of prey; red wolf packs consumed more white-tailed deer, fur bearers, and pig than coyote and congeneric pairs. Coyotes that formed pairs with red wolves had 10% more whited-tailed deer in their diet than conspecifics that paired with coyotes. Contrary to many studies on coyote diet in the southeastern United States, we found coyotes in northeastern North Carolina to be largely carnivorous with a narrow dietary breadth. We found breeder weight, pack size, age, white-tailed deer density, and season to be important factors influencing the diet of red wolf packs. Breeder weight and season were important factors influencing diets of coyote pairs, whereas season and white-tailed deer density influenced diets of congeneric pairs. Although prey selection was largely similar among the three groups, differences in diet among different breeding pairs were associated with body size. Larger individuals within and among different breeding pairs consumed more white-tailed deer, and less rabbits and small mammals. Therefore, partitioning of food resources by red wolves and coyotes in northeastern North Carolina is mostly via differences in quantity of similar prey rather than differences in types of prey exploited. We suggest that similarities in energetic demand of individual red wolves and coyotes that approach each other in body size may partially contribute to successful congeneric pairing and hybridization through similar use of prey.

Introduction

Understanding relationships between organisms and their food resources is a central goal in ecology, and describing mechanisms that influence foraging behavior can assist management and conservation of wildlife. In particular, diets of carnivores have always interested ecologists because predation is an essential ecological process that structures communities and influences

ecosystem productivity (Hairston *et al*., 1960; Schmitz *et al*., 2000; Ripple & Bescheta, 2004; Fortin *et al*., 2005). Foraging behavior of carnivores is a fundamental component of their ecology and evolution because it is directly related to behavior, morphology, and physiology (Christiansen & Wroe, 2007; Van Valkenburgh, 2007). A thorough understanding of a carnivore's dietary needs requires identifying primary food resources and describing what factors influence variation in the consumption of those resources. Thereafter, ecologists can use that information to understand how foraging behavior affects life history traits and population processes that will ultimately influence community- and ecosystem-level processes.

Traits affecting foraging behavior are similar between closely related and similarly sized species of Carnivora. This is particularly true for Canidae in which members of this family share similar body plans and monogamous breeding behaviors (Finarelli, 2007; Finarelli, 2008). Recently diverged taxa within Canidae tend to be ecologically similar because there is a direct link between their evolutionary relatedness and the ecological processes that determine their distribution and abundance (Johnson *et al*., 1996). Despite understanding characteristics unique to members of modern Canidae and how those traits influence foraging behaviors (Van Valkenburgh *et al*., 2004; Andersson, 2005; Slater *et al*., 2009), we still know little about factors affecting prey selection of two sympatric *Canis* species in the southeastern United States. Determining what these factors are and how they influence prey selection of red wolves (*Canis rufus*) and coyotes (*Canis latrans*) is essential for enhancing red wolf conservation, understanding mechanisms facilitating coyote expansion into the Southeast, and identifying key components of *Canis* foraging ecology.

Although a common predator of the Southeast prior to European settlement, government-supported eradication campaigns reduced red wolves to a remnant population of approximately 100 individuals by mid-20th century (USFWS, 1989; Hinton *et al*., 2013). As red wolves were eradicated, coyotes expanded east into Arkansas, Louisiana, and other southwestern regions of the red wolf's historic range (McCarley, 1962; Paradiso & Nowak, 1972). With rapidly declining

red wolf populations and extensive hybridization with the expanding coyote population, the United States Fish and Wildlife Service (USFWS) removed the last remaining red wolves from eastern Texas and western Louisiana and later reintroduced their progeny into northeastern North Carolina during the late 20th-century to begin red wolf restoration efforts (USFWS, 1989). Today, red wolves exist as a remnant population of approximately 100 individuals whereas coyotes have become ubiquitous throughout the red wolf's historic range posing a serious ecological threat because of their ability to hybridize with red wolves (Hinton *et al*., 2013).

Red wolves and coyotes share similar canid body shapes with red wolves being the larger of the two species. The effects of body size on red wolf and coyote interactions are currently unknown (Hinton *et al*., 2013). Body size represents a key morphological trait that separates red wolves from coyotes and it may affect differential use of prey between the species. Red wolves, weighing 7-18 kg heavier than the largest coyotes (Chapter 3), should feed at higher trophic levels than coyotes because body size has been shown to predict carnivore interactions with prey (LaBarbera, 1989; Gittleman, 1985; Donadio & Buskirk, 2006). The ability of both species to form congeneric breeding pairs raises an interesting question regarding how differences in body size between congeneric mates determine the efficiency with which those mates acquire and use food resources. Both species face energetic constraints that affect many aspects of their ecology, and small differences in body size between individual red wolves and coyotes may allow for successful formation of congeneric pairs because the effects on the breeder's ability to transfer energy from homeostasis to reproductive efforts is negligible.

Understanding dietary needs of red wolves and coyotes is a primary step to improving management of both species and minimizing hybridization. Our objective was to describe the diets of red wolves and coyotes by identifying the remains of prey found in red wolf and coyote scat. We used several variables (i.e., body weight, social structure, age, etc.) that have not traditionally been used in analyses of scat remains to account for variation in diet. Furthermore, this study is the first to assess dietary behaviors of congeneric canid breeding units that are the

source of hybridization. To accomplish this, we monitored over 35 canid packs and pairs over more than 6,000 km^2. As a result, this study represents the most comprehensive assessment of canid diet in the eastern United States. Assessing red wolf diet and factors influencing its variation will allow us to understand the red wolf's ecological role in the Southeast. Additionally, diets of eastern coyotes have lain at the heart of the species' impact on eastern ecosystems and the need to determine the ecological role of eastern coyotes goes beyond the scope of red wolf conservation.

Study Area

The study was conducted in the Red Wolf Recovery Area (hereafter Recovery Area) on the Albemarle Peninsula of northeastern North Carolina (Beaufort, Dare, Hyde, Tyrrell, and Washington counties). The Recovery Area consisted of approximately 6,800 km² of federal, state, and private lands. The Albemarle Peninsula is an intensively farmed agricultural-hardwood bottomland forest matrix in which approximately 45% of the landscape was driven by agricultural and commercial timber activities. Corn, cotton, soybean, and winter wheat were the primary agricultural crops and comprise approximately 30% of the land cover. Managed pine (*Pinus* spp) plantations comprise approximately 15% of the land cover. The remaining 55% of land cover types were pocosin (15%), bottomland hardwood forests (15%), saltwater marsh (5%), open water (10%), and other land cover types (10%). Potential mammalian prey of red wolves and coyotes in the Recovery Area were white-tailed deer (*Odocoileus virginianus*), raccoon (*Procyon lotor*), eastern cotton-tail rabbit (*Sylvilagus floridanus*), marsh rabbit (*Sylvilagus palustris*), feral pig (*Sus scrofa*), nutria (*Myocastor coypus*), muskrat (*Ondatra zibethicus*), hispid cotton rat (*Sigmodon hispidus*), white-footed mouse (*Peromyscus leucopus*), deer mouse (*Peromyscus maniculatus*), house mouse (*Mus musculus*), eastern harvest mouse (*Reithrodontomys humulis*), voles (*Microtus* spp), and shrews (*Blarina* spp). Primary carnivores sympatric with red wolves and coyotes were gray foxes (*Urocyon cineroargenteus*), red foxes (*Vulpes vulpes*), feral dogs (*Canis lupus familiaris*), bobcats (*Lynx rufus*), and black bears (*Ursus americanus*).

Methods

Red wolves and coyotes were captured within the Recovery Area during annual trapping efforts conducted by the United States Fish and Wildlife Service Red Wolf Recovery Program (hereafter Recovery Program). Red wolves and coyotes were sexed, measured, weighed, aged by tooth wear (Gier, 1968), and blood sampled for genetic identification. The Recovery Program categorizes red wolves and coyotes > 2 years old as adults, < 2 but > 1 year old as juveniles, and < 1 year old as pups. Coyotes captured within the Recovery Area by USFWS personnel were reproductively sterilized (hereafter sterilized) and used as space holders until red wolves moved in and occupied those areas (Hinton *et al*., 2013; Rabon *et al*., 2013). Coyotes were taken to a local veterinary clinic for surgical sterilization where males and females were sterilized by vasectomy and tubal ligation, respectively. This process kept hormonal systems intact and avoided disrupting breeding and territorial behavior. Once red wolves and coyotes were fully processed, individuals were fitted with radio-collars, released, and then monitored by the Recovery Program during weekly telemetry flights. Monitoring efforts allowed the Recovery Program to identify red wolf and coyote space use on the landscape.

Territories of red wolf packs, coyote pairs, and red wolf-coyote pairs (hereafter congeneric pairs) were surveyed at least once a month for scat from 2009 until 2011 (Dellinger *et al*., 2011a; McVey *et al*., 2013). Paved, gravel, and dirt roads were surveyed by foot, all-terrain vehicles, and trucks. We also opportunistically collected defecations from red wolves and coyotes captured during annual trapping. Scats collected were bagged, dated, marked with a unique identification number, and stored in a freezer for later dissection and analysis. We identified scats by physical appearance, including size (Dellinger *et al*., 2011b), and the presence of tracks or other predator sign in the immediate area around the scat. Approximately 40% of the scats were identified to species and individual animals using fecal DNA genotyping (Dellinger *et al*., 2011a; McVey *et al*., 2013). We assigned scats collected within known territories to red wolf packs,

coyote pairs, or congeneric pairs but excluded those that could not be associated with known pairs and packs.

We examined scats identified to red wolf packs, coyote pairs, and congeneric pairs for prey remains. Individual scats were placed in nylon panty hose and then secured in small, nylon mesh bags with water-proof labels for washing. Scats were soaked in water for 24 hours before being transferred to a washing machine and washed on the regular cycle with detergent 3 times to separate hair and bone fragments from fecal matter. We allowed scats to air dry for 72 hours prior to examining scat contents. Once dried, prey remains for each scat was analyzed for species composition. We identified the undigested food items microscopically and macroscopically by comparing to reference collections and identification manuals (Moore *et al*., 1997; Debelica & Theis, 2009). We assigned prey remains in scats to one of 5 categories: white-tailed deer (hereafter deer), rabbits (eastern cotton-tail and marsh rabbit), small mammals (mice, rats, shrews, and voles), fur bearer (muskrat, nutria, and raccoon), pig, and other food items (bird, insect, fruit, and anthropogenic material). We excluded prey items that comprised < 5% of prey found in scat from the analysis. Following identification of prey remains in scats, we estimated the percent of occurrence (PO) for each prey item using the common visual estimation of PO (Dellinger *et al*., 2011a; McVey *et al*., 2013).

Red wolf packs, coyote pairs, and congeneric pairs are the only 3 types of *Canis* breeding units monitored by the Recovery Program in northeastern North Carolina. Red wolf packs were comprised of a breeding pair along with juveniles and pups from previous litters. Some red wolves monitored for this study were newly formed breeding pairs and did not have juveniles or pups. Coyote pairs did not have juveniles and pups because at least 1 of the 2 breeders was sterilized as a management technique to suppress coyote reproduction. Congeneric pairs were comprised of a red wolf and a coyote and did not have juveniles and pups because the coyote in the pair was sterilized to prevent hybridization. Therefore, our sampling units were red wolf packs, coyote pairs, and congeneric pairs. We used breeder weight (combined weight of both

breeders), breeder age (mean age of both breeders), pack size (# of individuals in pack), deer density (# deer harvested by hunters/km^2), and season (summer and winter) as explanatory variables to account for changes in dietary composition for red wolf packs. However, because coyote pairs and mixed pairs did not have juveniles and pups, we could not include pack size as explanatory variables to account for variation in diet.

We included a measurement of deer abundance as a variable because deer are known to be an important food resource for red wolves (Dellinger *et al*., 2011a, McVey *et al*., 2013) and there is a growing concern that coyotes are negatively affecting deer populations across the Southeast (Kilgo *et al*., 2012). We used county-level hunter harvest data collected by the North Carolina Wildlife Resources Commission as measures of deer abundance in the Recovery Area. Estimates of deer harvests were divided into 3 categories, which likely corresponded with deer population sizes for the 5 counties (Beaufort, Dare, Hyde, Tyrrell, and Washington) in the Recovery Area. Our categorization resulted in areas of low (< 0.75 deer harvested/km^2), medium (0.75 – 1.5 deer harvested/km^2), and high (> 1.5 deer harvested/km^2) deer densities. Although these harvest reports do not reflect true deer densities, these categories do provide a benchmark by which to judge the effect of deer abundance on red wolf and coyote diets. To further aid in univariate comparisons, we pooled scat into 2 seasons (summer and winter) for comparison of prey selection between seasons by breeding pairs. We also collapsed pack size into 2 categories: packs of 4 or fewer individuals (hereafter smaller packs) and packs with 5 or more individuals (hereafter larger packs).

We analyzed the effects of explanatory variables on diet using univariate and multivariate statistical methods in R Statistical Environment, version 2.14.2 (R Development Core Team, 2012). We used analysis of variances (ANOVAs), Tukey tests for multiple comparisons, and *t*-tests to determine if the percentage of prey items consumed differed with respect to breeder weight, breeder age, pack size, deer density, and season. We then developed generalized linear models (GLMs) to model the percentage of a prey category for each sampling unit as a linear

function of the explanatory variables. Changes in coefficient estimates of GLMs represent the change in percent prey consumption following a one-unit change in the explanatory variables. We assessed models using a stepwise procedure by calculating Akaike information criterion (AIC_c) for each model to select which variables best explained diet by selecting the most parsimonious model with the highest weight and rank relative to the entire set of models under consideration (Burnham & Anderson, 2002). With the exception of season, all measurements were continuous data. The GLM analysis was conducted using arcsine-square root transformation to percentage data to correct for non-constant error variance.

Results

From 2009-2011, we collected and analyzed 1754 scats from 13 red wolf packs, 17 coyote pairs, and 8 congeneric pairs. Red wolf packs, coyote pairs, and congeneric pairs accounted for 55.4%, 31.6%, and 13% of the scat, respectively. Breeders of red wolf packs had the heaviest combined weights followed by those in congeneric pairs and coyote pairs and average breeder age was older for red wolves than coyotes and congeneric pairs (Table 1).

Red wolf packs, coyote pairs, and congeneric pairs differentially used deer, rabbits, small mammals, fur bearers, and pigs ($F_{2, 1754} \geq 6.77$, $P < 0.001$); deer and rabbits comprised most prey items found in scat (Table 2). No difference was detected in use of other food items ($F_{2, 1754} = 2.21$, $P = 0.110$). Coyote pairs consumed less deer and more rabbits than red wolf packs and congeneric pairs (Table 2). Coyotes consumed more small mammals than red wolves, but consumption of small mammals by congeneric pairs did not differ from coyote pairs or red wolf packs. Red wolf packs consumed more fur bearers and pig than coyote pairs and congeneric pairs.

Red wolf packs consumed more deer and pig in areas of medium deer density than areas of low and high density ($F_{2,968} \geq 6.43$, $P < 0.001$). Red wolf packs consumed more rabbits in areas of high deer density than in areas of low and medium density ($F_{2,968} = 33.40$, $P < 0.001$). Red wolf consumption of small mammals, fur bearers, and other food items were greater in areas of low deer density than areas of medium and high deer density ($F_{2,968} \geq 8.01$, $P < 0.001$). We only

compare diet between medium and high deer density areas for coyote pairs and congeneric pairs because they were absent in counties with low deer density (Table 3). We detected no difference in coyote consumption of white-tailed deer, rabbit, small mammals and pig between medium and high deer density ($t_{552} \leq 0.86$, $P \geq 0.392$). We did find that coyotes in areas of medium deer density consumed more fur bearers and other food items than in areas of high deer density ($t_{552} \geq 2.00$, $P \leq 0.046$). We detected no difference in consumption of any prey species by congeneric pairs between medium and high deer densities ($t_{227} \leq 1.77$, $P \geq 0.079$).

Older red wolf breeders consumed more rabbits and pig than younger breeders, whereas younger red wolf breeders' consumed more deer, small mammals, and other food items ($t_{969} \geq 2.47$, $P \leq 0.014$) than older breeders (Table 4). No differences were observed in the consumption of fur bearers by older and younger red wolf breeders ($t_{969} = 1.47$, $P = 0.142$). Younger coyote breeders consumed less deer and more rabbits than older breeders ($t_{552} \geq 2.49$, $P \leq 0.014$). No differences were observed between older and younger coyote breeders in their consumption of small mammals, fur bearers, pig and other food items ($t_{552} \leq 1.32$, $P \geq 0.188$). Older breeders in congeneric pairs consumed more small mammals ($t_{227} = 2.22$, $P = 0.027$) than younger breeders. No differences were observed between older and younger breeders in congeneric pairs of their consumption of deer, rabbits, fur bearer, pig, and other food items ($t_{227} \leq 1.83$, $P \geq 0.065$).

No seasonal differences were detected in consumption of deer, small mammals, and other food items ($t_{969} \leq 0.70$, $P \geq 0.484$) by red wolves. Red wolves consumed less fur bearers and pigs and more rabbits during winter than summer (Table 5; $t_{969} \geq 2.24$, $P \leq 0.025$). Coyote pairs consumed more deer and less rabbits during winter than summer ($t_{552} \geq 3.38$, $P \leq 0.001$). No seasonal differences were detected in coyote consumption of small mammals, fur bearers, pig, and other food items ($t_{552} \leq 1.57$, $P \geq 0.060$). Congeneric pairs consumed more deer and less other food items ($t_{227} \geq 2.01$, $P \leq 0.046$) during summer than winter. No seasonal differences were detected in the consumption of rabbits, small mammals, fur bearers, and pig by congeneric pairs ($t_{227} \leq 1.93$, $P \geq 0.060$). Also, smaller red wolf packs consumed more deer than larger packs

whereas larger packs consumed more rabbit, small mammals, fur bearers, pig, and other food items (Figure 1; $t_{969} \geq 2.63$, $P \leq 0.009$).

The most important factors for explaining variation of deer in red wolf diet was breeder weight and pack size (Table 6). Consumption of rabbits of was best explained by breeder age and deer density. All factors were important in explaining red wolf consumption of small mammals and pig. Red wolf consumption of fur bearer was best explained by summer and weight and other food items were influenced by deer density and season. Coyote consumption of deer and rabbits were best explained by weight and season (Table 7). Age, weight, deer density, and season best explained coyote consumption of small mammals and deer density best explained consumption of other food items. Season best explained consumption of deer and other food items by congeneric pairs (Table 8). Deer density, season, and age influenced consumption of rabbits and deer density and season influenced use of small mammals. Consumption of fur bearers and pig by coyote pairs and congeneric pairs was negligible and therefore not modeled.

Discussion

Little is known about the historic diets of red wolves throughout the Southeast because red wolf natural history and ecology was never well-documented. Previous diet assessments of remnant, declining red wolf populations in salt marsh and coastal habitats of Texas and Louisiana during the mid-20th century indicated red wolf diet consisted of nutria, rabbits, and cotton rats (Paradiso & Nowak, 1972; Shaw, 1975). Recent studies conducted after red wolves were reintroduced into NENC indicated greater use of deer and rabbits than the source population (Phillips *et al*., 2003; Dillenger *et al*., 2011a; McVey et al., 2013). Conversely, coyote diet has been studied extensively throughout North America in which they have been labeled as generalists or opportunistic foragers (Henderson, 1930; Korschgen, 1957; Prugh, 2005; Chamberlain & Leopold, 1999; Schecengost *et al*., 2008). Our results demonstrate that red wolves and coyotes in northeastern North Carolina have a strong carnivorous diet and consume primarily mammalian prey, such as deer, rabbits, and small mammals.

Management activities to sterilize coyotes within the Recovery Area influence factors affecting coyote interactions with prey by preventing coyote and congeneric packs from forming packs. For instance, pack size was an important factor influencing red wolf diet in which the diet of packs of fewer than 4 individuals contained greater amounts of deer and less small mammal prey than packs of 4 or more individuals. The negative relationship between pack size and food acquisition has been observed in gray wolves (Nudds, 1978; Thurber & Peterson, 1993; Schmidt & Mech, 1997; MacNulty *et al*., 2011) and our data suggest that red wolves are constrained by similar group dynamics. Although we couldn't assess effects of pack size on coyote diet, we can only speculate that the diets of coyote and congeneric pairs would be similarly constrained by group living dynamics that affect cooperation and conflict within their packs as they increase in size.

Pack size likely caused variation in red wolf diet by effecting pack hunting efficiency and energetic gains acquired from kills. Recently, MacNulty *et al*. (2011) examined hunting efficiency of gray wolf packs and proposed the free-riding hypothesis in which pack members can decrease hunting efficiency by superficially cooperating in hunts to gain access to kills. Although our study was not designed to assess hunting efficiency of red wolves, deer consumption peaked with smaller red wolf packs and that may indicate greater hunting efficiencies at smaller group sizes. It is difficult for our study to discern whether pack hunting efficiency was truly affected by pack size because larger wolf packs had greater percentages of rabbits, fur bearers, pig, and other food items in their diet to compensate for the decrease in use of deer. If hunting efficiency remained the same between small and large red wolf packs, it is likely that deer comprised a lower percentage of the diets of larger packs because kills had to be divided and shared among more individuals. This would cause larger red wolf packs to broaden their diet to include other prey to supplement energetic loses from sharing their deer kills with offspring. Whether large packs experience lower hunting efficiencies or reduce energetic profits from kills through sharing, it is likely that increasing red wolf density within territories has a negative effect on

foraging that may eventually facilitate fragmentation of packs through parent-offspring conflicts over food acquisition (Gese *et al*., 1996).

Canis species lack adaptations for prey control (i.e., grappling abilities) and increased body weight likely improves their killing ability by allowing individuals to more effectively hold down large prey while other pack members deliver repeated bites to the abdomen and hindquarters. Dentition is also a primary trait used to subdue prey and substantial, prolonged bite forces that are necessary for handling large prey put considerable stress on teeth (Van Valkenburgh, 1991; Slater *et al*., 2009). MacNulty *et al*. (2009a) observed that the ability of gray wolves in Yellowstone National Park to kill ungulates improved with increased body size. Also, hunting performance of gray wolves was observed to decrease with age because of physiological deterioration caused by senescence (MacNulty *et al*., 2009b). Similarly, we found body weight and age of red wolf breeders to influence pack diet. Although age was not an important variable predicting red wolf consumption of deer, its positive correlation with consumption of smaller-sized prey indicates that older breeders depended more on rabbits and small mammals for food than did younger breeders. As individuals age, canines and incisors are eventually worn down and fractured because of repetitive use and it's not unusual for red wolves > 4 years of age to have substantially worn and damaged teeth (USFWS, *unpublished data*). As a result, we suspect that deterioration to dentition through aging was a primary reason older breeders relied on smaller-sized prey.

As observed with red wolf packs, larger coyote pairs consumed more deer than smaller conspecifics. Coyote pairs also consumed more deer during winter than summer and our findings are contrary to many studies conducted on coyote diet in the southeastern United States (Chamberlain & Leopold, 1999; Schrecengost *et al*., 2008; Kilgo *et al*., 2012). These studies have indicated that coyote predation of deer occurs primarily on fawns during summer and coyote consumption of deer during winter is a result of scavenging of hunter dump sites or deer crippled or un-recovered by hunters (Chamberlain & Leopold, 1999; Thornton *et al*., 2004; Schrecengost

et al., 2008). We do not believe that scavenging explains increased use of deer during winter because the positive relationship between coyote consumption of deer and coyote body weight implies that body size is an important trait for coyotes to acquire deer in their diet through predation, whereas scavenging is opportunistic and should not be affected by body size. Coyotes in the western United States have been observed hunting and killing white-tailed deer (Patterson & Messier, 2000; Lingle & Pellis, 2002), mule deer (*Odocoileus hemionus*; Bowyer, 1987; Lingle & Pellis, 2002), elk (*Cervus elaphus*; Gese & Grothe, 1995), bighorn sheep (*Ovis Canadensis*; Bleich, 1999), pronghorn (*Antilocapra americana*; Keller *et al*. 2013) and other large prey. Therefore, it is reasonable to assume that coyotes in the southeastern United States are capable of killing deer outside of the fawning season.

The average coyote lifespan in this study was statistically lower than red wolves by almost 2.5 years because many coyotes were removed from the landscape for management reasons related to red wolf recovery or opportunistically by hunters and trappers (Hinton, *unpublished data*). Therefore, it is difficult to insinuate whether the effects of age on coyote and congeneric pair food habits were related to physiological deterioration or experience. Older coyote breeders consumed more white-tailed deer, but this consumption is probably a result of a few coyote breeders approaching their peak performance age of 3-4 years old. If natural senescence had been more common with coyotes in our study area, we believe that age would have had a similar effect on coyote and congeneric pair food habits as it did on red wolf packs.

Although congeneric pairs typically weighed 20-40% more than coyote pairs and consumed 10% more deer, breeder weight was not useful in explaining variation in use of deer in the diets of congeneric pairs. This discrepancy is likely a result of management actions that remove coyotes from congeneric pairs to make resident red wolves available to dispersing red wolves during the breeding season. Therefore, most congeneric pairs form during late winter or early spring when management actions shift to monitoring red wolf denning behavior. Solitary red wolves acquiring a coyote mate likely increase hunting efficiency during spring and summer

but, when they lose their coyote mate to management action prior to the breeding season, they hunt solitarily until they find a new mate.

A 15-20 kg threshold was proposed in which carnivores weighing above that threshold would have to switch to larger vertebrate prey that approach their body weight because of higher energetic demands and constraints related their body size (Carbone *et al*., 1999; Carbone *et al*., 2007). Coyotes in northeastern North Carolina approach the 15-20 kg threshold and the smallest red wolves are above it. How these pairs adjust energy budgets associated with changes in breeder body mass and hunting efficiency is unknown. Differences in body size between red wolves and coyotes will affect energy requirements and capacities for searching for and processing prey which, in turn, may affect how they perceive the distribution, abundance, and profitability of prey on the landscape. Therefore, the formation of congeneric pairs and the stability of those pairs to successfully raise hybrid litters may be related to how similar individuals are in their energy demands. Partitioning of food resources by red wolves and coyotes in northeastern North Carolina is mostly via differences in the quantity of similar prey exploited and via differences in types of prey used. This is probably a result of greater energetic demands placed on red wolves from their larger body size to rely more on deer, rabbits, and fur bearers and indicates that the diets of red wolves and coyotes conform to the predictions from existing theory on foraging behavior in which relative body size appear to be important factors governing the overlap of resources and intensity of competition (Rosenzweig, 1966; Gittleman, 1985; Carbone *et al*., 2007). Different use of prey, habitat, and space use by red wolves and coyotes resulting from differences in body sizes may serve as a reproductive barrier by preventing congeneric pairing. Therefore, we hypothesize that hybridization rates between red wolves and coyotes increase as both populations approach each other in body size. Our ability to identify key traits and understand how they facilitate reproductive barriers is crucial for red wolf recovery.

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Table 4.1. Average combined weight and age of red wolf breeders, coyote pairs, and congeneric pairs in northeastern North Carolina during 2009-2011.

	Red Wolf		Coyote		Congeneric			
	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$F_{2,37}$	P
Weight (kg)	57.2	0.9	29.5	0.7	43.5	1.2	284.65	0.001
Age (yrs)	4.6	0.4	2.8	0.3	3.0	0.3	7.32	0.002

Table 4.2. Percent volume of foods in red wolf and coyote scats in northeastern North Carolina during 2009-2011. Different letters in parentheses next to values represent statistical differences among breeding units ($P < 0.05$, Tukey's test).

	N	% Deer	% Rabbit	% Small Mammal[a]	% Fur Bearer[b]	%Pig	% Other[c]
Red Wolves[d]	972	40.7(A)	26.8(A)	14.4(A)	8.1(A)	4.1(A)	6.0(A)
Congeneric Pairs[e]	228	40.2(A)	29.7(A)	16.8(AB)	3.7(B)	0.4(B)	9.1(A)
Coyotes[f]	554	30.0(B)	38.3(B)	20.5(B)	3.2(B)	0.6(B)	7.6(A)

[a]Rat, mouse, shrew, and vole species
[b]Muskrat, nutria, and raccoon
[c]Insects (i.e., grasshoppers and beetles), grass/seeds, bird species, and human trash
[d]Red wolf pairs and packs
[e]Coyote and red wolf (congeneric) pair bonds
[f]Coyote pairs

Table 4.3. Percent volume of foods in the scats of red wolf packs (*n* = 972), coyote pairs (*n* =554), and congeneric pairs (*n* =228) collected in areas of low (< 0.75 deer harvested/km²), medium (0.75-1.5 deer harvested/km²), and high (>1.5 deer harvested/km²) deer density of northeastern North Carolina during 2009-2011.

	Red Wolf Packs			Coyote Pairs			Congeneric Pairs		
	Low	Medium	High	Low	Medium	High	Low	Medium	High
Deer	23.1 ± 4.4	45.7 ± 1.8	35.8 ± 2.9	N/A	27.3 ± 3.6	30.7 ± 1.9	N/A	36.9 ± 4.2	42.3 ± 3.6
Rabbit	6.4 ± 3.8	24.3 ± 16	41.9 ± 2.5	N/A	37.7 ± 3.6	38.4 ± 1.9	N/A	25.3 ± 3.9	32.8 ± 3.4
Small Mammals	30.2 ± 3.0	12.2 ± 1.2	13.3 ± 2.0	N/A	21.5 ± 2.8	20.2 ± 1.5	N/A	20.6 ± 2.8	14.1 ± 2.4
Fur Bearer	12.5 ± 2.5	9.3 ± 1.0	2.8 ± 1.6	N/A	1.3 ± 1.1	3.8 ± 0.6	N/A	6.1 ± 1.6	2.6 ± 1.4
Pig	2.7 ± 1.8	5.6 ± 0.7	0.8 ± 1.2	N/A	0.1 ± 0.6	0.7 ± 0.3	N/A	0 ± 0	0.8 ± 0.6
Other	25.1 ± 1.9	2.9 ± 0.8	5.9 ± 1.2	N/A	12.3 ± 2.0	6.3 ± 1.1	N/A	11.1 ± 2.2	7.4 ± 1.9

Table 4.4. Percent volume of foods in the scats of red wolf packs (*n* = 972), coyote pairs (*n* =554), and congeneric pairs (*n* =228) by age the breeders in northeastern North Carolina during 2009-2011.

	Red Wolf Packs		Coyote Pairs		Mixed Pairs	
	≤ 4 yrs	> 4 yrs	≤ 4 yrs	> 4 yrs	≤ 4 yrs	> 4 yrs
Deer	47.5 ± 2.4	36.8 ± 1.8	28.8 ± 1.7	45.1 ± 6.5	42.6 ± 3.1	30.1 ± 6.0
Rabbits	16.1 ± 2.1	33.2 ± 1.6	39.3 ± 1.7	24.0 ± 6.4	28.4 ± 2.9	34.5 ± 5.7
Small Mammals	17.7 ± 1.6	12.6 ± 1.3	20.2 ± 1.4	24.2 ± 5.0	14.9 ± 2.0	24.8 ± 4.0
Fur Bearer	6.5 ± 1.3	8.9 ± 1.0	3.2 ± 0.6	3.9 ± 2.0	3.7 ± 1.2	5.5 ± 2.3
Pig	2.1 ± 1.0	5.3 ± 0.7	0.6 ± 0.3	0.3 ± 1.1	0.6 ± 0.5	0.0 ± 1.0
Other	10.2 ± 1.1	3.6 ± 0.8	7.9 ± 1.0	3.1 ± 3.6	9.9 ± 1.6	5.3 ± 3.2

Table 4.5. Percent volume of foods in the scats of red wolf packs (n = 972), coyote pairs (n =554), and congeneric pairs (n =228) by season in northeastern North Carolina during 2009-2011.

	Red Wolf Packs		Coyote Pairs		Mixed Pairs	
	Winter	Summer	Winter	Summer	Winter	Summer
Deer	42.3 ± 2.7	40.1 ± 1.7	37.5 ± 2.4	22.7 ± 2.3	32.0 ± 3.4	52.8 ± 4.3
Rabbits	33.9 ± 2.4	23.8 ± 1.5	32.5 ± 2.3	43.8 ± 2.4	33.1 ± 3.3	24.1 ± 4.1
Small Mammals	14.7 ± 1.8	14.3 ± 1.2	18.8 ± 1.9	22.0 ± 1.8	19.7 ± 2.3	12.4 ± 2.9
Fur Bearer	1.4 ± 1.5	10.8 ± 0.9	2.2 ± 0.8	4.2 ± 0.7	3.3 ± 1.3	5.3 ± 1.7
Pig	2.1 ± 1.0	4.9 ± 0.7	0.1 ± 0.4	1.1 ± 0.4	0.7 ± 0.6	0.0 ± 0.7
Other	5.5 ± 1.2	6.2 ± 0.8	9.1 ± 1.4	6.1 ± 1.3	11.3 ± 1.9	5.3 ± 2.3

Table 4.6. Results of the 3 best models for factors influencing selection of 5 food categories by red wolf packs in northeastern North Carolina during 2009-2011.

Model	**k**[a]	**AIC$_c$**[b]	**ΔAIC$_c$**[c]	**w_i**[d]
White-tailed deer				
Weight + pack size	4	5603.73	0.00	0.35
Weight + pack size + age	5	5605.34	1.62	0.16
Weight + pack size + summer	5	5605.63	1.90	0.14
Rabbits				
Age + deer density	4	5468.28	0.00	0.31
Age + deer density + summer	5	5469.37	1.09	0.18
Age + deer density + weight	5	5469.63	1.34	0.16
Small Mammals				
Age + summer + pack size + deer density + weight	7	5085.47	0.00	0.29
Age + summer + pack size + deer density	6	5086.00	0.52	0.23
Age + summer + pack size + weight	6	5086.37	0.89	0.19
Fur bearers				
Summer + weight	4	4626.08	0.00	0.29
Summer + weight + pack size	5	4627.76	1.69	0.13
Summer + weight + age	5	4627.89	1.82	0.12
Pig				
Age + deer density + pack size + weight + summer	7	4012.21	0.00	0.65
Age + deer density + pack size + weight	6	4013.85	1.64	0.29
Age + deer density + pack size + summer	6	4017.50	5.29	0.05
Other				
Deer density + summer	4	4303.20	0.00	0.31
Deer density + summer + pack size	5	4304.95	1.75	0.13
Deer density + summer + pack size + weight	6	4304.96	1.76	0.13

[a]Model parameters
[b]Akaike's Information Criterion
[c]Difference in AIC
[d]Akaike weight

Table 4.7. Results of the 3 best models for factors influencing selection of 5 food categories by coyote pairs in northeastern North Carolina during 2009-2011.

Model	**k**[a]	**AIC$_c$**[b]	**ΔAIC$_c$**[c]	**w_i**[d]
White-tailed deer				
Weight + summer	4	3132.08	0.00	0.44
Weight + summer + deer density	5	3132.94	0.86	0.29
Weight + summer + age	5	3134.04	1.96	0.17
Rabbits				
Summer + weight	4	3153.34	0.00	0.34
Summer + weight + age	5	3153.89	0.55	0.26
Summer + weight + deer density	5	3155.37	2.03	0.12
Small Mammals				
Age + weight + deer density + summer	6	2960.97	0.00	0.26
Age + weight + deer density	5	2960.98	0.01	0.26
Age + weight + summer	5	2961.94	0.97	0.16
Other				
Deer density	3	2620.65	0.00	0.18
Null model	2	2621.44	0.79	0.12
Deer density + summer	4	2621.81	1.15	0.10

[a]Model parameters
[b]Akaike's Information Criterion
[c]Difference in AIC
[d]Akaike weight

Table 4.8. Results of the 3 best models for factors influencing selection of 5 food categories by congeneric pairs in northeastern North Carolina during 2009-2011.

Model	**k**[a]	**AIC$_c$**[b]	**ΔAIC$_c$**[c]	**w_i**[d]
White-tailed deer				
Summer	3	1312.34	0.00	0.23
Summer + age	4	1312.95	0.61	0.17
Summer + age + deer density	5	1313.55	1.20	0.13
Rabbits				
Deer density + summer + age	5	1294.51	0.00	0.23
Deer density + summer	4	1295.02	0.51	0.18
Deer density + age	4	1295.69	1.18	0.13
Small Mammals				
Deer density + summer	4	1187.97	0.00	0.21
Deer density	3	1188.91	0.94	0.13
Deer density + age	4	1189.09	1.12	0.12
Other				
Summer	3	1108.24	0.00	0.15
Weight	3	1108.85	0.61	0.11
Summer + age	4	1108.97	0.73	0.10

[a]Model parameters
[b]Akaike's Information Criterion
[c]Difference in AIC
[d]Akaike weight

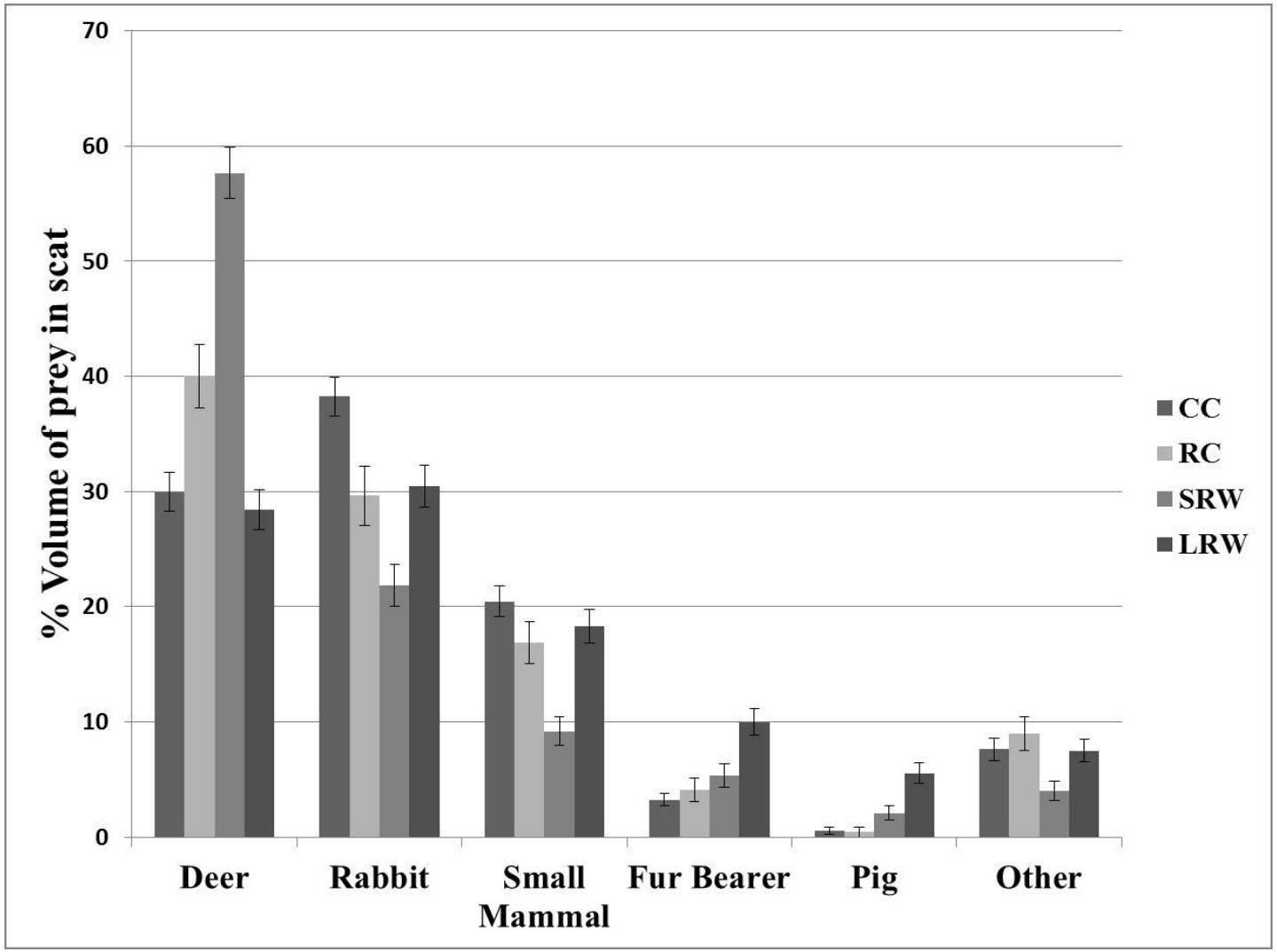


Figure 4.1. Percent volume of prey in the scats of coyote pairs (CC), congeneric pairs (RC), red wolf packs with ≤ 4 individuals (SRR), and red wolf packs with > 4 individuals (LRR) in northeastern North Carolina, during 2009-2011.

CHAPTER 5

SPACE USE AND HABITAT SELECTION BY RESIDENT AND TRANSIENT COYOTES

Hinton, J.W., M.J. Chamberlain, and F.T. van Manen. To be submitted to the *Journal of Animal Ecology*.

Abstract

Little information exists on coyote spatial ecology in the southeastern United States and the few studies conducted have been conducted at small scales (e.g., ≤ 500 km2). Studies on coyote ecology in the Southeast have typically been conducted at small scales (e.g., ≤ 500 km²) and often provide conflicting insights regarding coyote ecology. Therefore, studies of coyote spatial ecology at broader geographic areas (e.g., ≥ 2,500 km2) may provide relevant insights as to how coyote populations adjust to various ecological circumstances on the landscape. During 2009-2011, we studied coyote space use and habitat selection on the Albemarle Peninsula (>6,000 km^2) of northeastern North Carolina using GPS radio-collars. We quantified home range sizes and 2nd- and 3rd-order habitat selection for resident and transient coyotes to describe space use patterns in response to a dynamic agricultural landscape. We observed an upper limit on coyote home-range sizes to be approximately 50 km² and suggest body size constraints may limit the amount of finite space coyote groups can maintain as a territory. We also observed preferences for agricultural habitats over forested habitats by resident and transient coyotes, and resident coyotes pushed transients into marginal forest habitats. Coyotes had exhibited avoidance of roads during diurnal hours despite exhibiting preferences for them during nocturnal hours. Overall, loss of cover resulting from harvest of agricultural crops facilitated strong shifts to using forested areas for cover by resident coyotes during fall and winter. Consequently, use of forested areas by resident coyotes forced transient coyotes to rely more on road and edge habitats during fall and winter.

Introduction

Coyote colonization of eastern North America has generated much interest from ecologists and the general public (Gompper 2002; Levy 2012) because it occurred in several waves (Parker 1995; Nowak 2002; Bozarth et al. 2011), resulting in noticeable changes in phenotype (i.e., body size and pelt color; Thurber and Peterson 1991; Way 2007) and hybridization with remnant wolf populations (Kays et al. 2010; Wheeldon et al. 2010). Presence

in eastern North America during the Pleistocene indicates that coyotes have history of range expansions and contractions that can be attributed to the emergence and loss of other *Canis* competitors on the landscape (Nowak 2002) and changes in climate (Koblmüller et al. 2012). Although successful colonization has been attributed to the coyote's generalist behaviors, phenotypic plasticity, and ability to hybridize with remnant wolf populations, developing a conceptual framework for understanding coyote range expansion remains contentious (Thurber and Peterson 1991; Lariviére and Créte 1993; Kays et al. 2010; Wheeldon et al. 2010).

Coyote colonization of the southeastern United States has received more attention in recent years, but little information exists on large scale spatial and temporal patterns of landscape use by coyotes in the region. Studies on coyote ecology in the Southeast have typically been conducted at small extents (e.g., $\leq$ 500 km²) and often provide conflicting insights. Fine-scale studies are problematic because they fail to capture broad scale variations in coyote ecology and landscape structure that can be used to explain why coyotes have become established throughout the Southeast. Aspects of coyote spatial ecology that influence variation in size and habitat composition of home ranges have important consequences for processes such as population growth and regulation because differential use of space and habitats allows access to important prey species and reduces risks of mortality, both of which affect survival and reproduction. Therefore, studying the placement, size, and habitat composition of coyote home ranges over broad geographic areas (e.g., $\geq$ 2,500 km^2) will provide relevant insights as to how coyote populations adjust regionally varying ecological conditions.

In particular, the effects of eastern forested and agricultural landscapes on coyote movements and space use in the Southeast are not well known. While it has been suggested that eastern forested landscapes represent marginal habitat for coyotes (Tremblay et al. 1998; Crête et al. 2001; Richer et al. 2002), other studies have suggested that eastern forests are suitable habitat (Kays et al. 2008). Although these studies were conducted in the Northeast, many regions of the Southeast are characterized by large agriculture-forested mosaics similar to areas colonized by

coyotes in the Northeast and generalities can be drawn by comparing studies conducted in different regions. For instance, coyote home-range sizes typically vary between 2.5 – 70 km^2 (Bekoff and Gese 2003; Leopold and Chamberlain 2001). Although variability can be attributed to adjustments of space use patterns to local environmental conditions, a central tendency of coyote space use is driven by their metabolic needs, which is known to vary with body mass (McNab 1963; Gompper and Gittleman 1991). Along with body size, locomotor mode is known to be a key parameter for explaining large scale patterns in carnivores (Van Valkenburgh 1999). Coyotes are cursorial carnivores that evolved in the extensive grassland region of central North America. Dense forested areas may make pursuit hunting, and therefore resource acquisition, more difficult for coyotes. On the other hand, agricultural fields and early successional habitats may be analogous to the open, expansive habitats to which coyotes are adapted, and may provide ideal habitat for population centers. Therefore, understanding coyote distributional patterns in response to habitat heterogeneity is fundamental to develop a full understanding of how this species successfully colonized eastern North America.

Coyotes are sympatric with red wolves in northeastern North Carolina and both species are managed and monitored by the United States Fish and Wildlife Service (USFWS) Red Wolf Recovery Program (Recovery Program) on the Albemarle Peninsula of northeastern North Carolina (Hinton et al. 2013; Rabon et al. 2013). Red wolves show strong preferences for agricultural fields over the surrounding forested areas (Chadwick et al. 2010, Hinton and Chamberlain 2010, Dellinger et al. 2013) and very high frequency (VHF) radio-telemetry data indicates that coyotes exhibit similar habitat preferences (USFWS *unpublished*). It is suspected that coastal bottomland forests and wetlands are unsuitable habitat to red wolves and coyotes in northeastern North Carolina because dense understories and periodic inundation hinder or prevent movements. On the other hand, agricultural croplands may provide suitable habitat because they are dry, treeless environments with no understory structure to hinder movements and foraging efforts. Although the effect of roads on coyote movements remains unknown, previous gray wolf

(James and Stuart-Smith 2000; Whittington et al. 2005) and red wolf (Dellinger et al. 2013) studies suggested that secondary, low-use roads provided some benefit to wolves by increasing foraging efficiency and lowering movement costs. Coyotes are known to have higher tolerance to human presence than wolves (Grinder and Krausman 2001; Atwood et al. 2004; Way et al. 2004; Gehrt et al. 2009) and studies have documented coyote use of roads in heavily populated urban areas (Tigas et al. 2002; Way 2009; Gehrt et al. 2011; Hinton et al. 2012). This trait may allow them to exploit primary (paved) and secondary (unpaved) roads as travel corridors through barriers (i.e., rivers) and unsuitable habitats regardless of human density.

With *a priori* assumptions that forested areas in northeastern North Carolina represent poor habitat for coyotes, we monitored resident and transient coyotes fitted with global positioning system (GPS) radio-collars to assess ways in which coyotes move, interact, and use several primary habitats on the Albemarle Peninsula. During summer, we expected coyotes to avoid forested areas and increase their use of row crops (i.e., corn, soybean, and winter wheat) because crops provide adequate cover with little understory to impede movements. We also expected coyotes to increase their use of forested areas for cover during winter because crops were harvested and forests provided the only cover during that time of year. Transient coyotes are individuals that have not established residency and display nomadic movement with no fidelity for any one area; they also may display different space use patterns than resident coyotes that maintain home ranges (Gese et al. 1988, Kamler and Gipson 2000; Hinton et al. 2012). Previous work observed localized space use patterns lasting between 2-8 weeks that were analogous to patterns of home range use (Hinton et al. 2012). These space use patterns of transients were called biding areas and studying them may provide important insights into how coyotes move through the landscape searching for unoccupied areas and/or mates to establish residency. This study represents the first broad scaled study (> 5000 km^2) of resident and transient coyotes in the southeastern United States.

Study Area

Our study was conducted on the Albemarle Peninsula in the northeastern region of North Carolina (Figure 1). The study area was approximately 6000 km^2 of federal, state, and private lands comprised of a row-crop agricultural-bottomland matrix with little change in elevation (0-50m). Agricultural crops (i.e., corn, cotton, soybean, and winter wheat) and managed pine (*Pinus* spp) comprised approximately 30% and 15% of the land cover, respectively (Figure 1). Other prominent land cover types were coastal bottomland forests and pocosin (35%), herbaceous wetlands and saltwater marshes (5%), open water (5%), and other minor land cover types (10%). The climate was typical of the mid-Atlantic: 4 full seasons, nearly equal in length, with an annual precipitation averaging between 122-132 cm. Summer climate was typically hot and humid with temperatures ranging from 27°C to over 38°C and winters were relatively cool with temperatures ranging between -4°C to 7°C.

Methods

We captured coyotes using padded foot-hold traps (Victor no.3 Softcatch, Lititz, Pennsylvania, USA) from October through May during 2009-2011. Coyotes were sexed, measured, weighed, aged by tooth wear (Gier, 1968), and a blood sample was collected. We categorized coyotes as > 2 years old as adults, < 2 but > 1 year old as juveniles, and < 1 year old as pups. Coyotes on the Albemarle Peninsula were reproductively sterilized by the USFWS to prevent introgression into the red wolf population (Hinton et al. 2013; Rabon et al. 2013). Coyotes were taken to a local veterinary clinic for surgical sterilization where males and females were reproductively sterilized by vasectomy and tubal ligation, respectively. This process kept hormonal systems intact to avoid disrupting breeding and territorial behavior (Seidler and Gese 2012). Prior to release at the original capture sites, we fitted coyotes with a mortality-sensitive GPS radio-collar (Lotek 3300s, Newmarket, Ontario, Canada) scheduled to record a location every 4 hours (0:00, 04:00, 08:00, etc.) throughout the year. Animal handling methods were

approved by the Louisiana State University Agricultural Center Institutional Animal Care and Use Committee (Protocol Number AE2009-19).

To reflect the anthropogenic effects of agriculture on the landscape, we divided year into 2 6-month seasons based on agricultural activity: planting/growing (1 March – 31 August) and harvest/fallow (1 September – 28 February). We also separated coyote locations for each season into diurnal and nocturnal categories based monthly photoperiods. We estimated space use of resident and transient coyotes by fitting dynamic Brownian bridge movement models (dBBMMs) to the time-specific location data to estimate the probability of use along the full movement track of each coyote (Kranstauber and Smolla 2013) using the R package moveud (Collier 2013) in the R statistical environment (R Core Team 2013). We chose window sizes based on the temporal resolution of each track and our *a priori* assumptions of the time scale of major behavioral shifts (Byrne et al. 2014). For resident coyotes, 95% and 50% contour intervals were considered home ranges and core areas, respectively. For transient coyotes, 95% and 50% contour intervals were considered transient range and biding areas (Hinton et al. 2012), respectively. We used *t*-tests to examine changes in home range and space use sizes between seasons.

Predominant habitat types were estimated from a digitalized landscape map of vegetative communities developed by the North Carolina Gap Analysis Project (McKerrow et al. 2006). We collapsed the vegetative communities estimated by McKerrow et al. (2006) into 7 general habitat types with 30m resolution. For the habitat selection analysis, we divided the landscape into agriculture, coastal bottomland forest, pine forest, open water, upland forest, urban, and wetland. Because roads may serve as corridors for coyote movements, we included road as the 8th habitat type by superimposing a linear feature layer with a 30m buffer around roads onto the final habitat raster map with 30m resolution.

We used analysis of variances (ANOVAs) and *t*-tests to determine if the percentage of habitat composition of home ranges and transient ranges differed between each other and between seasons. We also developed generalized linear models (GLMs) to examine the effects of coyote

body weight and age, white-tailed deer abundance, and habitat composition on coyote home-range size. We used county-level harvest data collected by the North Carolina Wildlife Resources Commission as a measure of deer abundance in the study area. Although harvest reports do not reflect true white-tailed deer densities, hunter harvest/km^2 does provide a benchmark by which to judge the effect of white-tailed deer abundance on coyote home-range size. Habitat composition of home ranges were calculated as % agricultural, % forest (coastal bottomland and pine), and % road. We assessed models using a stepwise procedure by calculating Akaike's information criterion for small sample sizes (AIC_c) for each model to select which variables best explained home-range size.

We compared habitat selection of coyotes at two scales: population (2^{nd}-order) and individual (3^{rd}-order). Habitats were converted into continuous variables by quantifying percent of habitat cover for each 30m cell using a moving window with a 150m radius in FRAGSTATS (McGarigal et al. 2012). We also quantified edge density and patch richness across the study area because coyotes are known to forage along edges (Tigas et al. 2002). Information from raster maps were extracted to coyote locations and home ranges using ArcGIS 10.1 (Environmental Systems Research Institute Inc., Redlands, California). We used resource-selection functions (RSFs) to examine the effect of habitat type on where coyotes established home ranges on the landscape (2^{nd}-order selection of resources; Johnson 1980) and examine the effect of habitat type on how coyotes use their home ranges (3^{rd}-order selection of resources; Johnson 1980) following Manly et al. (2002). We assumed seasonal and photoperiod variation in habitat use by residents and transients and, therefore, developed RSFs for residents and transients by season and photoperiod for 3^{rd}-order selection. We used a binomial approach to estimate resource-selection functions by comparing characteristics of known (used) locations to random (available) locations (Manly et al. 2002). We used logistic regression and AIC_c to form RSFs that identified habitats important to individual coyotes. We evaluated the relative importance of coefficients associated with the habitat types by examining Akaike weights (w_i) after adding each of these covariates to a

core model set (e.g., higher w_i and lower AIC_c suggested model improvement; Burnham and Anderson 2002). We also evaluated the predictive performances of the most parsimonious core models using the *k*-fold cross validation method (Boyce et al. 2002; Johnson et al. 2006). The cross-validation method performs *k* iterations of training and validation in which a different fold of the data is held out for validation while the remaining $k - 1$ folds are used for learning. For cross-validation, we used 10 folds ($k = 10$) to estimate performance of RSF models.

Results

During 2009-2011, we monitored 28 coyotes fitted with GPS radio-collars. We monitored 22 (79%) resident and 6 (21%) transient coyotes and 8 (29%) coyotes were transients prior to becoming residents. Mean weight and age of coyotes monitored were 14.0 kg ± 0.4 and 2.5 yrs ± 0.2, respectively, in which weights and age of residents were greater than transients (Table 1; $t_{26} \geq 2.23$, $P \leq 0.034$). Home ranges and core areas of residents did not differ between seasons (Table 2; $t_{45} \leq 0.024$, $P \geq 0.800$) and home ranges ranged from 13.4 km² to 47.3 km². We also detected no seasonal difference of transient ranges and biding areas (Table 1; $t_{17} \leq 1.86$, $P \geq 0.080$) and transient areas ranged from 64.5 km² to 633.4 km². Home range size was best explained by the percentage of agricultural fields, white-tailed deer density, and forested areas in which home range size decreased with increasing percentage of agricultural fields ($r^2 = 0.30$, $P = 0.007$) and deer density ($r^2 = 0.40$, $P = 0.001$), but increased with increasing percentage of forests ($r^2 = 0.33$, $P = 0.004$).

Home ranges and core areas were comprised mostly of agricultural fields, coastal bottomland and pine forest, and roads (Figure 2; $F_{6, 161} = 36.69$, $P < 0.001$). Pine and upland forest, urban, road, and wetland composition between home ranges and core areas did not differ ($t_{46} \leq 1.31$, $P \geq 0.195$) but home ranges typically consisted of more coastal bottomland forest and less agricultural fields than did core areas ($t_{46} \geq 2.39$, $P \geq 0.022$). Similarly, transient ranges and biding areas were comprised mostly of agricultural fields, coastal bottomland and pine forests, and roads (Figure 2; $F_{6, 161} = 60.23$, $P < 0.001$). We found no differences in habitat composition

between transient ranges and biding areas ($t_{28} \leq 1.67$, $P \geq 0.105$). Home ranges consisted of more pine forests and roads and less wetlands than transient ranges ($t_{103} \geq 2.07$, $P \leq 0.022$), whereas all other habitat types were similar ($t_{103} \leq 1.06$, $P \geq 0.293$). Core areas consisted of more pine forests and less coastal bottomland forests and wetlands than biding areas ($t_{103} \geq 2.30$, $P \leq 0.024$), whereas all other habitat types were similar ($t_{103} \leq 0.96$, $P \geq 0.337$). We detected no seasonal differences between habitat types of home ranges and core areas ($t_{45} \leq 1.25$, $P \geq 0.219$) and transient ranges and biding areas ($t_{17} \leq 1.27$, $P \geq 0.220$).

We excluded wetland, upland forest, and urban habitats from our models because their occurrence in home ranges and transient ranges were negligible. Therefore, we only included edge density, patch richness, and agriculture, pine forest, coastal bottomland forest, and road habitats in our model. Only 1 covariate (edge density) was not retained in the top-ranked model for 2nd-order selection by residents (Table 2) whereas all 6 covariates were retained for transients (Tables 3). Roads, coastal bottomland forests, and patch richness were better predictors of transient occurrence than residents at the landscape level (Table 4). Agriculture, pine forest, and road habitats were retained in all top-ranked models for 3rd-order selection by residents (Table 2). Residents appeared to favor agricultural fields and pine forests during both seasons and photoperiods, whereas roads were avoided during day but used at night (Figures 4&5; Table 4). Coastal bottomland forest, pine forest, and patch richness were retained in all top-ranked models for 3rd-order selection by transients (Table 3). Coastal bottomland and pine forests were used by transients more during the growing season than harvest season, whereas patch rich areas were preferred during both seasons and photoperiods (Figures 6&7; Table 4). Similar to residents, transients used roads more at night than during day.

Discussion

The broad front of coyote expansion throughout North America is a result of dynamic space-use patterns by coyotes that permit them to move across and persist in a variety of environments. In particular, coyote populations consist of resident and transient individuals

(Andelt et al. 1985, Gese et al. 1988, Kamler and Gipson 2000). Similar to other studies (Gese et al. 1988, Windberg and Knowlton 1988, Chamberlain et al. 2000), our results indicate that approximately 70% of coyotes in northeastern North Carolina are likely residents whereas the remaining 30% are transients.

Home-range sizes of coyotes did not vary between seasons despite an average 35% reduction in winter cover within home ranges resulting from crop harvest (Figure 2). This indicates that coyotes may not adjust home range size to immediate demand, but rather potential demand. In other words, coyotes most likely learn changes in the environment prior to establishing residency so that space acquired for home ranges is adequate to accommodate seasonal fluctuations in resource needs. Home ranges did not exceed 50 km^2 indicating that coyotes may have an upper limit to the amount of space they can effectively exploit and defend. Coyotes must be able to defend a finite area and handle the distribution of prey while maintaining a consumption rate below resource renewal to assure long-term maintenance of their home ranges. Our mean home-range sizes are typical of those reported in other studies (see Table 22.4 in Bekoff and Gese 2003 & Table 21 in Leopold and Chamberlain 2001) and similarity among studies indicates that there is a central tendency in coyote space use that is likely constrained by the effects of body size (McNab 1963; Swihart et al. 1988; LaBarbera 1989). Although we found habitat type and white-tailed deer density to have a stronger effect on variation of home-range size than did body size, it is important to note that body size is an endogenous factor resulting from evolutionary forces that reduce variability, whereas exogenous factors such as habitat and resource density would influence variation around a central tendency in coyote space use. Effects of body size on space use patterns are well established and they should be routinely tested and reported in studies of coyote spatial use regardless of statistical significance. Coyotes exhibit phenotypic variation by regions (Thurber and Peterson 1991; Way 2007) and reporting such information allows ecologists to accurately draw conclusions regarding the effects of habitat and physiology on coyote space use.

Territorial behavior in coyotes assures ideal reproductive possibilities to residents holding space (Gaston 1978). Although this prevents transients from reproducing, transiency is likely an important trait that allows populations to reconstruct themselves rapidly after suffering drastic and extensive mortality. This may be particularly important for coyote populations to persist where they are heavily exploited. Despite their wide-ranging space use patterns, many transients exhibited localized movements that were analogous to home ranges and we referred to them as biding areas (Hinton et al. 2012). Seven of the 8 (88%) residents that were transients established home ranges in or nearby their biding areas. We suggest this behavior may prove beneficial to coyote populations and should be examined in future studies because it increases survivorship of transients via familiarity of areas they roam, allows transients to assess potential areas prior to establishing home ranges, and, when opportunities arise, they can replace residents upon death.

Effects of agriculture and forest habitat on coyote space use in northeastern North Carolina are similar to those reported in other studies in the Northeast and indicate general preferences for open, treeless environments by coyotes (Crête et al. 2002, Gosselink et al. 2003, Van Deelen and Gooselink 2006). The general compositional pattern in coyote home ranges were high percentages of agricultural fields in the interior (i.e., core areas) with forest edges increasing in outer fringes. The forest cover coyotes favored in our study were pine plantations. During harvest season, coyotes typically loafed in forest habitats within 50-300m of edges adjacent to agricultural fields and roads. As winter wheat reached heights of approximately 0.5 meters during the growing season, coyotes abandoned forest habitats to loaf in wheat fields when available and then shifted to corn later in the season as wheat was harvested (Hinton, *personal observation*). Home range size decreased as agricultural fields became the predominant habitat type and vice versa for forested habitats. For example, the home range of a female coyote with the smallest home-range size (13.4 km^2) consisted of approximately 40% and 30% agricultural and forested habitat, respectively. Of her 1987 GPS locations, approximately 87% of them occurred in agricultural fields. On the other hand, the home range of a female coyote with the largest home-

range size (47.3 km^2) consisted of approximately 10% and 70% agricultural and forested habitat, respectively. Of her 2296 GPS locations, approximately 35% of them were in agricultural fields.

Although transients displayed similar attraction to habitat types as residents, residents occupied ideal habitats and most likely push transients into marginal habitats. Resource-selection models were useful in teasing out this effect and demonstrated where patterns of habitat use diverged from those of residents. Models of 2^{nd}-order selection indicated that coastal bottomland forest, roads, and edges were more important to transients than residents. Transients were typically pushed into forested areas and frequent use of roads and edges was likely to reduce the energetic costs of nomadic movements in these highly structured habitats. Conversely, models of 3^{rd}-order selection indicated 2 temporal changes in habitat use by residents that are related to foraging and security. First, they avoided roads during diurnal hours despite relying on them during nocturnal hours when they were foraging and defending their home ranges. This behavior is likely a way to avoid contact with humans, which will occur more during diurnal hours. Second, residents avoided coastal bottomland forest during the growing season and increased use of them during the harvest season, specifically during diurnal hours. Residents ceased use of coastal bottomland forests during nocturnal hours and the diurnal use by residents suggests coastal bottomland forests were used for security. Transient use of roads during nocturnal hours is likely for similar reasons as residents. Nevertheless, their habitat use patterns deviated significantly from residents during the harvest season. Agricultural fields had little influence on transient habitat use and transients avoided forested areas while depending more on roads and edge habitats for foraging and security. Most agricultural fields are barren after harvest and likely provide little foraging or security benefit to transients. Avoidance of forest habitats by transients during the harvest season is likely a result of increased use of these habitats by residents. In other words, shifts in the use of habitats by residents as a result of landscape-wide agricultural activities created significant shifts in habitat use by transients.

Coyote populations appear adept at exploiting human modified landscapes, specifically road networks, because linear features facilitate travel while providing foraging opportunities. Although transients were documented using coastal bottomland forests, we suspect those locations were more associated with the road network than the actual forested habitat (Figure 7). Roads may provide benefits to coyotes through efficient movements that improve foraging and territorial defense (i.e., scent marking) and may allow resident coyotes to detect human presence and assess predictable patterns of human activities to increase security. While facilitating transient movements on the landscape, roads may also guide coyotes into suitable habitats modified by humans such as agricultural fields. Interestingly, road networks through unsuitable forest habitat may decrease intraspecific strife by reducing or masking transient movements through territories of residents.

Coyotes colonized eastern North America in several waves occurring at different periods of the 20th century (Nowak 2002; Bozarth et al. 2011). Although it is well documented that coyotes began colonizing Arkansas, Louisiana, Mississippi, and Alabama during the mid-20th century after the extirpation of red wolves (McCarley 1962; Nowak 2002), there has been no parsimonious explanation of how coyotes have colonized the remainder of the Southeast. Large-scaled construction of the Interstate Highway system facilitated significant changes to the physical landscape of the United States during the 1960s, 1970s, and 1980s as a result of the Federal Highway Act of 1956 (Lewis 2013). Additionally, the Watershed Protection and Flood Prevention Act of 1954 encouraged land drainage and wetland destruction that resulted in significant loss of bottomland forests in the Southeast (Harris and Gosselink 1990, Dahl and Allord 1996). Several studies, including this one, have found eastern forests to be relatively poor habitat for coyotes (Tremblay et al. 1998; Crête et al. 2001; Richer et al. 2002) and that coyotes are capable of exploiting human altered landscapes and road networks (Tigas et al. 2002; Way 2009; Gehrt et al. 2011; Hinton et al. 2012). Therefore, we propose that, in concomitant with the extirpation of red wolves, large-scale changes to the landscape through development of extensive

road networks, agriculture, and residential areas during the 1960s-1980s allowed for the eventual colonization of the Southeast by coyotes by the turn of the 21st century.

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Table 5.1. Mean body weight, age, and space use of resident and transient coyotes in northeastern North Carolina during 2009-2011.

Coyote Status	Mean Weight (kg)	Mean Age (yr)	Size of Area Used (km²)					
			Growing		Harvest		Composite	
			95%	50%	95%	50%	95%	50%
Resident	14.7 ± 0.4	2.7 ± 0.2	24.1 ± 2.3	4.0 ± 0.5	25.0 ± 2.8	4.0 ± 0.4	27.2 ± 2.0	4.2 ± 0.4
Transient	12.3 ± 0.7	1.6 ± 0.5	212.5 ± 58.0	11.6 ± 4.1	296.9 ± 55.0	21.7 ± 3.9	307.9 ± 44.9	20.6 ± 3.2

Table 5.2. Statistics of the best models selected from the generalized linear model (GLM) analysis for 2nd-order and 3rd-order resource selection of resident coyotes in northeastern North Carolina during 2009-2011.

Season	Order	Model	*k*	AIC_c	w_i	CV[7]
All	2nd	Ag[1], CPB[2], Pine[3], Road[4], PR[5]	6	105853.45	0.62	79.9
Growing (Day)	3rd	Ag, Pine, Road, ED[6], PR	6	31488.75	0.31	77.5
Growing (Night)	3rd	Ag, CPB, Pine, Road	5	25619.80	0.44	78.1
Harvest (Day)	3rd	Global	7	17983.49	0.61	77.4
Harvest (Night)	3rd	Global	7	21470.41	0.75	79.2

[1]Agricultural fields
[2]Coastal bottomland forests
[3]Pine forests
[4]Roads
[5]Patch richness
[6]Edge density
[7]Estimated accuracy of 10-fold cross-validation

Table 5.3. Statistics of the best models selected from the generalized linear model (GLM) analysis for 2nd-order and 3rd-order resource selection of transient coyotes in northeastern North Carolina during 2009-2011.

Season	Order	Model	*k*	AIC_c	w_i	CV[1]
All	2nd	Global[2]	7	33601.99	0.41	79.9
Growing (Day)	3rd	Ag[3], CPB[4], Pine[5], ED[6], PR[7]	6	10279.93	0.38	76.8
Growing (Night)	3rd	Ag, CPB, Pine, Road, PR	6	8426.62	0.54	77.4
Harvest (Day)	3rd	CPB, Pine, ED, PR	5	6918.13	0.49	77.2
Harvest (Night)	3rd	CPB, Pine, Road, ED, PR	6	9366.49	0.69	78.4

[1]Estimated accuracy of 10-fold cross-validation
[2]Global model
[3]Agricultural fields
[4]Coastal bottomland forests
[5]Pine forests
[6]Edge density
[7]Patch richness

Table 5.4. Effects of model averaged habitat selection parameter estimates for 2nd- and 3rd-order habitat selection for resident and transient coyotes in northeastern North Carolina during 2009-2011.

Model	Season	Photoperiod	Agriculture	Coastal Bottomland Forest	Pine Forest	Road	Edge Density	Patch Richness
2nd Order - Resident	All	All	+++[a]	---[a]	+++	++[b]	0[d]	+++
3rd Order - Resident	Growing	Day	+++	0	+++	---[b]	0	--
3rd Order - Resident	Growing	Night	+++	--	+++	+++	0	0
3rd Order - Resident	Harvest	Day	+++	+++	+++	---	-[c]	--
3rd Order - Resident	Harvest	Night	+++	+[c]	+++	+++	---	+++
2nd Order - Transient	All	All	+++	+	-	+++	+	+++
3rd Order - Transient	Growing	Day	+++	+	+++	0	-	+++
3rd Order - Transient	Growing	Night	+++	++	+++	+++	0	+++
3rd Order - Transient	Harvest	Day	0	---	---	0	++	+++
3rd Order - Transient	Harvest	Night	0	---	---	+++	+++	+++

[a] Significance level 0.0001
[b] Significance level 0.001
[c] Significance level 0.01
[d] Significance level 0.1

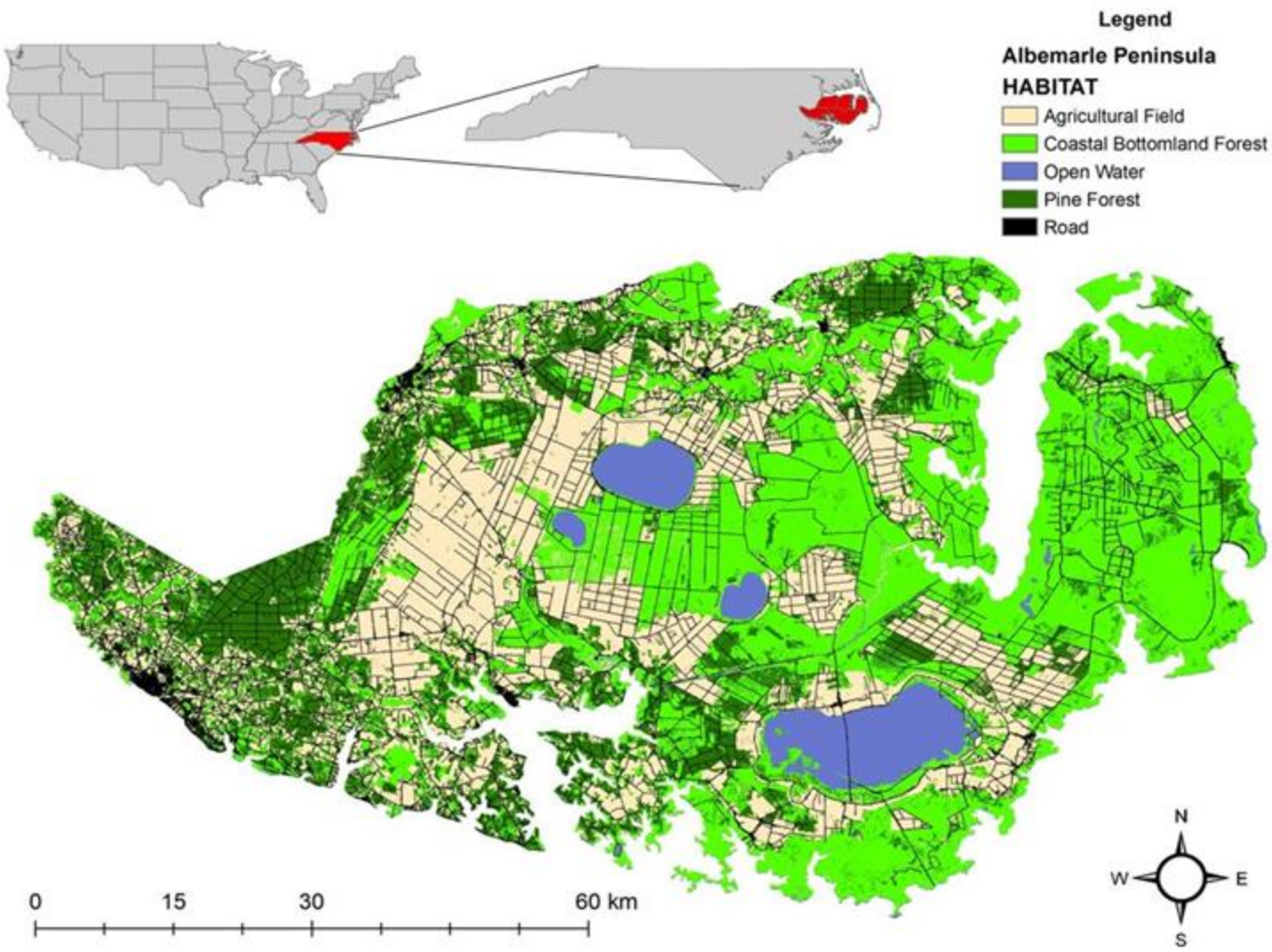


Figure 5.1. Map of the Albemarle Peninsula of northeastern North Carolina with primary habitat types during 2009-2011.

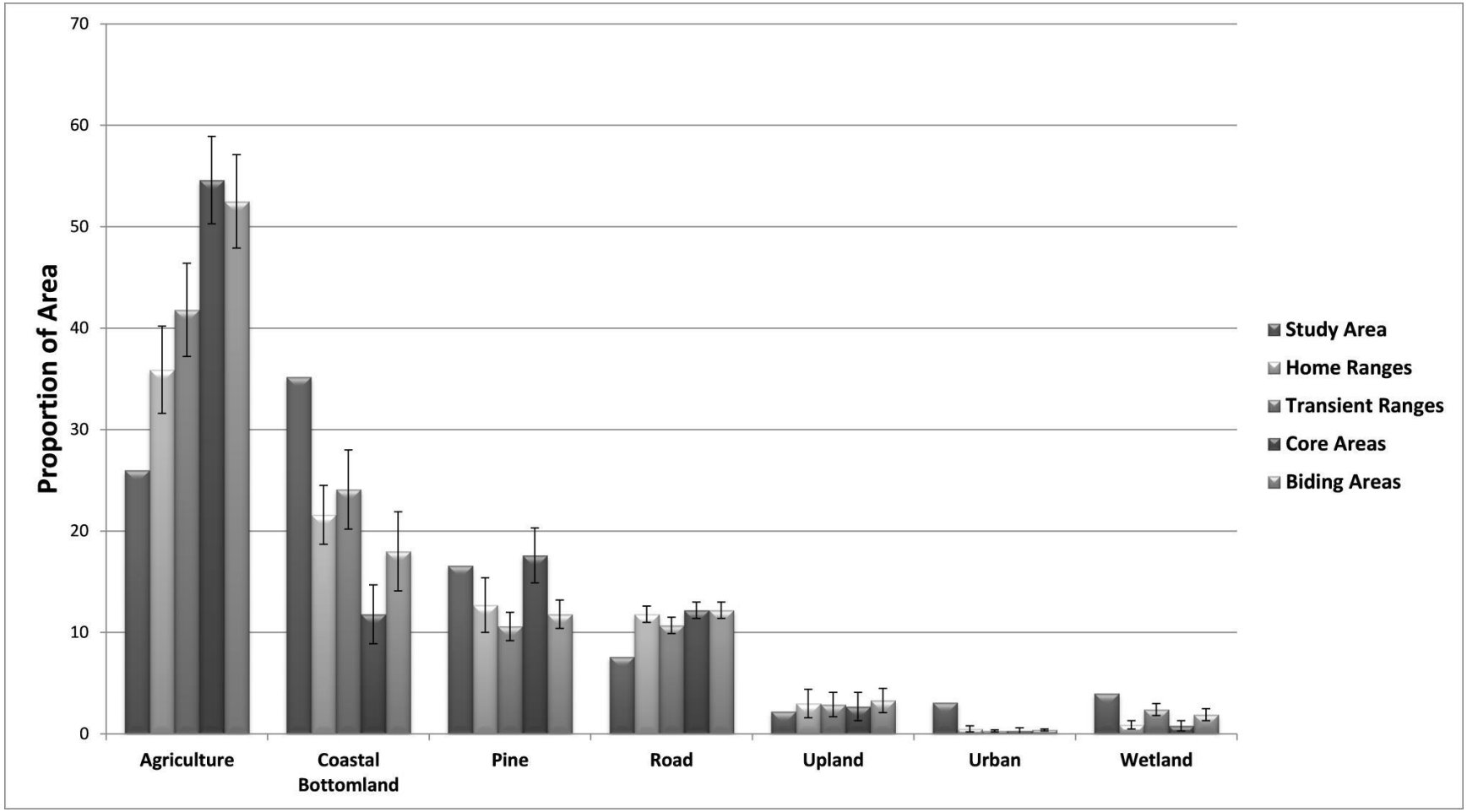


Figure 5.2. Habitat availability and habitat proportions of space used by resident and transient coyotes in northeastern North Carolina during 2009-2011.

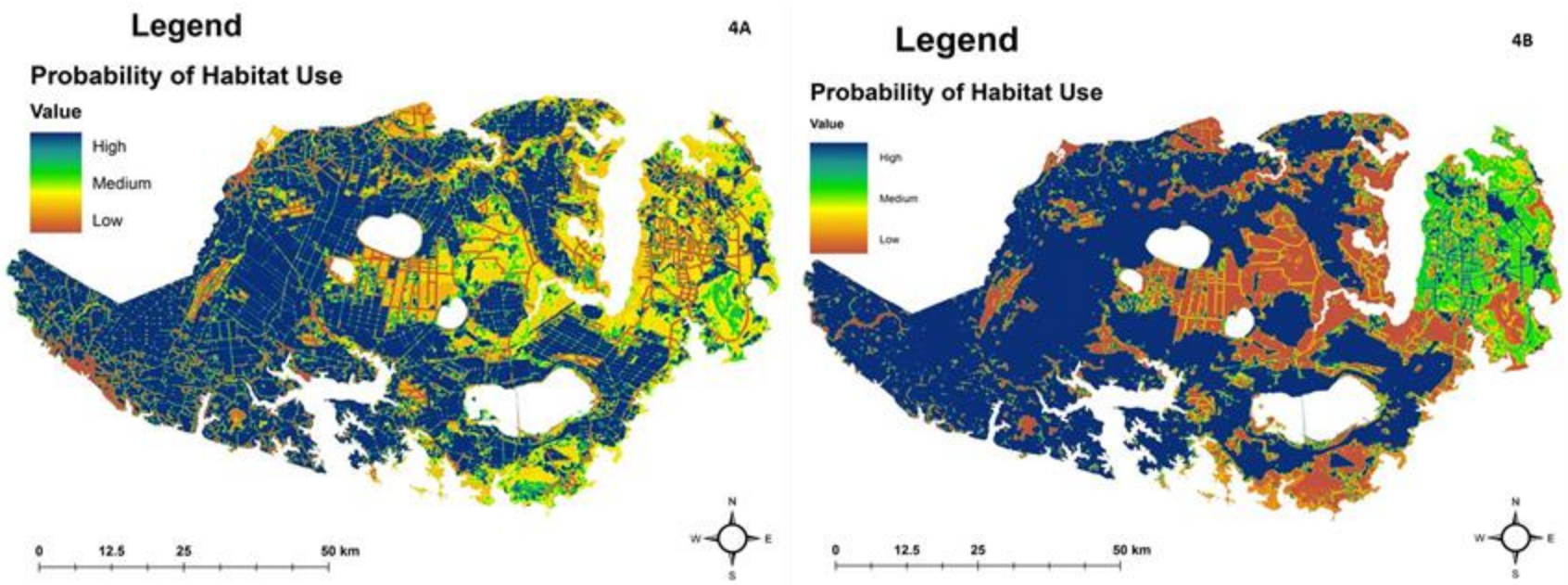


Figure 5.3. Proportional probability of 3rd-order habitat selection by residents during the growing season's diurnal (4A) and nocturnal (4B) hours for coyotes across the Albemarle Peninsula in northeastern North Carolina during 2009-2011.

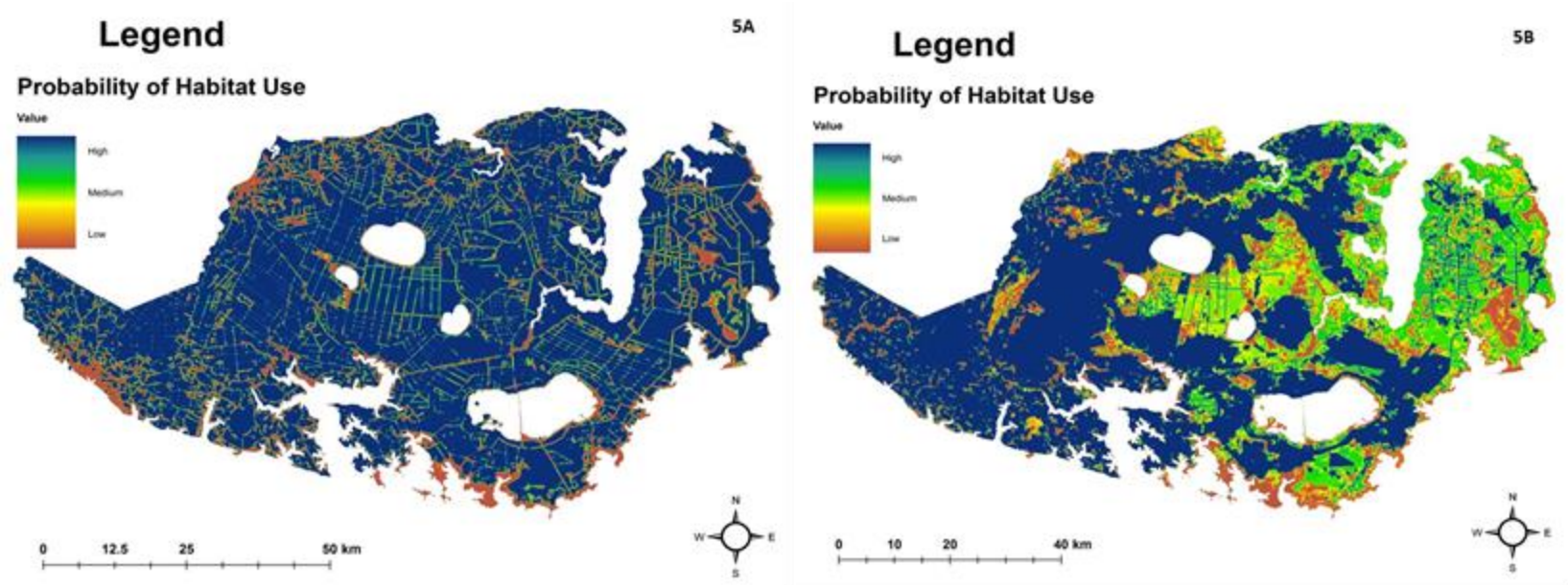


Figure 5.4. Proportional probability of 3rd-order habitat selection by residents during the harvest season's diurnal (5A) and nocturnal (5B) hours for coyotes across the Albemarle Peninsula in northeastern North Carolina during 2009-2011.

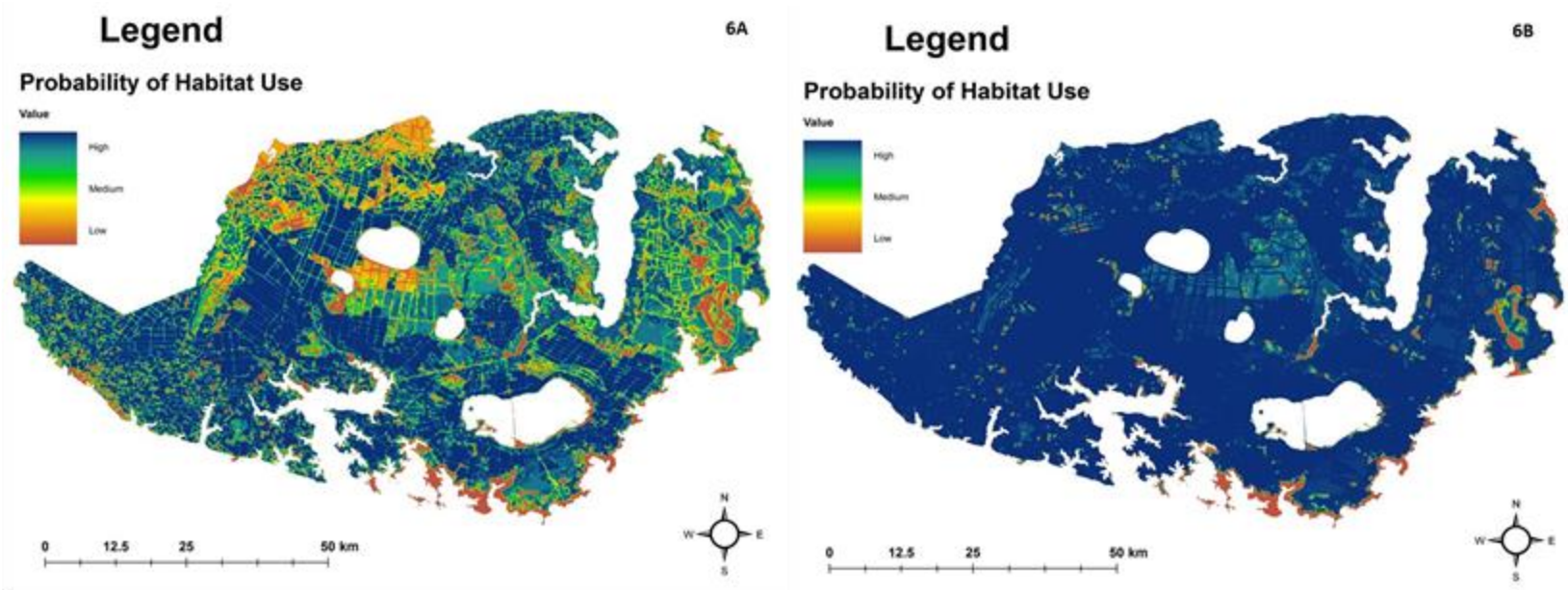


Figure 5.5. Proportional probability of 3rd-order habitat selection by transients during the growing season's diurnal (6A) and nocturnal (6B) hours for coyotes across the Albemarle Peninsula in northeastern North Carolina during 2009-2011.

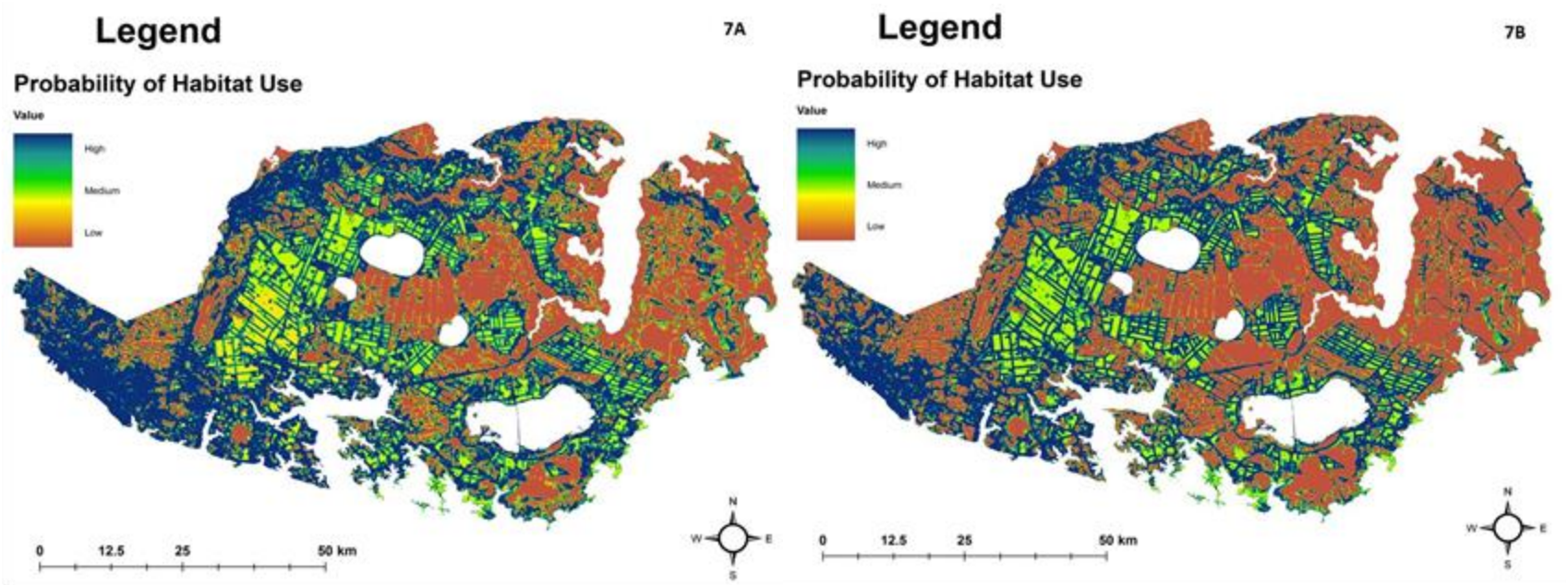


Figure 5.6. Proportional probability of 3rd-order habitat selection by transients during the harvest season's diurnal (7A) and nocturnal (7B) hours for coyotes across the Albemarle Peninsula in northeastern North Carolina during 2009-2011.

CHAPTER 6

SPACE USE AND HABITAT SELECTION BY RED WOLVES

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Abstract

A general lack of knowledge regarding the ecology of our most imperiled carnivores continues to hamper recovery efforts. This is particularly true for red wolves because they were completely extirpated before any ecological profile was developed to assist recovery efforts. Therefore, reintroduction efforts were conducted with little-to-no knowledge of the species ecology. In this study, we radio-collared 34 red wolves in northeastern North Carolina to identify patterns of space use and habitat selection for resident and transient red wolves. Red wolf home range size scales positively with body weight and energetic requirements may influence variation in home range more than vegetation cover. Overall, red wolves prefer open, treeless agricultural fields over the forested habitats in the Recovery Area. Although transients display similar attraction to habitat types as residents do, resource-selection models are useful in defining differences in habitat selection between transients and resident red wolves. Specifically, transients are more likely to use forest cover and rely on road networks for travel. Reduced use of forest habitats and reliance on road networks indicates the importance of open habitats for red wolves. We suggest, prior to European settlement, fire regimes created by Native Americans and natural processes that maintained grasslands and open woodlands may have influenced red wolf abundance and distribution. We also suggest that the use of control burns to create early successional habitats and reduce forest understory may be beneficial to red wolf recovery via creating more suitable habitat.

Introduction

Carnivore reintroductions are extremely difficult and typically result in failure (Reading & Clark 1996; Breitenmoser *et al*. 2001; Gittleman and Gompper 2001). This is because the persistence of large carnivore populations is dependent on specific ecological requirements (i.e., expansive areas, access to large prey, and low mortality rates) that are difficult to achieve. Our general lack of knowledge regarding those requirements hinders conservation strategies because recovery efforts are conducted in the presence of factors responsible for global declines in large

carnivores (Breitenmoser *et al*. 2001; Hayward *et al.* 2007). As a result, recovery of large carnivores remains a primary challenge to conservation biologists because area-size requirements, negative public perception, and government-supported campaigns designed to protect livestock and hunting industries continue to hamper recovery of large carnivores in the United States (Kellert *et al*. 1996; Ripple *et al.* 2014). In particular, the conservation of red wolves (*Canis rufus*) has been exceptionally difficult because of their vulnerability to extinction via human-caused mortality and hybridization with coyotes (*Canis latrans*; Hinton *et al*.2013).

Indigenous to the United States, red wolves were completely extirpated from their historic range by 1980 and later reintroduced into northeastern North Carolina in 1987 (USFWS 1989). Although the North Carolina reintroduction has been successful, a lesser well known reintroduction attempt from 1991 until 1998 in Great Smoky Mountains National Park failed because red wolves were unable to maintain territories within park boundaries and the population suffered from low pup survivorship (Henry 1998). Similarly, red wolves in northeastern North Carolina preferred agricultural habitats of private lands over forested habitats provided by federal lands. To address this constraint, the Red Wolf Recovery Program (Recovery Program) developed management strategies to include private lands and non-federal stakeholders that allows for the expansion and management of the red wolf population on private, non-federal lands (Rabon *et al*. 2013). As a result, red wolves persist in an agricultural-bottomland forest landscape that is a mosaic of private and public lands. Recovery Program biologists are therefore faced with potential issues of predicting how the red wolf population will organize itself on the landscape as it increases, anticipate logistic and social constraints (i.e., conflicts with landowners and hunters), and understanding red wolf-coyote interactions. Therefore, studying the size and placement of red wolf home-ranges on the landscape will not only allow us to describe red wolf space use and habitat selection, but it will also allow us to identify landscape characteristics that are favorable to red wolf recovery. Additionally, space use patterns can provide information regarding where red wolves forage, disperse, and interact with coyotes.

Initial research conducted on remnant red wolf populations failed to develop an ecological profile of the species because biologists were constrained by the necessity to locate small pockets of declining populations, develop techniques to distinguish red wolves from coyotes and red wolf/coyote hybrids, and to establish a captive breeding program (McCarely 1962; Shaw 1975; Carley 2000). Although the Recovery Program has monitored and maintained a wild population in northeastern North Carolina for over 2 decades, a general lack of ecological knowledge still hinders developing practical approaches to address issues of hybridization, inbreeding, and stunted demographic trends (Hinton *et al*. 2013). Understanding patterns of red wolf space use and habitat selection is a first step towards identifying key processes responsible for red wolf persistence. Previous studies of red wolf space use and habitat selection reported home ranges that varied between 10-150 km^2 (Phillips *et al*. 2003; Chadwick *et al*. 2010) with strong preferences for agricultural habitats (Chadwick *et al.* 2010; Hinton & Chamberlain 2010; Dellinger e*t al*. 2013); however, these studies lacked testable hypotheses to explain variation observed in red wolf spatial ecology. For instance, home-range size is widely measured to study the relationship between the distribution of animals and their ecological resources and consistent statistical patterns observed in home-range sizes of carnivores are largely influenced by body size (Harestad &Bunnell 1979; Gompper & Gittleman 1991). As a large carnivore (> 20 kg), body size is a critical factor influencing red wolf prey selection (Chapter 3) and it is likely to influence spacing patterns observed in red wolves. Furthermore, *Canis* species are known to rely on open habitats and linear corridors because their locomotor habits are favored in these habitats (Van Valkenburgh 1985; Andersson 2004; McKenzie *et al*. 2012). Aligning empirical data of space use within a larger theoretical framework is essential for identifying key traits and ecological requirements of red wolves that will assist in developing conservation strategies to overcome challenges to recovery efforts.

We monitored resident and transient red wolves fitted with global positioning system (GPS) radio-collars to assess red wolf spatial ecology in northeastern North Carolina. Here we

assess the ways in which red wolves interact and use several primary habitats. We also assess if body weight influences variation observed in red wolf home ranges. Although transient individuals are known to exist in gray wolf (*Canis lupus*) and coyote populations (Thurber & Peterson 1993; Berger & Gese 2007), their general relevance to *Canis* ecology are rarely understood and have never been investigated in red wolves. Transients are nomadic individuals that have not established residency and show little-to-no fidelity for one area (Berger & Gese 2007; Hinton *et al*. 2012). We examined space use and habitat selection patterns of transients and compared them to residents. Using our analyses, we extrapolate reasons for the red wolf's decline after European colonization of North America and offer suggestions for improving red wolf recovery.

Study Area

Our study was conducted on the Albemarle Peninsula in the northeastern region of North Carolina (Figure 1). The study area was approximately 6000 km^2 of federal, state, and private lands and is hereafter referred to as The Red Wolf Recovery Area (Recovery Area). The Recovery Area was comprised of a row-crop agricultural-bottomland matrix in which agricultural crops (i.e., corn, cotton, soybean, and winter wheat) made up approximately 30% of the vegetative cover (Figure 1). Managed pine (*Pinus* spp) comprised approximately 15% of the land cover. Other prominent land cover types were coastal bottomland forests and pocosin (35%), herbaceous wetlands and saltwater marshes (5%), open water (5%), and other minor land cover types (10%). Changes in elevation were minor (0-50m) and the climate was typical of the mid-Atlantic: 4 full seasons, nearly equal in length, with annual precipitation averaging between 122-132 cm. Summer climate was typically hot and humid with temperatures ranging from 27°C to over 38°C and winters were relatively cool with temperatures ranging between -4°C to 7°C.

Methods

We captured red wolves using padded foot-hold traps (Victor no.3 Softcatch, Lititz, Pennsylvania, USA) from October through May during 2007-2011. Red wolves were sexed,

measured, and weighed. Ages and genetic confirmation of captured red wolves were known if individuals were carrying a subcutaneous passive integrated transponder (PIT) tags inserted into pups during annual surveys of suspected red wolf dens (Beck *et al*. 2009; Rabon *et al.* 2013). Individuals without PIT tags were aged by tooth wear (Gier 1968) and a blood sample was taken.

We categorized wolves > 2 years old as adults, < 2 but > 1 year old as juveniles, and < 1 year old as pups. Prior to release at the original capture sites, we fitted red wolves with a mortality-sensitive GPS radio-collars (Lotek 4400S, Newmarket, Ontario, Canada) scheduled to record a location every 5 hours on a scheduled to rotate around the 24-hour clock throughout the year. Animal handling methods were approved by the Louisiana State University Agricultural Center Institutional Animal Care and Use Committee (Protocol Number AE2009-19).

To examine the anthropogenic effects of agriculture on the landscape, we divided year into 2 6-month seasons based on agricultural activity: planting/growing (1 March – 31 August) and harvest/fallow (1 September – 28 February). Locations were further separated into diurnal and nocturnal categories based on monthly photoperiods. We estimated space use of resident and transient red wolves by fitting dynamic Brownian bridge movement models (dBBMMs) to the time-specific location data to estimate the probability of use along the full movement track of each red wolf (Kranstauber & Smolla 2013) using the R package moveud (Collier 2013) in the R statistical environment (R Core Team 2013). We chose window sizes based on the temporal resolution of each track and our *a priori* assumptions of the time scale of major behavioral shifts (Byrne *et al*. 2014). For residents, 95% and 50% contour intervals were considered home ranges and core areas, respectively. For transients, 95% and 50% contour intervals were considered transient range and biding areas (Hinton *et al*. 2012), respectively. We used *t*-tests to examine changes in home range and space use sizes between seasons.

Predominant habitat types were estimated from a digitalized landscape map of vegetative communities developed by the North Carolina Gap Analysis Project (McKerrow *et al*. 2006). We collapsed the vegetative communities estimated by McKerrow *et al*. (2006) into 7 general habitat

types with 30m resolution. For the habitat selection analysis, we divided the landscape into agriculture, coastal bottomland forest, pine forest, open water, upland forest, urban, and wetland. Because roads may serve as corridors for red wolf movements (Dellinger *et al*. 2013), we included road as the 8th habitat type by superimposing a linear feature layer with a 30m buffer around roads onto the final habitat raster map with 30m resolution.

We used analysis of variances (ANOVAs) and *t*-tests to determine if the percentage of habitat composition of home ranges and transient ranges differed between each other and between seasons. We also developed generalized linear models (GLMs) to examine the effects of body weight and age, pack size, white-tailed deer abundance, and habitat composition on red wolf home-range size. We used county-level harvest data collected by the North Carolina Wildlife Resources Commission as measures of deer abundance in the study area. Although harvest reports do not reflect true white-tailed deer densities, hunter harvest/km^2 do provide a benchmark by which to judge the effect of white-tailed deer abundance on red wolf home-range size. Habitat composition of home ranges was calculated as the percentages of the 8 habitat types. We assessed models using a stepwise procedure by calculating Akaike's information criterion for small sample sizes (AIC_c) for each model to select which variables best explained home-range size.

We compared habitat selection of red wolves at 2 scales: population (2nd-order) and individual (3rd-order). Habitats were converted into continuous variables by quantifying percent of habitat cover for each 30m cell using a moving window with a 150m radius in FRAGSTATS (McGarigal *et al*. 2012). We also quantified edge density and patch richness across the study area because we suspected red wolves of foraging along edges. Information from raster maps were extracted to red wolf locations and home ranges using ArcGIS 10.1 (Environmental Systems Research Institute Inc., Redlands, California). We used resource-selection functions (RSFs) to examine the effect of habitat type on where red wolves established home ranges on the landscape (2nd-order selection of resources; Johnson 1980) and examine the effect of habitat type on how they use their home ranges (3rd-order selection of resources; Johnson 1980) following Manly *et*

al. (2002). We assumed seasonal and photoperiod variation in habitat use by residents and transients and, therefore, developed RSFs for residents and transients by season and photoperiod for 3rd-order selection. We used a binomial approach to estimate resource-selection functions by comparing characteristics of known (used) locations to random (available) locations (Manly *et al*. 2002). We used logistic regression and AIC_c to form RSFs that identified habitats important to individual red wolves and evaluated the relative importance of coefficients associated with the habitat types by examining Akaike weights (w_i) after adding each of these covariates to a core model set (e.g., higher w_i and lower AIC_c suggested model improvement; Burnham and Anderson 2002). We also evaluated the predictive performances of the most parsimonious core models using the *k*-fold cross validation method (Boyce et al. 2002; Johnson et al. 2006). The cross-validation method performs *k* iterations of training and validation in which a different fold of the data is held out for validation while remaining $k - 1$ folds are used for learning. For cross-validation, we used 10 folds ($k = 10$) to estimate performance of RSF models.

Results

During 2007-2011, we monitored 34 red wolves fitted with GPS radio-collars. Of those red wolves, 30 (88%) were residents and 11 (32%) were transients with 7 (63%) of the residents being transients prior to establishing home ranges. Mean weight and age of red wolves monitored were 27.1 kg ± 0.4 and 3.1 yrs ± 0.2, respectively, in which weights and age of residents did not differ from transients (Table 1; $t_{43} \leq 1.41$, $P \geq 0.017$). Home ranges and core areas of residents did not differ between seasons (Table 1; $t_{65} \leq 0.46$, $P \geq 0.657$) and home ranges ranged from 25.4 km² to 183.0 km². We also detected no seasonal difference of transient ranges and biding areas (Table 1; $t_{12} \leq 0.16$, $P \geq 0.878$) and transient areas ranged from 125.1 km² to 709.9 km². Home-range size scaled positively with body weight (Figure 2; $r^2=0.37$, $P = 0.002$), occurred in the top 5 models (Table 2), and best explained the variation observed in red wolf home-range size.

Home ranges and core areas were comprised mostly of agricultural fields, coastal bottomland and pine forest, and roads (Figure 3; $F_{6, 231} = 111.98$, $P < 0.001$). Pine and upland

forest, urban, and road composition of home ranges and core areas did not differ ($t_{66} \leq 1.78$, $P \geq 0.084$) but home ranges typically consisted of more coastal bottomland forest and wetland habitat and less agricultural habitat than did core areas ($t_{66} \geq 2.31$, $P \leq 0.024$). Similarly, transient ranges and biding areas comprised mostly of agricultural fields, coastal bottomland and pine forests, and roads (Figure 3; $F_{6, 70} = 25.15$, $P < 0.001$). With the exception of roads ($t_{22} \leq 3.29$, $P = 0.004$), we found no differences in habitat composition between transient ranges and biding areas ($t_{22} \leq 1.40$, $P \geq 0.176$). Home ranges consisted of more roads and less wetland habitat than transient ranges ($t_{43} \geq 2.11$, $P \leq 0.043$), whereas all other habitat types were similar ($t_{43} \leq 1.64$, $P \geq 0.109$). Core areas consisted of more agricultural habitat and less coastal bottomland forest and wetland habitats than biding areas ($t_{43} \geq 2.04$, $P \leq 0.047$), whereas all other habitat types were similar ($t_{43} \leq 0.55$, $P \geq 0.586$). We detected no seasonal differences between habitat types within home ranges ($t_{65} \leq 1.21$, $P \geq 0.230$). Core areas consisted of more agricultural habitat and less coastal bottomland forest and wetland habitat during the growing season ($t_{65} \geq 2.21$, $P \leq 0.031$), whereas all other habitat types did not differ between seasons ($t_{65} \leq 1.17$, $P \geq 0.268$). We detected no seasonal differences between habitat types within transient ranges and biding areas ($t_{12} \leq 1.39$, $P \geq 0.188$).

We excluded wetland, upland forest, and urban habitats from our models because their occurrence in home ranges and transient ranges was little. Therefore, we only included edge density, agriculture, pine forest, coastal bottomland forest, and road habitats in our model. All 5 covariates were retained in the top-ranked model for 2nd-order selection by residents (Table 3), whereas only 1 covariate (edge density) was not retained for transients (Table 4). Agriculture and pine forest habitats were retained in all top-ranked models for 3rd-order selection by residents (Table 3). Residents appeared to favor agricultural fields and pine forests during all seasons and photoperiods (Figures 4 & 5; Table 5). Agriculture and road habitats were retained in all top-ranked models for 3rd-order selection by transients (Table 4). Coastal bottomland and pine forests

were used by transients more during the harvest season than growing season, whereas agriculture and road habitats were preferred during both seasons and photoperiods (Figures 6 & 7; Table 5).

Discussion

In general, measurements of home ranges have proven useful in understanding spacing patterns of carnivore populations and comparative studies have demonstrated that carnivore home-range size scales positively with body size (Gittleman and Harvey 1982; Gompper and Gittleman 1991). Given the red wolf's intermediate body size between gray wolves and coyotes, it's not surprising that our mean home-range sizes fall between those estimated for gray wolves (see Table 6.3 in Fuller *et al*. 2003) and coyotes (see Table 22.4 in Bekoff & Gese 2003) in North America. Our findings appear similar to those observed in comparative studies of home ranges, and suggest that body weight is a primary driver of red wolf space use with larger individuals generally maintaining larger home ranges than smaller individuals. Results of our simple model, using red wolf body weight, pack size, white-tailed deer density, and % agricultural cover , indicated that body weight alone best explained variation in home-range size. This is not surprising because we should expect the energetic requirements of red wolves and the distribution of their food resources to influence the size of home ranges. Although deviations from the regression slope can be attributed to differences in diet, we found no effect of white-tailed deer density on red wolf home-range size. We suspect that our density estimate was too crude and, because white-tailed deer only comprise approximately 40-50% of red wolf diet (Dellinger *et al*. 2011; McVey *et al*. 2012; Chapter 4), a measurement of overall prey productivity might better serve as a variable for prey.

Home-range sizes of red wolves did not vary between seasons despite the loss of agricultural cover resulting from crop harvest during the fall. The size and placement red wolf home-ranges are likely driven by energetic demands and home ranges are large enough to handle seasonal changes in food resources. Although most red wolf home-ranges (50%) fell within the 45-80 km^2 range, 25% of the red wolves maintained home ranges > 85 km^2 and < 185 km^2. Long-

term maintenance of home ranges requires red wolves to defend a finite area and consume resources at a rate low enough to allow prey populations to persist. Therefore, we suggest that 175 km^2 may be an upper limit in which red wolves can efficiently maintain and defend a home range due to body size constraints.

The general compositional pattern in red wolf home ranges were high percentages of agricultural fields in the interior (i.e., core areas) with forest edges increasing in the outer areas. Red wolf home ranges typically had more coastal bottomland forest habitat than pine forest, but this was a result of most pine plantations residing in the western portion of the Recovery Area where red wolf packs are the fewest. Similar to behaviors observed by coyotes in the Recovery Area (Chapter 5), red wolves typically loafed in forest habitats within 50-300m of edges adjacent to agricultural fields during the harvest season. As crop cover reaches heights of approximately 0.5 meters during the growing season, red wolves abandon early successional and forest habitats to loaf under crop cover. Red wolf packs typically abandon their dens and day beds in early successional and forested habitats 4-6 weeks after whelping pups to center their activities, including pup rearing, in corn fields (Hinton & Chamberlain 2010).

Transient individuals lack mates because of their nomadic behaviors and do not contribute reproductively to the population. Despite this, transiency may be an important life history trait for red wolves because they facilitate metapopulation dynamics (Hanski 1998), replace residents upon death, and may allow populations to reconstruct themselves after suffering drastic mortality event. Transient red wolves displayed localized movements similar to those observed by coyotes in northeastern North Carolina (Hinton et al. 2012). These movements were analogous to home ranges and we referred to them as biding areas (Hinton et al. 2012). Seven of the 11 (63%) transients established residency near their biding areas. We suggest this behavior allows red wolves to assess resource availability and become familiar with areas before establishing residency.

Overall, red wolves prefer the open, treeless agricultural fields over the forested habitats in the Recovery Area. For instance, 52% of approximately 55,000 GPS locations recorded were in agricultural fields, whereas 30% were in forested habitats. Although transients displayed similar attraction to habitat types as residents did, resource-selection models were useful in identifying differences in habitat selection between transients and resident red wolves. Models of 2nd-order selection indicated that agricultural fields, forested habitats, and roads were important to transients and residents; however, transients relied more on roads than did residents. Increased use of roads by transients indicates that they likely travel more and forage less than residents and roads reduce energetic costs of movements. Models of 3rd-order selection indicated that residents and transients had temporal changes in habitat use. During the growing season, residents loafed in agricultural fields near roads during the day but included some moderate use of forested habitats adjacent to roads at night, whereas transients decreased their use of forested habitats at night to increase their use of roads and edges in agricultural fields. During the harvest season, residents used agricultural fields and forested habitats near roads and decreased their use of roads and forested habitats at night to forage in the agricultural fields. Similarly, transients used agricultural fields and forest habitat during the day, but relied mostly on roads and agricultural fields during the night. Despite low use of forested habitats, red wolves do benefit from the surrounding forests because those habitats provide security during the fall and winter when agricultural fields are barren after harvest. Similar to coyotes, red wolves take advantage of road networks and other linear features to reduce costs associated with travel and increase foraging opportunities. In fact, red wolf use of forested habitats is mostly associated with the use of roads (Dellinger *et al*. 2013).

The red wolf's low-to-moderate use of forested habitats and preference for agricultural fields indicates that red wolves most likely occupied grassland and early successional habitats preying mostly on white-tailed deer and rabbits (*Sylvilagus* spp.) prior to European settlement. Forested habitats may have offered marginal habitat that was used by dispersing and transient individuals to maintain metapopulation dynamics. Prior to European settlement, fire was

widespread and frequent throughout the eastern United States in which Native Americans used fire for forest clearance and maintenance to promote growth of hard mast trees and browse for game species (Delcourt & Delcourt 2004; Nowacki & Abrams 2008). Red wolves likely exploited the mosaic of grasslands, savannas, and open woodlands maintained by natural and Native American fire-regimes. As Europeans colonized the eastern United States, Native American populations were greatly reduced and land-use practices shifted to an agricultural-grazing system. This system created significant shifts in vegetation composition and structure from grasslands, savannas, and open woodlands to closed-canopy forests with dense understories (Nowacki & Abrams 2008) that would have disrupted red wolf metapopulaton dynamics by impeding movements and creating isolated pockets of red wolf populations. Therefore, we suggest that red wolf populations first became isolated through the conversion of open habitats to closed-canopy forests. The extirpation of white-tailed deer likely lowered red wolf recruitment while increased conflict with European and American settlers disrupted pack dynamics and increased mortality rates. Together these factors eventually led to the complete extirpation of red wolves by the mid-20th century. As coyotes began colonizing the eastern United States, hybridization became a primary conservation challenge to red wolf recovery (Kelly *et al*. 1999; Hinton *et al*. 2013).

Nowak (2002) noted that the modern red wolf morphology still shows continuity with fossilized remains of small wolves in the eastern United States dating back to the Pleistocene. Therefore, the morphology of modern red wolves may not have been significantly altered from modern hybridization with coyotes. Results of this study indicate that body size is a primary trait influencing red wolf space use and it is likely that modern red wolves maintain a body size adapted to a vastly more open landscape that existed prior to European settlement of North America. Therefore, it is likely that red wolf populations will require extensive areas of open, early successional habitat with high prey productivity to support red wolf packs and facilitate the movement of dispersers and transients. Currently, red wolves use approximately 50-60% of the Recovery Area and current management strategies may need to use controlled burns to create

early successional habitat and reduce forest understory, thereby increasing the amount of suitable forest habitat available to red wolves. Understanding how red wolf populations structure themselves on the landscape is critical for making accurate inferences and promoting processes and conditions that will not only allow for the gradual expansion of red wolf populations, but permit red wolves to gradually adapt to modern landscapes.

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Table 6.1. Mean body weight, age, and space use of resident and transient red wolves in northeastern North Carolina during 2009-2011.

Coyote Status	Mean Weight (kg)	Mean Age (yr)	Size of Area Used (km²)					
			Growing		Harvest		Composite	
			95%	50%	95%	50%	95%	50%
Resident	27.2 ± 0.5	3.0 ± 0.2	73.3 ± 8.5	9.1 ± 1.4	67.8 ± 8.3	9.0 ± 1.6	68.4 ± 7.5	8.7 ± 1.3
Transient	26.8 ± 0.8	3.5 ± 0.4	277.9 ± 80.7	27.3 ± 14.5	260.7 ± 66.1	29.3 ± 8.6	319.2 ± 57.3	32.8 ± 10.8

Table 6.2. Results of the 5 best models for stepwise analysis of factors influencing home range size of red wolves in northeastern North Carolina during 2009-2011.

Model	**k**[a]	**AIC$_c$**[b]	**ΔAIC$_c$**[c]	**w_i**[d]
Weight, pack size	4	253.52	0.00	0.33
Weight	3	253.72	0.20	0.30
Weight, agriculture	4	256.01	2.49	0.09
Weight, deer density	4	256.06	2.54	0.09
Weight, pack size, deer density	5	256.46	2.94	0.08

[a]Model parameters
[b]Akaike's Information Criterion
[c]Difference in AIC
[d]Akaike weight

Table 6.3. Statistics of the best models selected from the generalized linear model (GLM) analysis for 2nd-order and 3rd-order resource selection of resident red wolves in northeastern North Carolina during 2009-2011.

Season	Order	Model	*k*	AIC_c	w_i	CV[1]
All	2nd	Global[2]	6	117708.4	1.00	80.6
Growing (Day)	3rd	Ag[3], Pine[4], Road, Edge[5]	5	41478.78	0.57	78.1
Growing (Night)	3rd	Global	6	26786.21	0.85	77.6
Harvest (Day)	3rd	Global	6	27084.75	0.67	76.7
Harvest (Night)	3rd	Ag, Edge, Pine	4	32234.26	0.34	76.4

[1]Estimated accuracy of 10-fold cross-validation
[2]Global model
[3]Agricultural fields
[4]Pine forests
[5]Edge density

Table 6.4. Statistics of the best models selected from the generalized linear model (GLM) analysis for 2nd-order and 3rd-order resource selection of transient red wolves in northeastern North Carolina during 2009-2011.

Season	Order	Model	*k*	AIC_c	w_i	CV[1]
All	2nd	Ag[2], CPB[3], Pine[4], Roads	5	12948.76	0.59	78.2
Growing (Day)	3rd	Global[5]	6	3759.36	0.75	78.1
Growing (Night)	3rd	Ag, Edge[6], Roads	4	2808.94	0.51	78.5
Harvest (Day)	3rd	Global	6	3300.29	0.66	76.8
Harvest (Night)	3rd	Ag, CPB, Pine, Roads,	6	9366.49	0.57	77.0

[1]Estimated accuracy of 10-fold cross-validation
[2]Agricultural fields
[3]Coastal plains bottomland forests
[4]Pine forests
[5]Global model
[6]Edge density

Table 6.5. Effects of model averaged habitat selection parameter estimates for 2nd- and 3rd-order habitat selection for resident and transient red wolves in northeastern North Carolina during 2009-2011.

Model	Season	Photoperiod	Agriculture	Coastal Bottomland Forest	Pine Forest	Road	Edge Density
2nd Order - Resident	All	All	+++[a]	+++	+++	+++	---[a]
3rd Order - Resident	Growing	Day	+++	0[d]	+++	+++	+++
3rd Order - Resident	Growing	Night	+++	+[c]	+++	+++	--[b]
3rd Order - Resident	Harvest	Day	+++	+++	+++	+++	+
3rd Order - Resident	Harvest	Night	+++	0	+++	0	+
2nd Order - Transient	All	All	+++	+++	+++	+++	0
3rd Order - Transient	Growing	Day	+++	+	++[b]	+++	++
3rd Order - Transient	Growing	Night	+++	0	0	+++	+++
3rd Order - Transient	Harvest	Day	+++	++	++	+++	+
3rd Order - Transient	Harvest	Night	+	++	++	+++	0

[a] Significance level 0.0001
[b] Significance level 0.001
[c] Significance level 0.01
[d] Significance level 0.1

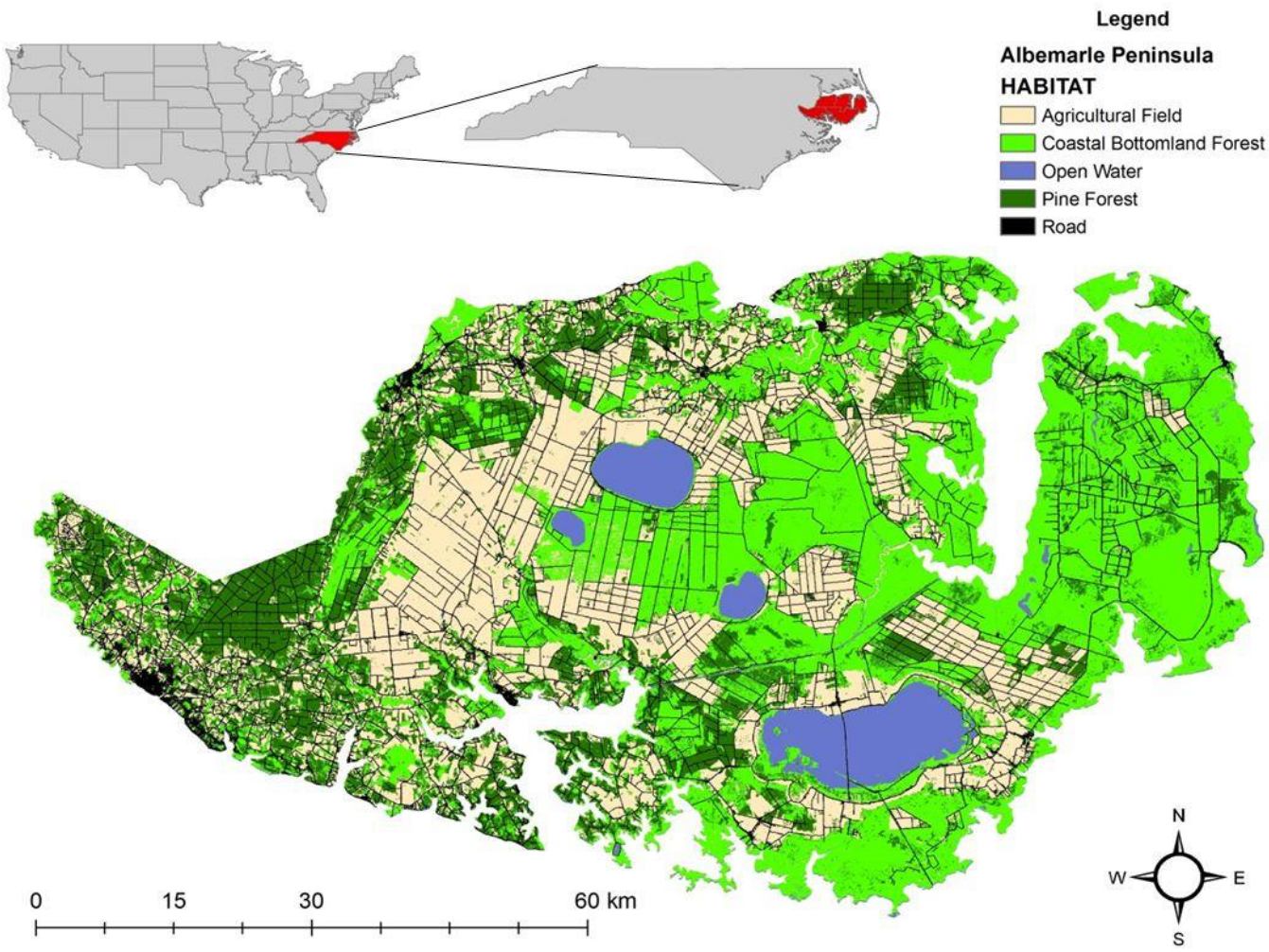


Figure 6.1. Map of the Red Wolf Recovery Area in northeastern North Carolina with primary habitat types during 2009-2011.

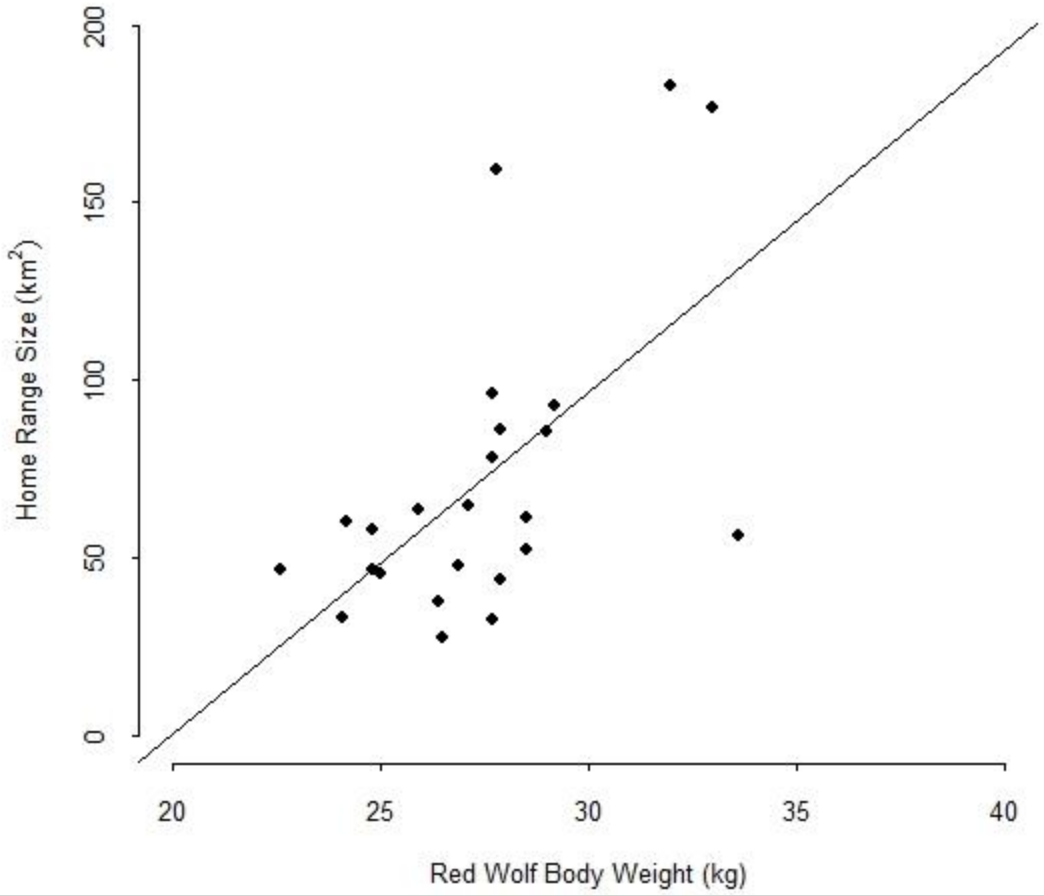


Figure 6.2. Correlation between home range size and body weight of red wolves.

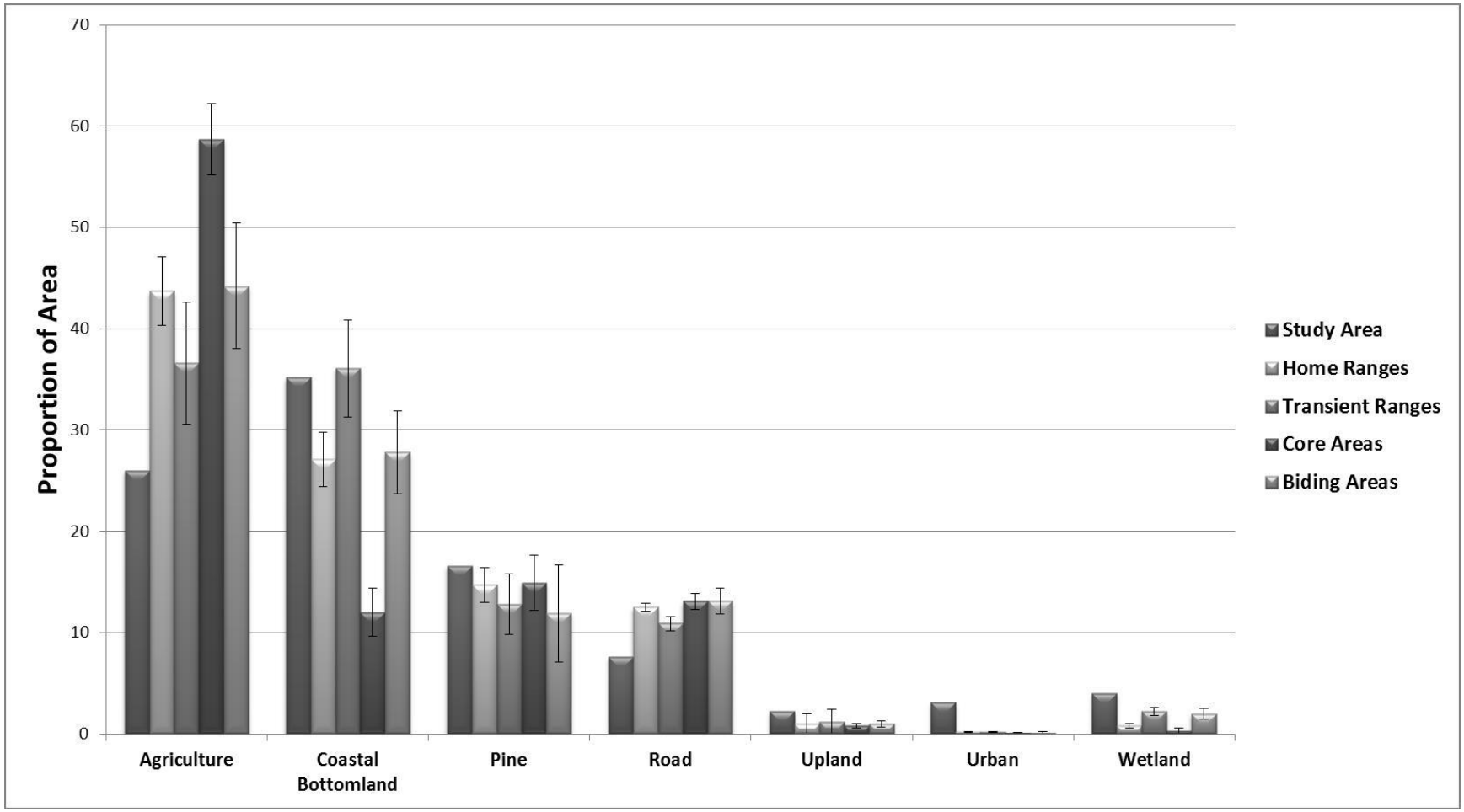


Figure 6.3. Habitat availability and habitat proportions of space used by resident and transient coyotes in northeastern North Carolina during 2009-2011.

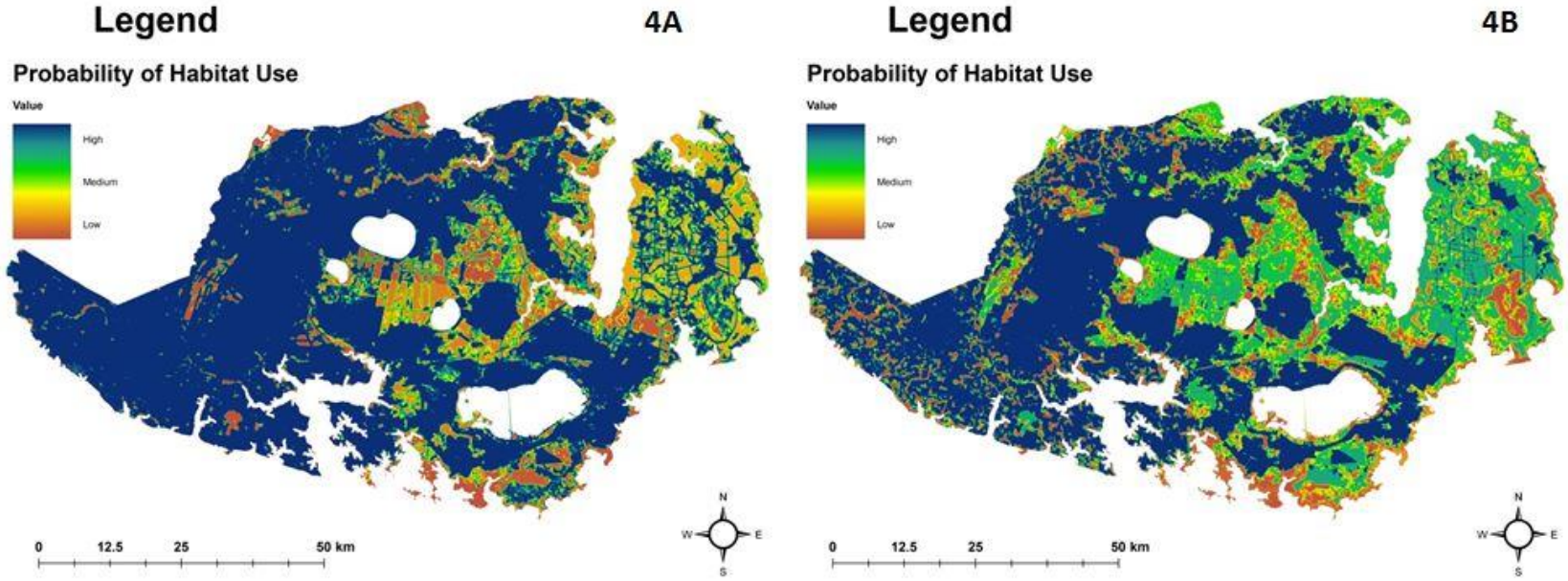


Figure 6.4. Proportional probability of 3rd-order habitat selection by residents during the growing season's diurnal (4A) and nocturnal (4B) hours for red wolves across the Red Wolf Recovery Area in northeastern North Carolina during 2009-2011.

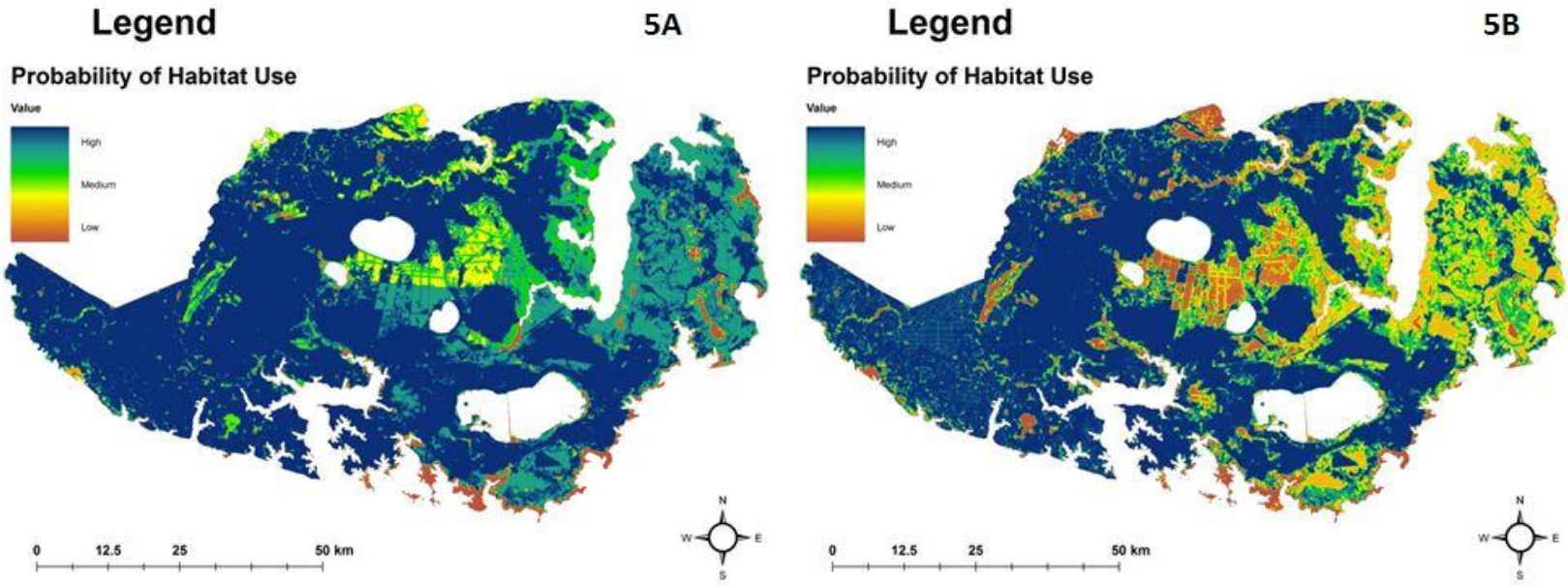


Figure 6.5. Proportional probability of 3rd-order habitat selection by residents during the harvest season's diurnal (5A) and nocturnal (5B) hours for red wolves across the Red Wolf Recovery Area in northeastern North Carolina during 2009-2011.

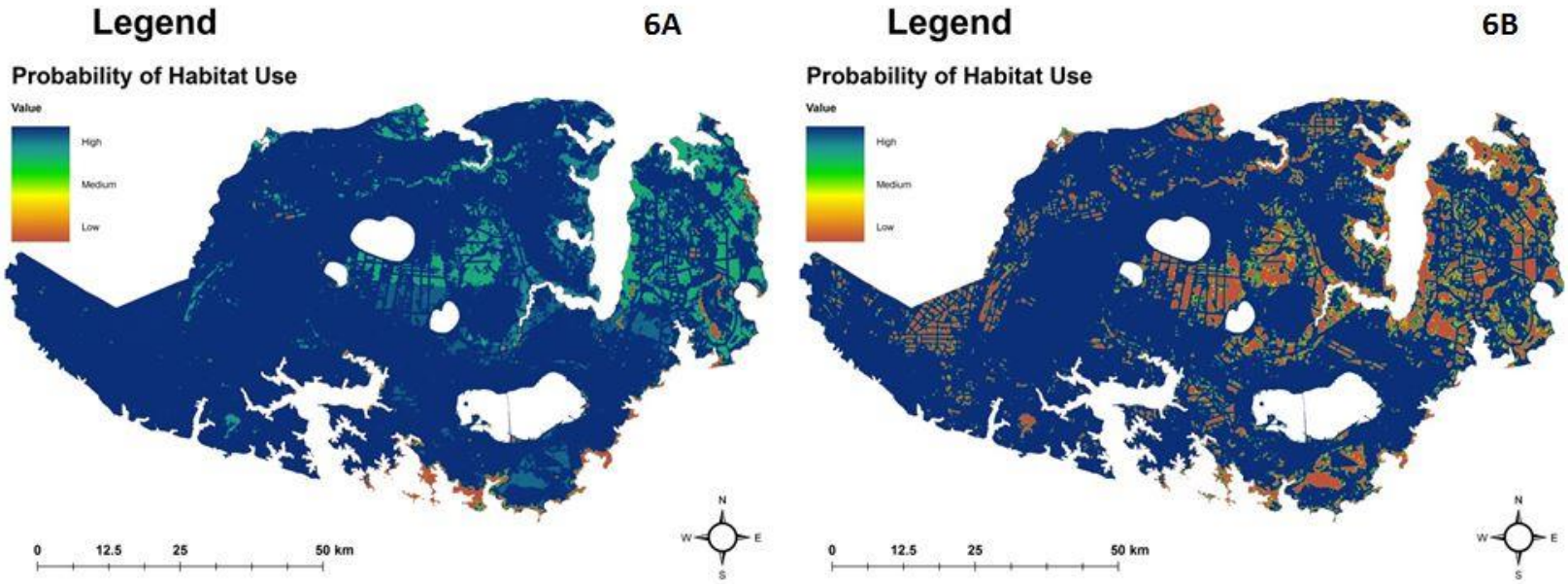


Figure 6.6. Proportional probability of 3rd-order habitat selection by transients during the growing season's diurnal (6A) and nocturnal (6B) hours for red wolves across the Red Wolf Recovery Area in northeastern North Carolina during 2009-2011.

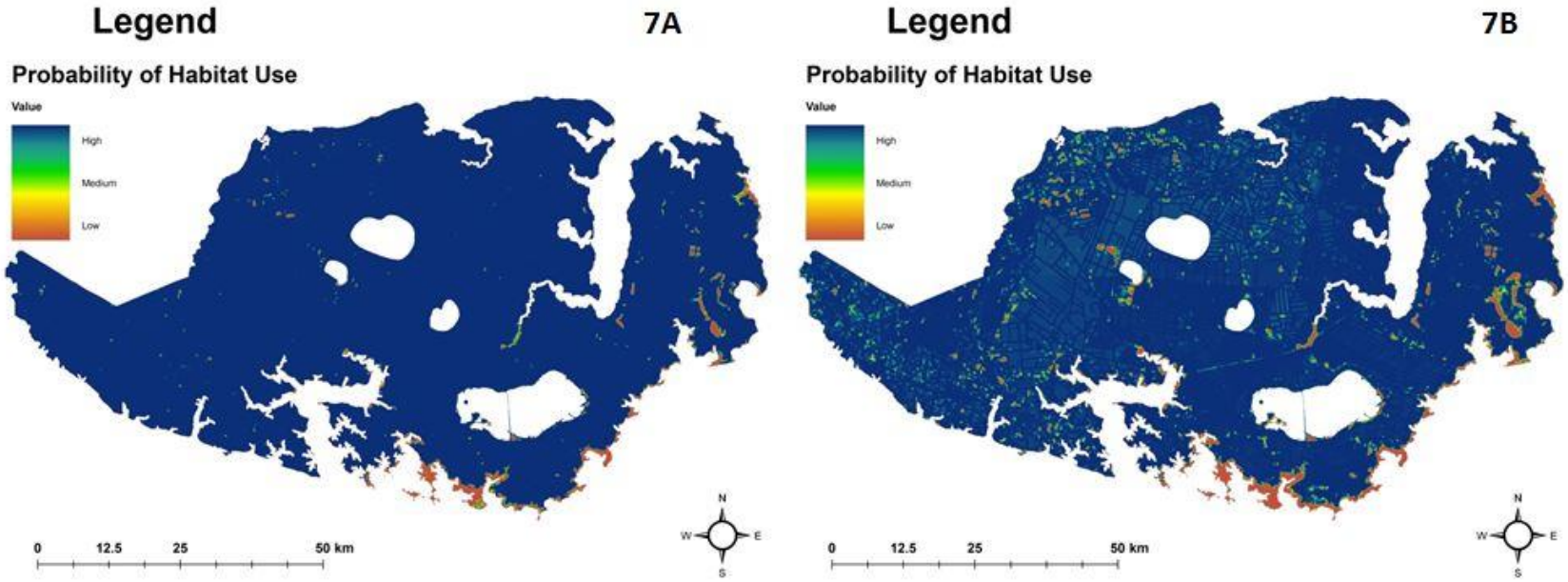


Figure 6.7. Proportional probability of 3rd-order habitat selection by transients during the harvest season's diurnal (7A) and nocturnal (7B) hours for red wolves across the Red Wolf Recovery Area in northeastern North Carolina during 2009-2011.

CHAPTER 7

BODY SIZE AS A REPRODUCTIVE BARRIER IN *CANIS*: A HYPOTHESIS

Hinton, J.W., J.L. Gittleman, and M.J. Chamberlain. 2014. To be submitted to *Science*.

Abstract

Anthropogenic exploitation of natural resources has a ubiquitous presence across the globe, resulting in the elimination of geographic and biological barriers that prevented secondary contact between closely related, allopatric taxa. This is particularly problematic for endangered carnivores because they can be genetically assimilated into the more common sister species' population. Hybridization has become the primary challenge for red wolf recovery and conservation. Red wolves and coyotes exist as a panmictic population in northeastern North Carolina and hybridization occurs when individuals form congeneric breeding pairs. We hypothesize that differences in individual body size between red wolves and coyotes can serve as a reproductive barrier by promoting differential use of space and resources. Our results indicated that home-range size and consumption of white-tailed deer scaled positively with red wolf and coyote body weight. Additionally, red wolves in congeneric breeding pairs were smaller than red wolves in conspecific breeding pairs. Therefore, we suggest that body size differences between red wolves and coyotes serve as a reproductive barrier.

Introduction

Globally, carnivore species have been extirpated from most of their historic ranges and exist as remnant populations as a result of excessive killing and habitat alteration by humans. Although societal beliefs have resulted in profound changes to how carnivores are perceived, successful recovery and conservation of carnivores remains one of the most difficult ecological challenges facing our society today. What makes this challenge so difficult to overcome is that conservation efforts must be carried out in the presence of factors responsible for the global declines of carnivores (Breitenmoser *et al*. 2001; Hayward *et al*. 2007). Furthermore, anthropogenic exploitation of natural resources has a ubiquitous presence across the globe, resulting in the elimination of geographic and biological barriers that prevented secondary contact between closely related, allopatric taxa. This is particularly problematic for endangered carnivores because they can be genetically assimilated into the more common sister species

population. As a result, hybridization has become a primary conservation challenge for some carnivore species.

In particular, wolves have been extirpated from much of their historic ranges in North America by government-supported eradication campaigns to protect livestock and hunting industries. With the passage of the Endangered Species Act of 1973, several reintroductions of gray (*Canis lupus*) and red (*Canis rufus*) wolves occurred in the United States during the late 20th century. During this same time period, coyotes (*Canis latrans*) expanded their range throughout North America and are currently ubiquitous throughout the United States. Although gray wolves are reproductively isolated from coyotes (Pilgrim *et al*. 1998; Wheeldon *et al*. 2010), ongoing hybridization with coyotes has created unique conservation challenges for eastern wolves (*Canis lycaon*) in eastern Canada and red wolves in the southeastern United States (Chambers et al. 2012; Rutledge et al. 2012; Hinton et al. 2013). Despite suggestions for a more holistic approach to examining *Canis* evolution by using ecology, natural history, and the fossil record in concomitant with genetic analyses (Rutledge *et al*. 2012), research has focused *Canis* taxonomy with little effort to identify traits responsible for reproductive isolation among *Canis* species. Even in the presence of modern hybridization with coyotes by eastern and red wolves, morphological and genetic differences among the populations indicate past isolation and, therefore, the existence of isolating mechanisms. Although the literature pertaining to reproductive isolation and speciation is voluminous, its integration into carnivore conservation has been lacking despite the increasing threat hybridization now plays in the conservation of imperiled species (Rhymer and Simberloff 1996; Simberloff 1996; Genovart 2009; Ellstrand et al. 2010).

Red wolves and coyotes exist as a panmictic population in northeastern North Carolina and the Red Wolf Recovery Program (Recovery Program) intensively manages hybridization via reproductive sterilization of coyotes within the designated Red Wolf Recovery Area (Hinton et al. 2013). Although this technique ensures that hybridization does not occur when red wolves form

breeding pairs with sterilized coyotes, continued use of sterilization and efforts to increase the number of red wolves on the landscape will likely fail to prevent hybridization if reproductive barriers do not exist (Fredrickson and Hedrick 2006). Nevertheless, assortative mating may exist within both populations as some individual red wolves and sterile coyotes appear to always prefer to pair with conspecifics after the loss of a mate, whereas others show random preferences (USFWS unpublished data). A central characteristic of *Canis* is monogamous breeding which manifests in pair-bonding behavior and group living (Gittleman 1989; Geffen et al. 1996). As a result, sexual isolation between red wolves and coyotes likely occurs when both species are incapable of forming congeneric pairs to maintain breeding territories.

Red wolves and coyotes exhibit similarity in morphology and ecology, in which red wolves are the larger species (Chapter 3). Additionally, red wolves and coyotes exhibit similar use of prey and habitat selection and differences in resource use are associated with body size (Chapters 4, 5, and 6). These studies have shown red wolves to rely on larger prey than coyotes and require larger home ranges to fulfill their energetic requirements. This is not surprising given that body size is a major phenotypic trait that commonly differentiates co-occurring species (LaBarbera 1989) and co-occurring guilds of species frequently demonstrate greater morphological disparity than expected by chance (Dayan and Simberloff 2005; Davies *et al*. 2007). Long-term maintenance of monogamous breeding units by *Canis* likely requires similar and synchronized use of space and resources within each breeding pair. Differences in body size between red wolves and coyotes will affect energy requirements and capacities for searching for and processing prey which, in turn, may affect how they perceive the distribution, abundance, and profitability of prey on the landscape. Red wolves typically weigh about 10 kg or more than coyotes and the ability of congeneric pairs to adjust energy budgets associated with breeder body mass, hunting efficiency, and spatial requirements is likely key to maintaining breeding territories and, subsequently, successful hybridization. Therefore, the formation of congeneric pairs and the

stability of those pairs to successfully raise hybrid litters may be related to how similar individuals are in their energy demands via similarity in body size.

The functional significance of body size and *Canis* hybridization is unclear and the relationship between the two is worth examination. We hypothesize that as red wolves and coyotes approach each other in body size, they can complement each other as possible mates whereas larger red wolves and smaller coyotes are incapable of maintaining breeding pairs because of differences in resource needs. We use the interactions of red wolves and coyotes to predict that body size serves as a reproductive barrier for *Canis*.

Methods and Analysis

Our data are derived from red wolves, coyotes, and their breeding pairs monitored in North Carolina by the United States Fish and Wildlife Service. We attained data on known *Canis* breeding pairs during the duration of earlier studies specifically focused on red wolf and coyote morphology, diet, and space use in northeastern North Carolina (Hinton and Chamberlain 2014; Hinton *et al*. 2014a,b,c,). Methods used for estimating body weight, diet, home-range size, and habitat composition of home ranges were consistent in all studies.

Variables

1. Body weight: weight (kg) recorded from individual red wolves and coyotes prior to being released back into the wild (Chapter 3).

2. Breeding pair weight: combined weight (kg) of breeding pairs for coyote pairs, congeneric pairs, and red wolf packs (Chapter 4).

3. Home-range size: the total area (km^2) used by an individual or breeding unit as estimated in Chapters 5 and 6.

4. Percent of white-tailed deer in diet: the average percent (%) of occurrence in the diet as observed in Chapter 4.

5. Percent of rabbit in diet: the average percent (%) of occurrence in diet as observed in Chapter 4.

6. Percent of forest: percent (%) forest composition of home ranges as observed in Chapters 5 and 6.

7. Percent of agriculture: percent (%) agricultural composition of home ranges as observed in Chapters 5 and 6.

We used analysis of variance (ANOVAs) and *t*-tests to test for differences among breeding units and between red wolves and coyotes. We used simple linear regression to examine the effects of body weight and combined breeder weight on diet, home-range size, and habitat of red wolves and coyotes. We obtain the best-fitting lines between individual weight variables and ecological variables to calculate regression coefficients (r) and levels of significance.

Results

Red wolf packs had substantially larger home-range sizes than coyote and congeneric pairs (Figure 1; $F_{2,45} = 14.78$, $P < 0.001$), whereas no difference was detected in coyote and congeneric home-range sizes. We also detected no difference in habitat use among the breeding units ($F_{2, 45} \leq 0.94$, $P \geq 0.397$). We detected differential use in white-tailed deer and rabbits among the breeding units ($F_{2, 32} \geq 7.04$, $P \leq 0.002$). We found body weight of individual *Canis* positively influenced home-range size (Figure 3; $r^2 = 0.44$, $P < 0.001$) as did combined breeder weight (Figure 3; $r^2 = 0.34$, $P < 0.001$). Consumption of white-tailed deer was positively influenced by combined breeder weight (Figure 4; $r^2 = 0.38$, $P < 0.001$), whereas consumption of rabbit was negatively influenced (Figure 5; $r^2 = 0.28$, $P < 0.001$). No difference was detected in coyote body weight between breeding pairs ($t_{43} = 0.25$, $P = 0.802$). Overall, body weight of red wolves in conspecific pairs was greater than those in congeneric pairs ($t_{72} = 2.43$, $P = 0.017$). We found no difference between body weight of male red wolves in conspecific and congeneric pairs ($t_{40} = 1.22$, $P =$

0.23), whereas female red wolves in conspecific pairs were greater than those in congeneric pairs ($t_{30} = 3.09$, $P = 0.005$).

Discussion

The association between body size and spatial and feeding ecology in carnivores is well documented (Gittleman and Harvey 1982; Gittleman 1985; Gompper and Gittleman 1991; Carbone *et al*. 1999) and our results indicate that body size provides an important indicator of red wolf and coyote diet and space use patterns. Home-range size and use of white-tailed deer scaled positively with red wolf and coyote body weight. This pattern is associated with energetic requirements and foraging strategy because large carnivores have relatively high metabolic rates and increased ranging behavior would be required to fulfill greater energetic needs (Carbone *et al*. 1999; Carbone *et al.* 2007). Furthermore, we found that red wolves that formed congeneric breeding pairs with coyotes were, on average, smaller than red wolves in conspecific breeding pairs. It appears that this trend is largely driven by female red wolves, which are the smaller of the two red wolf sexes (Chapter 3). Small red wolves may approach similar ecological requirements to those of coyotes because of their smaller body size, and this may allow them to form and maintain breeding pairs with coyotes via similar spatial and feeding needs.

Coyote home-ranges in northeastern North Carolina did not exceed 50 km^2 indicating that energetic costs may limit the maximum size of coyote home ranges (Chapter 5). In this study, we observed home-range sizes of congeneric pairs to be under 50 km^2 and statistically similar to those of coyotes, whereas most red wolf home-ranges exceeded this threshold. Although coyote body weight had no effect on coyote home-range size (Chapter 5), it was the primary trait influencing variation in red wolf home-ranges (Chapter 6). Additionally, 41% of coyote pairs monitored in our study had diets in which white-tailed deer comprised < 25%, whereas white-tailed deer comprised > 30% of the diet for all red wolf packs monitored. For both coyotes and red wolves, body weight was the most important factor influencing consumption of white-tailed deer (Chapter 4). Less use of space and white-tailed deer by coyotes suggest that they impose

energetic constraints on congeneric pairs and are likely responsible for smaller home-range sizes and less reliance on white-tailed deer by congeneric pairs when compared to red wolf packs.

Intrinsic reproductive barriers are traits that prevent gene flow between populations of closely related taxa and facilitate speciation via ecological divergence (Mayr 1941; Schluter 2000; Coyne and Orr 2004; Pfennig and Pfennig 2010). As previous allopatric species, geography and habitat may have served as the primary reproductive barrier between red wolves and coyotes, but the inability to form monogamous breeding pairs likely serves as the primary barrier to gene flow between red wolves and coyotes during secondary contact. Phylogenetic relatedness and phenotypic similarities permit red wolves and coyotes to compete with each other for mating opportunities and conflict between consorting individuals may be a fundamental phenomenon preventing hybridization. Our study indicates that larger red wolves generally avoid consorting with coyotes and size-assortative mating may arise largely as a result of ecological differences resulting from divergence in body size. Conflict may arise between consorting red wolves and coyotes during energetically stressful situations, such as foraging and defending territories, that prevents successful pair formation. As red wolves and coyotes approach each other in body size, these conflicts may be reduced allowing for long-term maintenance of congeneric breeding pairs through similar use of space use and prey.

Our results highlight the need to better understand factors affecting hybridization in *Canis*, such as body size. As seen in comparative studies of carnivores, our results indicate that body size influences home-range size and prey selection of red wolves and coyotes. Morphological disparity between red wolves and coyotes likely promotes reproductive isolation and ecological divergence through energetic constraints. We believe that the key to understanding how body size affects interactions, and subsequently hybridization, between closely related *Canis* is to understand how energetic requirements scale with *Canis* body size and its effect on *Canis* ecology. For example, it has been observed that gray wolves and coyotes are reproductively isolated where populations are sympatric despite having the potential to hybridize (Pilgrim *et al*.

1998; Wheeldon *et al*. 2010). On the other hand, eastern wolves, which are intermediate in body size to gray wolves and coyotes, are capable of hybridizing with both species and are believed to serve as a conduit for genetic material between gray wolves and coyotes (Rutledge *et al*. 2010). Currently, it is unknown whether innate preferences or environmental conditions are responsible for reproductive barriers observed in eastern wolves (Benson *et al*. 2012), but it is believed that prey selection (Rutledge *et al*. 2010) and territorial aggression (Benson *et al*. 2013) play a role in reducing hybridization. Nevertheless, our findings are consistent with invariant trends observed in comparative studies which suggest that our hypothesis is biologically plausible. Our hypothesis is based on allometric relationships and represents a useful predictive framework to understand patterns of interactions and hybridization among *Canis* species. We also suggest more sophisticated comparisons using different methods and evidence are needed to fully evaluate this hypothesis.

Acknowledgements

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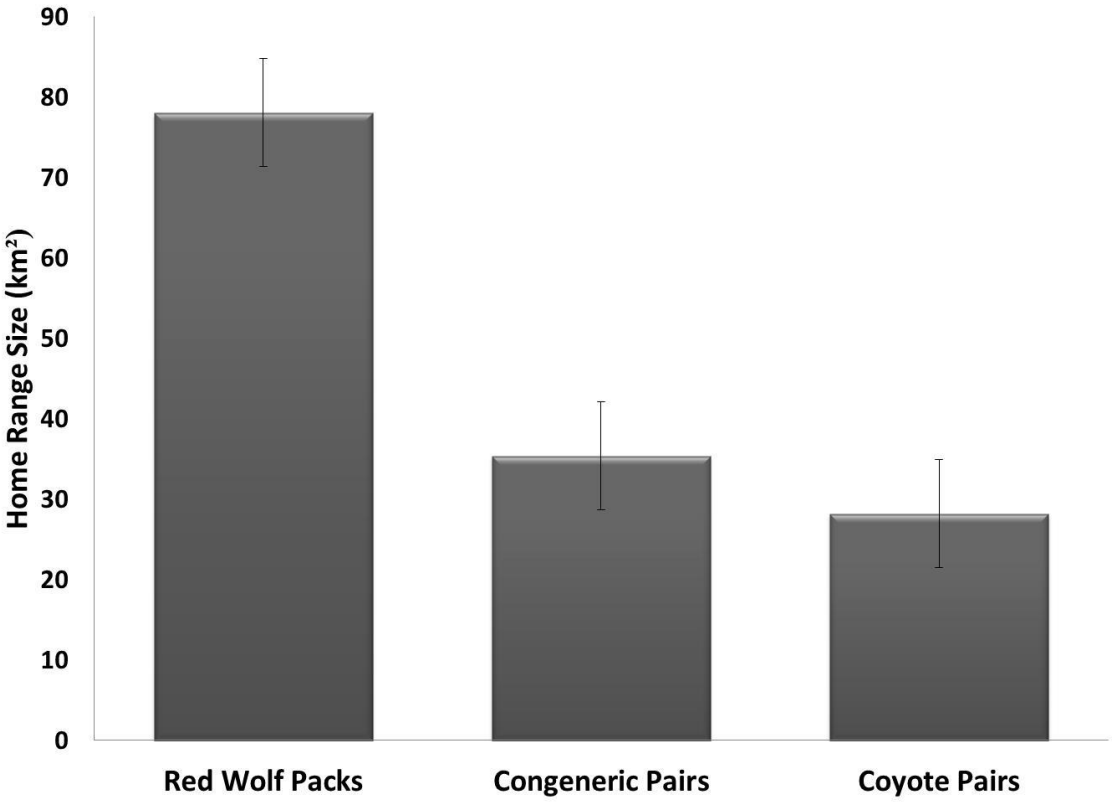


Figure 7.1. Mean home-range sizes of red wolf packs, congeneric pairs, and coyote pairs in northeastern North Carolina.

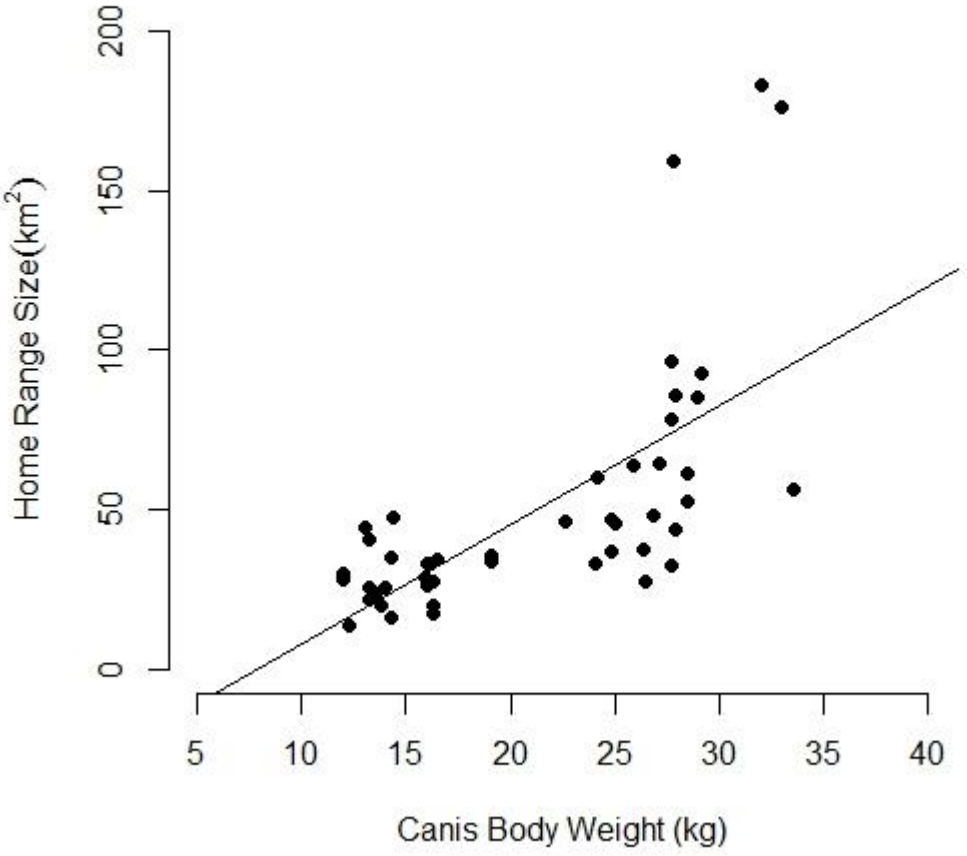


Figure 7.2. Correlation between home range size and body weight of red wolves and coyotes.

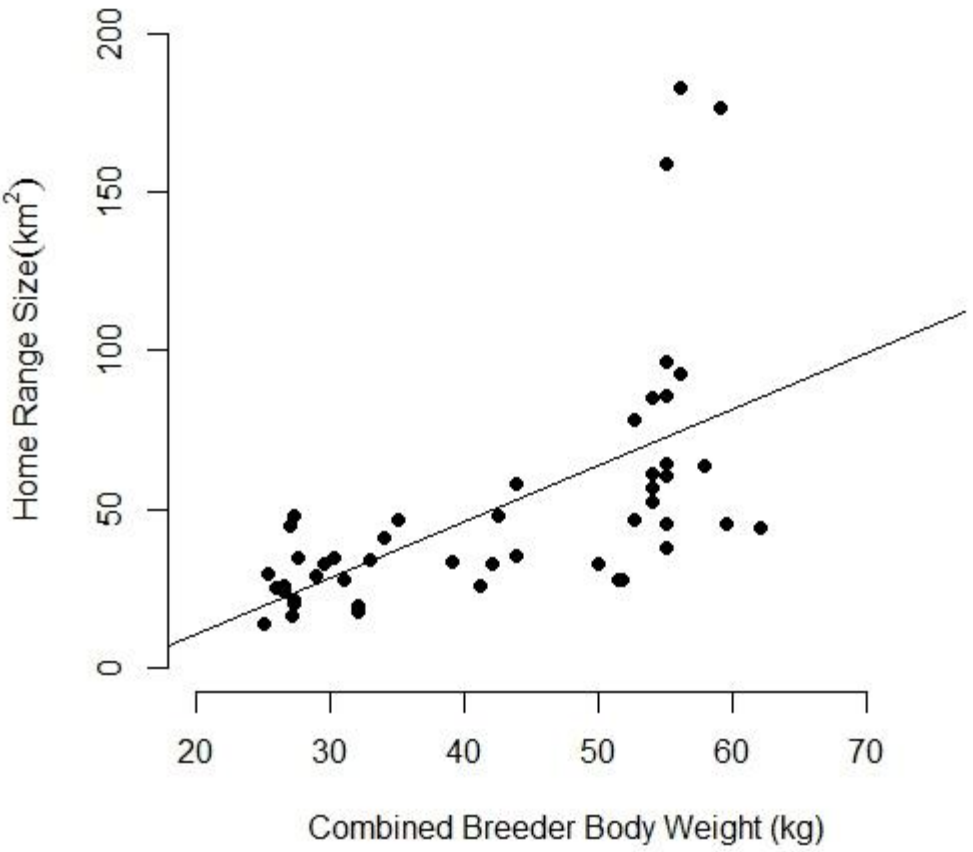


Figure 7.3. Correlation between home range size and combined breeder body weight of *Canis* breeding units.

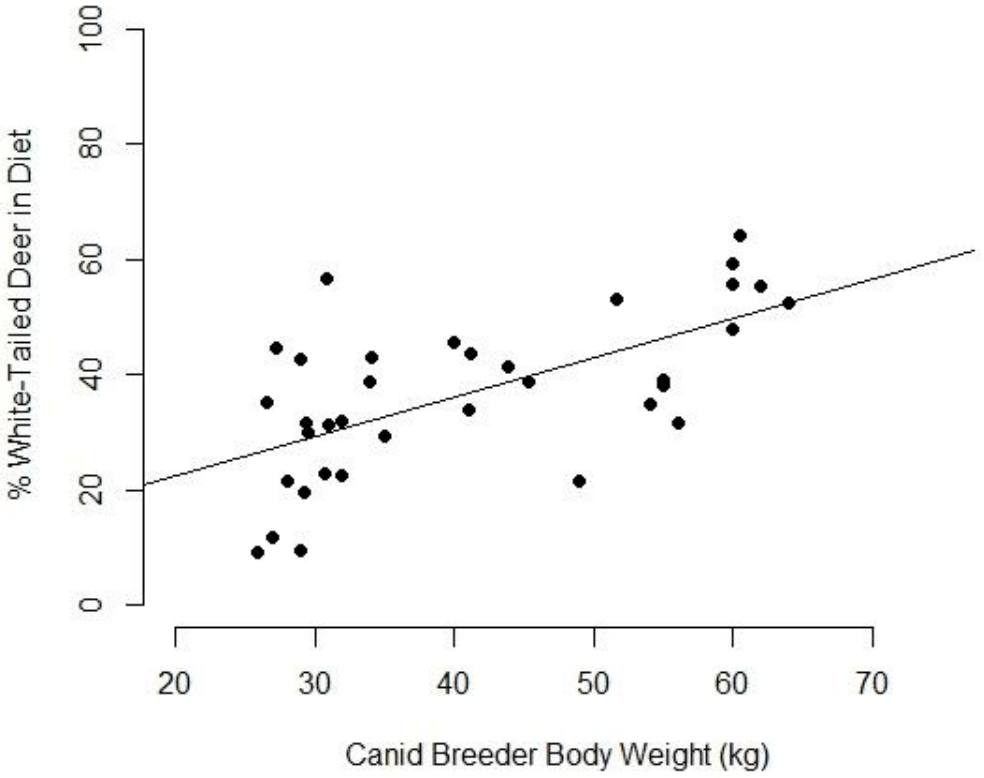


Figure 7.4. Correlation between percent white-tailed deer in diet and body weight of *Canis* breeding units.

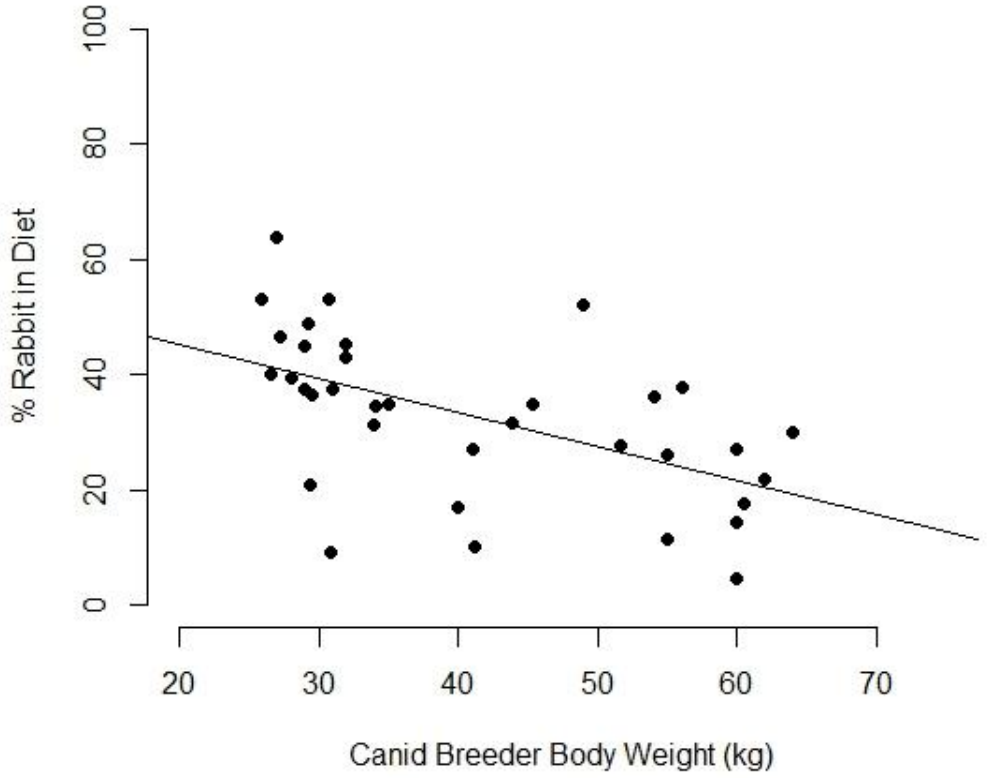


Figure 7.5. Correlation between percent rabbit in diet and body weight of *Canis* breeding units.

CHAPTER 8

CONCLUSIONS

Understanding how red wolves interact with coyotes is an important issue which could dictate the success of recovery efforts. It also presents an opportunity to explore mechanisms that facilitate ecological divergence and reproductive isolation between *Canis* species. There has been limited examination of potential reproductive barriers between sympatric *Canis*, partly due to the difficulty in monitoring the interactions of large carnivores. Recent studies have suggested several possible mechanisms responsible for slowing hybridization rates between *Canis* such as differences in prey selection (Rutledge et al. 2010), stability in social structure (Bohling 2011), and aggressive interactions related with territoriality (Benson et al. 2013). Noting that monogamous breeding and group living as a central characteristic of *Canis*, we hypothesized that difference in body size between interacting *Canis* species prevents congeneric breeding-pair formation via disparity in diet and spatial needs. In other words, long-term maintenance of monogamous breeding units by *Canis* likely requires similar and synchronized use of space and resources within each breeding pair and this is likely to happen when individuals are similar in body size.

This dissertation found 4 important components of red wolf and coyote ecology that demonstrate the biological plausibility that body size disparity can serve as a reproductive barrier. First, we demonstrated that red wolves are substantially larger than coyotes with hybrids intermediate to both coyotes and red wolves in body size. In fact, red wolves attain a body size that is not achieved by coyotes or hybrids. Therefore, good concordance was found between morphometric variables and the molecular methods accepted by the United States Fish and Wildlife Service for monitoring red wolf genetic ancestry.

Second, we found red wolves and coyotes to have similar and overlapping diets. Nevertheless, consumption of white-tailed deer positively scaled with body weight in which red wolves consumed more deer than did coyotes. Interestingly, our results of coyote diet are contrary to many studies conducted in the southeastern United States because we found coyotes in northeastern North Carolina to be largely carnivorous with a narrow dietary breadth. Partitioning of food resources by red wolves and coyotes is mostly via differences in quantity of similar prey rather than differences in types of prey exploited. This suggests foraging ecology of red wolves and coyotes become similar as they approach each other in body size.

Third, we found body size to have an effect on red wolf and coyote space use. Home-range size in red wolves scaled positively with body weight in which larger red wolves generally require more space than smaller red wolves. Although body size did not influence coyote space use, coyote home ranges did not exceed 50 km^2 indicating that coyotes cannot maintain large home ranges. This constraint of coyote space use is likely a result of their smaller body size because approximately 75% of red wolf home ranges were > 40 km^2. We also found red wolves and coyotes preferred open, treeless agricultural fields over the forested habitats in northeastern North Carolina. Red wolf and coyotes centered their home ranges in open, agricultural habitats and the primary difference in spatial ecology was size of their home ranges which was influenced by body size.

Fourth, we found that red wolves that formed congeneric breeding pairs with coyotes were, on average, smaller than red wolves in conspecific breeding pairs. It appears that this trend is largely driven by female red wolves, which are the smaller of the two red wolf sexes. Small red wolves may approach similar ecological requirements to those of coyotes because of their smaller body size, and this may allow them to form and maintain breeding pairs with coyotes via similar spatial and feeding needs. For instance, we observed home-range sizes of congeneric pairs to be under 50 km^2 and statistically similar to those of coyotes, whereas most red wolf home-ranges exceeded this threshold. For both coyotes and red wolves, body weight was the most important

factor influencing consumption of white-tailed deer. Less use of space and white-tailed deer by coyotes suggest that they impose energetic constraints on congeneric pairs and are likely responsible for smaller home-range sizes and less reliance on white-tailed deer by congeneric pairs when compared to red wolf packs.

In conclusion, we suspect morphological disparity between red wolves and coyotes likely promotes reproductive isolation and ecological divergence through energetic constraints. We believe that the key to understanding how body size affects interactions, and subsequently hybridization, between closely related *Canis* is to understand how energetic requirements scale with *Canis* body size and its effect on *Canis* ecology. Our findings are consistent with invariant trends observed in comparative studies that home-range size and prey size scale positively with carnivore body size and this suggests that our hypothesis is biologically plausible.

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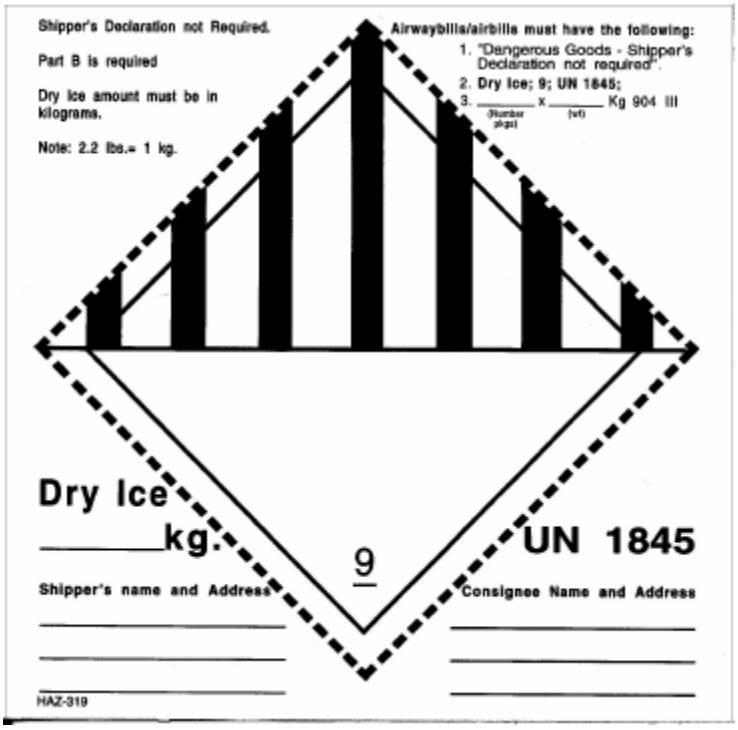
Rutledge, L.Y., C.J. Garroway, K.M. Loveless, and B.R. Patterson. 2010. Genetic differentiation of eastern wolves in Algonquin Park despite bridging gene flow between coyotes and grey wolves. Heredity 105: 520-531.

Protocol for fecal sample collection for hormone analysis

Duration: 1 year, can start anytime of the year
Frequency: 3 time/week
Protocol:

1. For animal housed in groups, one day prior to sample collection day, feed individual with food item (e.g. meat ball) mixed with some type of marker, e.g. food coloring (Baker's paste food color), glitters (Sulyn Ind. Inc., Coral Springs, Flato), etc. to identify an individual's sample.
2. Collect fresh sample (approximately 50 g [~ golf ball size]) and place into a plastic baggie.
3. Using a permanent maker please write the animal's studbook number, sex, date sample was collected, and institution on each baggie.
4. Keep the samples in -20C until shipped to SCBI
5. To ship samples please put the samples in a Styrofoam-lined box with dry ice (see label below). Samples should be sent early in the week (Mon. – Wed.) to avoid weekend delivery. Please put "red wolf" as the reference on shipping label.

   Dr. Nucharin Songsasen
   Smithsonian Conservation Biology Institute
   1500 Remount Road
   Front Royal, VA 22630
   Tel: 540-635-0030
6. Contact me, Morgan Bragg, at mbragg2@masonlive.gmu.edu before sending the samples for FedEx number.



From: rebekah_p_martin@fws.gov
To: rebekah_p_martin@fws.gov; pete_benjamin@fws.gov; joseph_madison@fws.gov; rebecca_harrison@fws.gov; arthur_beyer@fws.gov; scott_lanier@fws.gov
Subject: 10am Discuss Nov 28 Meeting (WRC Proposal)
Start: Monday, November 27, 2017 10:00:00 AM
End: Monday, November 27, 2017 11:00:00 AM

This will be a check in on the plans for the Nov 28 meeting.

(b) (5) cip

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Louisiana Draft Plan

In order to be able to make more informed decisions regarding the canid population and possible existence of red wolves in Louisiana we propose the following as very preliminary steps:

Short Term

- If possible, a good initial step would be for the Sabine NWR to pre-bait areas where there appears to be active canid use with road kill or something similar, and place remote sensing cameras. That would both serve to prime the areas pre-baited for trapping shortly after and give a visual of what visits those areas. Additionally, if hair snares could be placed at those pre-bait sites and other canid use areas, it would provide a lower effort/lower need for training way of obtaining samples for genetic testing. I believe Emily has the equipment and perhaps the protocol that was used previously. All hair samples should be sent to the appropriate lab for analysis. Would likely collect a lot of non-target hair samples.

- The preferred trapping window for the health and safety of the canids, and to not disrupt breeding would be during the winter months (December, January and February), in line with trapping in the NENC NEP. Trapping past February is not recommended due to affecting breeding season, subsequent denning, birth, and then heat issues. If local Sabine NWR staff, Wildlife Services, State of Louisiana personnel, university researchers or private trappers are authorized, available, trained and equipped to safely and effectively conduct canid capture operations they could potentially start trapping in January. If not, in February, two staff from the Eastern NC ES Sub-office's Red Wolf Recovery Program could drive down to Sabine NWR and in coordination with Refuge staff conduct canid capture operations throughout the appropriate habitats of the refuge. Trapping window should be a minimum of two weeks, if not longer.

- All canids captured will have the capture location GPS'd, full measurements taken (e.g. body length, skull, weight, etc.), blood drawn, vaccinated (?) and be photographed. All capture and handling operations conducted by Red Wolf Recovery Program personnel would be in accordance with the SOPs utilized in the NENC NEP. Coordination with Refuge staff will determine the appropriate steps if non-canids are captured. For example, if the animal should be released immediately or if they would like them processed for other purposes.

- Blood samples will be sent directly to the University of Idaho for genetic testing.

- All animals would be released at or in close proximity to where they are captured as soon as they are able to be released.

- All, or a sampling of animals, that fall within the accepted morphological measurements of red wolves should be radio collared before release for the purposes of tracking their movements to determine general habitat use and home range (e.g., how much of their movement is on the refuge) and to more easily facilitate recapture should it become desire. Radio collars and frequencies to be used would need to be coordinated with Sabine NWR, university researchers and or the State of Louisiana.

- Collared canids should be monitored for general location and mortality from the air or ground preferably at least once a week to get a sense for their movements.

Long Term

- Need for additional research to determine the structure of the canid population in Louisiana and Texas.

- Research could be guided by the SCBI research work group established at this past summer's red wolf workshop and focus on a broader effort to characterize the genetic, morphological and behavioral composition of the canid population in Louisiana and Texas. Their role would hopefully be to help guide a study plan that would provide the needed scientific foundation upon which to base decisions regarding these canid populations and their management.

- Recent publications regarding potential red wolves in Louisiana and Texas provide a valuable starting point and include recommendations for additional field work and analysis to determine what is present in those areas. Including how to deal with the "ghost alleles".

- Information collected this winter would help inform research needs and provide some additional of "baseline" information.

Discussion

- January is good month to trap, but if it is to be done by the red wolf staff, it would be better suited to trap in Louisiana in February to account for management needs here in the NENC NEP.

- There is a need to recognize that samples being tested for both of the published papers that give percentages of red wolf are only comparing the specimen genetics to the know genetics of the 14 founder red wolves. Consequently, such as Heppenheimer et al. (2018) suggest, alleles that may be representative of red wolf genetics not accounted for by the founders, but present on the landscape today, will not be accounted for in the genetic results from the University of Idaho lab that indicate what percent red wolf an individual canid is.

- As discussed, although we currently use 87.5% red wolf genes within the NENC NEP as the cut off for a red wolf, that may not be the appropriate percentage for such a determination in Louisiana, particularly in light of it not accounting for unknown red wolf genetics.

- Need to begin to have discussions with the States of Louisiana and Texas regarding these canid populations and the possibility of it being determined that red wolves are present as fully endangered species with no current provision for take.

Coyote Depredation Permit

Tele: (919) 707-0061
FAX: (919) 707-0292

North Carolina Wildlife Resources Commission
Regulated Activities Permits Section
1707 Mail Service Center
Raleigh, NC 27699-1707

AUTHORITY

STATUTES
GS 113-274

RULES
15A NCAC 10B .0106

PERMITTEE/LICENSEE

Tom Harrison
[redacted]

Telephone: [redacted]

PERMIT NUMBER
N/A

EFFECTIVE	EXPIRES
04/01/2018	5/30/2018
COUNTY See Text Below	**DISTRICT** See Text Below

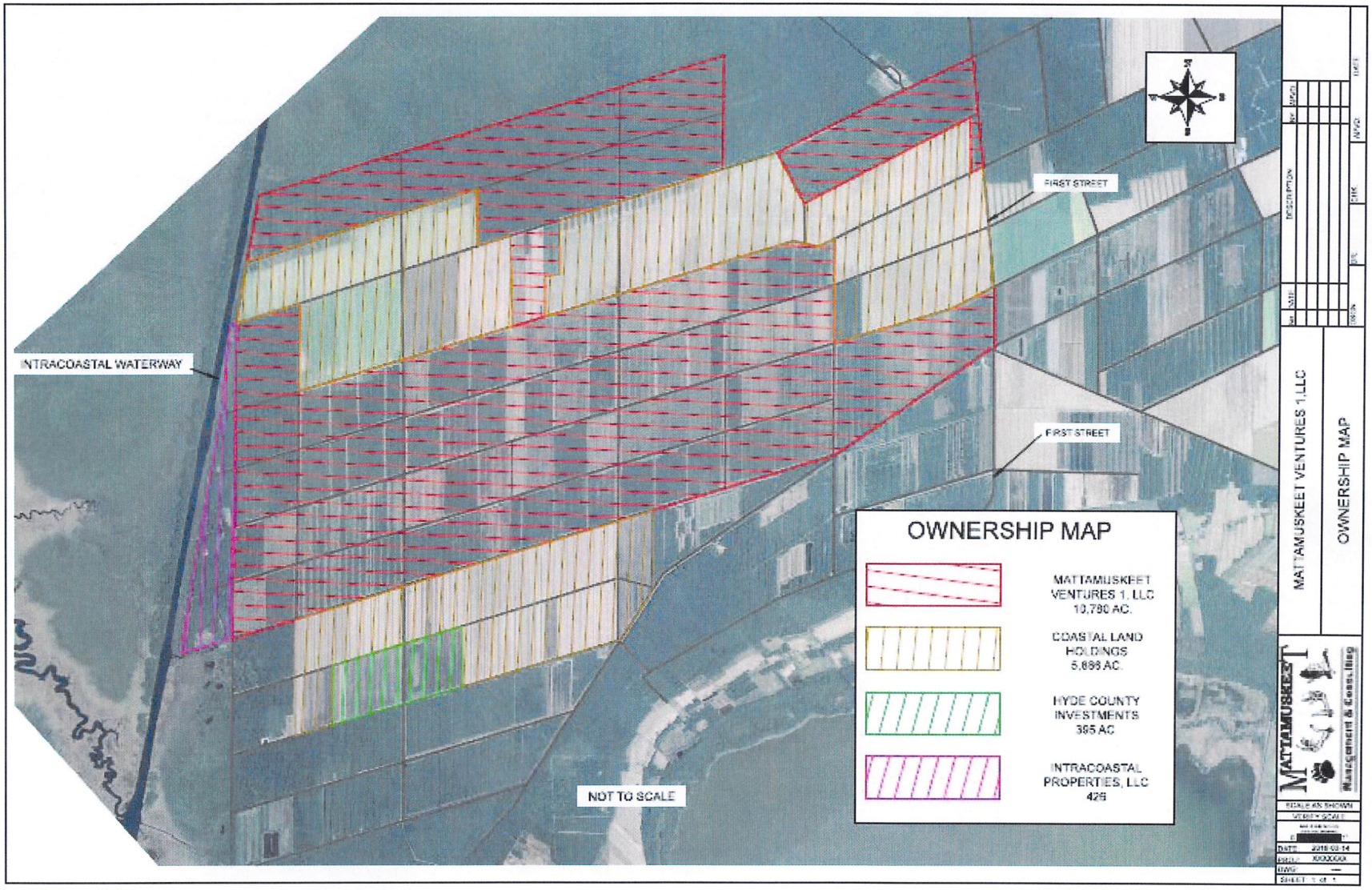
CONDITIONS AND AUTHORIZATIONS:

The above permittee and other individuals under written contract and under the supervision of the permittee are authorized to trap coyotes on the properties identified in **Attachment A** subject to the following conditions:

- Permit is valid for properties identified in **Attachment A**.
- This permit does not authorize access to any property, public or private.
- All individuals exercising the authority granted by this permit shall carry a copy of this permit and a letter of authorization from the permittee listed above while conducting trapping activities.
- Traps must be labeled as required by G.S. 113-291.6. Traps must be checked daily and any animals caught therein must be removed. All non-target wildlife must be released immediately onsite; however, any red wolf captured must be reported immediately to the Wildlife Resources Commission (WRC) at 800-662-7137 or the U.S. Fish and Wildlife Service to determine disposition of the red wolf.
- Coyotes being removed for depredation under this permit may only be trapped using legal foothold traps and the Collarum type trap as defined in G.S. 113-291.6. The reporting forms required for the use of Collarum type traps may be found at http://www.ncwildlife.org/Trapping/Laws-Safety. Collared animals must be reported immediately to the WRC at 800-662-7137 before final disposition is determined. All coyotes euthanized shall be disposed of in a sanitary manner. All collars from euthanized coyotes must be returned to the WRC.
- Permit holder must report the removal of coyotes to the WRC at 800-662-7137 or online at www.ncalvin.org/ckr/ckrmain.aspx within 24 hours of taking possession of each individual coyote. Each report must include the date; time; location; if the animal had a collar; and measurements of hind foot length and tail length taken from the carcass. Instructions for recording these measurements are enclosed and can be found at www.ncwildlife.org/Portals/0/License/Documents/Canid-Cooperator-Program-Instructions.pdf.
- A hair sample with follicle from each euthanized coyote must be submitted to WRC, Wildlife Management Division, 1722 Mail Service Center, Raleigh, NC 27699-1722.
- A report of all animals captured under this permit, date of capture, and their disposition is required within fifteen (15) days after the expiration of this permit.

This permit/license is nontransferable and expires at midnight on the above specified expiration date.

ISSUED BY:	TITLE:	DATE:
[signature]	EXECUTIVE DIRECTOR	3-23-18



ATTACHMENT A

STATE: North Carolina

GRANT TITLE: W79-Wildlife Management

PROJECT TITLE: Pilot Study – Using Fine Scale GPS Technology to Research Sympatric Canid Population Dynamics (Job 2.0?)

A. Problem and Need

The coyote (*Canis latrans*) is now abundant throughout the 100 counties in North Carolina (NC), and is managed as nongame with no closed season or bag limit (NC Wildlife Resources Commission 2016). Previously restricted to the West and Midwest regions of the United States, by the early 1990s coyotes had expanded their range into the Albemarle Peninsula (AP), which is situated in the northeast coastal plain region of NC (Hinton et al. 2012, Murray et al. 2014). In recent years as coyotes have increased their population, some have begun to make use of the Outer Banks region.

The United States Fish and Wildlife Service (USFWS) released a non-essential, experimental population of captive-bred red wolves (*Canis rufus*) on the Alligator River National Wildlife Refuge (ARNWR) in 1987 (Hinton et al. 2013). This population increased until 2008 and peaked at around 130 individuals (Group Solutions, Inc. 2016), short of the recovery goal of 220 in the wild (USFWS Red Wolf Recovery Program 2013). The AP has an estimated carrying capacity of 140-150 wolves (Hinton et al. 2013, Kelly et al. 1999, USFWS Red Wolf Recovery Program 2007). The exact number of red wolves is not known, but USFWS staff report a population estimate of 45-60 individuals with eight mortalities to date in 2016 (https://www.fws.gov/redwolf/index.html August 2016). Hybridization with coyotes and inbreeding depression are suspected factors that have affected red wolf population growth and viability since the inception of the Red Wolf Recovery Program (RWRP), while vehicular and gunshot mortality are known factors (Hinton et al. 2013). Because of hybridization between red wolves and coyotes, the AP supports a continuum of sympatric canids, hereafter referred to as "sympatric canids."

As part of a recent program review, the USFWS halted many aspects of the RWRP in 2015 and discontinued the coyote sterilization program, potentially affecting the spatial

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distribution and population dynamics of sympatric canids. Telemetry data from coyotes on the AP suggests that about 70% of coyotes are residents (i.e., those that defend set territories) while the other 30% are transients, with most being dispersing juveniles (Hinton et al. 2015). Transient coyotes do not defend set territories. Coyotes can travel long distances and become transient even as adults, especially when they lose their mate. Recently described as using "compensatory immigration," coyotes opportunistically fill spatial resource gaps by periodic transiency; when spots come open, individuals that do not yet have permanent territories and have been roaming in the area, are able to inhabit the new openings (Hinton 2016). These periods of transiency can sometimes bring coyotes into conflict with other canids and humans, especially when they are utilizing of anthropogenic resources.

Though a rural area, human land uses occupy a significant portion of space on the AP. The AP is comprised of approximately 30% agricultural fields, 50% forest and coastal marshes, and 20% "other" land cover types on federal, state and private lands (Dellinger 2011). Concerns about fear of attacks on humans and domestic pets, the effects of sympatric canids on white-tailed deer and other game populations, and homeowner property damage comprise many of the conflict calls regarding sympatric canids on the AP (Responsive Management, forthcoming data). Wildlife managers in this region frequently receive requests for information on canid management (C. Turner, personal communication, 2016).

The changes in state and federal canid management rules have resulted in confusion regarding residents' rights and options for management of property damage by sympatric canids. As a result, some citizens are unsure of the legal and most effective methods for canid conflict management. Adding to management complexity is the need to manage canids for conservation purposes, such as reducing predation on at-risk ground nesting species or reducing hybridization of sympatric canids.

In 2013, NCWRC and USFWS established a committee to oversee the collaborative management and conservation of sympatric canids on the AP. A USFWS and NCWRC joint memorandum documented detailed action items for the joint management of sympatric canids on the AP, including specific research objectives which this proposal seeks to address (Attachment 2). As sympatric canids on the AP increase in number, monitoring their

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movements, particularly in relation to individuals of differing ancestry, could provide important data to NCWRC and USFWS staff for science-based local and landscape-level decisions about sympatric canid populations and conflict management. Collection of finer temporal scale location data would help to manage interactions of sympatric canids with humans, as well as to support development of dynamic stochastic population models.

B. Objectives (after December 1, 2016-November 30, 2018)

Objective 1: Use GPS collar and proximity sensor technology to test performance under various conditions and evaluate the frequency and accuracy of the scheduled fix rates.

Objective 2: Use fine scale GPS data collection for investigating annual and seasonal spatial dynamics of sympatric canids: home range and core area sizes, amount of overlap in home range and core areas, movement pathways and daily activity patterns, and cover type selection and preference.

Objective 3: Use fine scale GPS data collection for investigating the number and age structure of offspring for family groups of collared sympatric canids.

Objective 4: Use fine scale GPS data collection for investigating sources of mortality for sympatric canids.

Objective 5: Use fine scale GPS data collection for preventing and mitigating canid conflicts with landowners.

Objective 6: Determine genetic profiles of sympatric canids through DNA identification of all captured individuals, parentage, and presence of hybridization.

At the end of this two-year pilot study, we will deliver an observational summary detailing the use of the GPS and sensor technology for spatial and population dynamics research on sympatric canids on the AP.

C. Expected Results and Benefits

As part of a pilot study, we will monitor the status of collared individuals by using a finer scale assessment of space and habitat use than previous studies. Earlier research focused on many of the same objectives we suggest investigating here, but during a time of intense, active

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management. Specific management techniques are no longer being carried out and dynamics between sympatric canids are expected to have changed substantially. The uncertainty regarding current dynamics presents a need for additional research in order to inform actions for the management of sympatric canids. Information gained from research may impact management rules and landowner's abilities to manage canids in some areas. Additionally, GPS technology has improved since earlier research was conducted allowing for more temporally detailed data collection and more nuanced analyses. Understanding how sympatric canids collectively use resources in areas of human-dominated landscapes will allow wildlife managers to tailor management options to local conditions. On the AP, row crop agriculture and hunting represent the primary and secondary land uses, respectively. Row crop agriculture is a significant nutrient resource on the landscape and, as opportunists, canids take advantage of such resources when they are available. Non-consumptive wildlife-driven tourism persists in all seasons and wildlife watching is a main draw for tourists in this area. For many tourists, the opportunity to see or hear large carnivores is the sole attraction for traveling to the AP. Information from this study will be provided to local constituents to establish a knowledge base regarding how sympatric canids use resources on private lands. Management and guidance could serve to prevent or minimize conflict while maximizing positive wildlife interaction opportunities for constituents. Development of a common understanding between wildlife managers and landowners based upon factual information is paramount for collaboratively achieving successful management of sympatric canids. The data collected in this pilot study is the foundation upon which this understanding and future management actions will be built.

The current level of hybridization between sympatric canids on the AP will be characterized using DNA gathered during this study. Body size exists as a continuum between coyotes and red wolves and has been documented as the most important factor for successful interspecific breeding pairs of these canids (Hinton 2014). Though both species have been found to use resources in similar manners, red wolves generally have more expansive home ranges and therefore may not use local resources as intensively as coyotes, depending on body size. Obtaining individual identification of study animals will allow managers, armed with spatial information, to infer how and why individuals in the canid species continuum exploit

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anthropogenic resources considering their life history traits.

In conjunction with prior research, data collected will contribute to knowledge on sympatric canid population dynamics on the AP. Estimating population size will allow managers to monitor population trends of sympatric canids and to examine the long and short-term impacts of different management strategies on their populations. While it is unknown whether sample size will allow for population estimation, obtaining population estimates for coyotes would provide wildlife managers with baseline data, when paired with annual mortality estimates, for monitoring changes in population abundance over time. Information on changes in abundance, reproductive dynamics, and habitat use could impact management strategies to influence long-term conservation outcomes. Results of this pilot study will allow managers to determine if future work will be necessary, what amount of effort will be required to achieve each objective, and whether or not population estimates will be an attainable goal.

D. Approach

The official Red Wolf Recovery Area (RWRA) covers approximately 6,900 square kilometers within Beaufort, Dare, Hyde, Tyrrell, and Washington counties (Wildlife Management Institute 2014). However, the USFWS has proposed the RWRA be constricted to the ARNWR and the Dare County Bombing Range in Dare county by the end of 2017. Due to these proposed RWRA changes, this study proposes to capture and radio-collar 25 sympatric canids within Dare, Hyde, and Tyrrell counties (hereafter referred to as “study area”); those counties being within and directly adjacent to the proposed new RWRA. The thematic subheadings below provide detailed descriptions of the approaches required for achieving the pilot study objectives.

Sampling Efforts

Trained NCWRC personnel will conduct live trapping of sympatric canids, with assistance from the USFWS RWRP biologists, and trained, experienced local trappers. NCWRC and USFWS wildlife personnel will select local trappers based on their past performance in trapping sympatric canids, but may also select trappers from the NCWRC coyote trappers list. NCWRC staff will train contracted trappers on specific trapping procedures before every trapping

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season. The project lead will supervise and coordinate all trapping activities including locations for installation and the operation of trap lines and handling of captured animals. Simultaneous personal trapping activities by contracted trappers will not be permitted while performing contracted trapping services, as specified in the draft service contract (Attachment 4).

Trapping efforts will follow a spatial capture-recapture (SCR) framework with a systematic targeted sampling design, focusing on areas that contain resources previously found to be used by sympatric canids (e.g. edge, agricultural fields, secondary roads, etc.) (Harris et al. 2013, Ivan et al. 2013), while attempting to sample a diversity of habitat types. This effort will allow us to increase the probability of detection of sympatric canids on the landscape (Tom 2012). While it is important to sample a wide range of habitats, the most important requirement for SCR is the number of collared individuals; this requirement provides flexibility in the other requirements for field sampling as needed (K. Pacifici, personal communication, 2016). We will initially focus trapping in areas of known red wolf packs, as advised by RWRP.

Trapping will take place during the breeding season when the likelihood of capturing females in the later stages of gestation or whelping females will be low. Capture efforts will be conducted from soon after 1 December 2017 – February 2018 and December 2018 – February 2019. Captured sympatric canids will be surrendered to NCWRC or the USFWS at capture sites. Trapping should occur on both public and private lands to obtain sampling coverage of the study area. Ideally, all federal and state lands would be accessible for trap and release (hereafter referred to as "capture") of sympatric canids, but it is most important to be able to trap and release on Alligator River NWR and the Dare County Bombing Range as those encompass the newly proposed RWRP recovery area and comprise the majority of land area for Dare county. Unlike Dare county, there are ample private lands that surround Pocosin Lakes NWR and Lake Mattamuskeet NWR in both Tyrrell and Hyde counties that may be utilized to effectively sample individuals who may use those federal lands, should they be excluded from capture activities. Capture on federal lands may require USFWS take permits and proposed activities may be subject to a compatibility assessment (P. Benjamin, personal communication, 2016). Scientific collection activities that take place on private lands will require agreements outlining conditions mutually decided by NCWRC and landowners (Attachment 3).

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To increase probability of detection of sympatric canids, the accessible study area will be partitioned by a grid, the cell size of which will based on the average annual home range size of resident coyotes previously reported for the AP, approximately 23 km^2 (Hinton et al. 2015). As a system of sampling, trap lines will be referred here as "traps," and the number of trap sets (i.e. the actual trapping device) and number of each trap set size may vary between traps as necessary. Sampling will be standardized within each grid cell by use of equal number of traps per cell, on average 3 per cell, each at an approximate length of 10 km (Andelt and Gipson 1979, Way et al. 2004).

Target canids will be captured by using Softcatch #3 Coyote 4x4 (Oneida Victor Inc. Ltd., P.O. Box 32398, Euclid, Ohio 44132, Hinton 2014, Schemnitz 1994), the EZ Grip #7 (Livestock Protection Company, P.O. Box 725, Alpine, Texas 79831, Frame and Meier 2007), or equivalent. Various lures and baits will be used to increase trapping efficiency (Frederick et al. 1989, Shipley 2012). Traps will be laid on the Monday of each week and will be opened at the time of deployment. Traps will be checked once daily at dawn, to reduce potential stress to trapped individuals and will not be operated on days where the temperature is expected to reach or exceed 80° F (R. Nordsven, personal communication, 2016) or during times of predicted inclement weather (e.g. snow, hail, high wind, etc., Sikes et al. 2011). To standardize effort and remain logistically realistic, traps should be open for three trap nights in a row before being removed. Trap sets that have been closed due to non-target bycatch or other circumstances may be reopened and all traps should be re-baited and lured as appropriate.

Trap set locations will be marked by NCWRC or USFWS personnel using handheld GPS units (Garmin GPSMAP 64S, 1200 E. 151st St., Olathe, KS 66062-3426) and given a sequential identification number. Traps will also be given an identification number and trap set points will be documented in ArcMap 10.4. Trappers will keep detailed records on trap set operation, non-target species trapped, and other relevant details. Non-target species will be released from traps after an in-field assessment of injuries, if any, and animals with life threatening injuries will be euthanized by the trap operator. Targeted recapture of collared canids will occur annually during the same months, to replace GPS collar batteries and drop-off collar release units in field. Trapping effort will be quantified (trap nights), the effective sample area will be

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estimated, the encounter (detection) probability will be estimated using a Gaussian detection model (Amundson et al. 2014), and an estimate of density for coyotes will be calculated using a modified Huggins closed-capture estimator in program MARK, if sample size allows (Harris et al. 2013, Ivan et al. 2013).

Animal Handling

Handling of canids will follow American Society of Mammalogists (ASM) guidelines (Sikes et al. 2011) and will be performed at the capture site. Chemical immobilization agents may be used depending on the number of field staff during processing (i.e., three or more staff required during non-chemical immobilizations, Craft 2007, M. Morse, personal communication, 2016).

Chemical Immobilization

Unless adequate numbers of personnel are available to safely employ mechanical restraint techniques, target animals will be anesthetized with the chemical immobilization agent BAM (Wildlife Pharmaceuticals, Inc., Windsor, CO 80550). BAM, a combination of Butorphanol tartrate, Azaperone tartrate and Medetomidine HCl., will be delivered by intramuscular injection by syringe pole to the hip. Dosage for canids is based on field trails performed by Wildlife Pharmaceuticals (Wildlife Pharmaceuticals, Inc. 2016) and the recommended dose for coyotes is 0.2CC and red wolves is 0.3CC, with adjunct doses of 0.1-0.2CC delivered if initial dosages do not cause induction (S. Kirschner, personal communication, 2017). Induction times for coyotes and wolves ranged from 5 to 10 minutes after initial and/or adjunct dosages (Wildlife Pharmaceuticals, Inc. 2016). After field handling is concluded the anesthesia will be reversed using two reversal agents, Atipamezole and Naltrexone, at double the CC of Atipamezole to BAM that was delivered (including adjunct doses, if given) and 0.5CC of Naltrexone. Recovery time from the reversal agents ranged from 10 to 25 minutes during field trails (Wildlife Pharmaceuticals, Inc. 2016). Field personnel will observe animals for signs of adverse effects for up to 30 minutes after reversal agents are delivered.

Mechanical Immobilization

Unlike other carnivore families, the submissive behavioral response of canids to

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perceived dominance reduces the need to use immobilization agents. Appropriate mechanical restraint techniques can reduce handling time of animals, allowing animals to reintegrate into social groups more quickly, subsequently reducing overall stress to the individual (Powell and Proulx 2003). Target canids will be mechanically restrained with a restraint pole, until two muzzles can be placed around the snout. While pinned with the restraint pole by one person, a second person will restrain the set of legs not in the trap against the ground and a third person will release the foot from the trap. This set of legs will then be restrained by the 3rd person as the restraint pole is removed. Once the restraint pole is removed the person restraining the front legs will also then restrain the head. The first person will then move forward with processing the captured animal.

Each animal will be placed on a towel or blanket to provide thermal protection from the ground, with eyes covered and lubricated with eye ointment; temperature will be monitored with a rectal thermometer. Overheating occurs at approximately 104-105°F for canids (AZA Canid TAG 2012) and the animal handling crew will monitor temperature at 5-minute intervals; if a temperature reading reaches 104°F, corrective actions will be taken and temperature will be monitored at 1-minute intervals. Should overheating occur, the individual will be removed from insulation to expedite the natural evaporative cooling process. During days that approach 80°F in temperature, measures will be taken to reduce heat stress, such as: wetting the animal with water, application of a cold pack to the groin area between the back legs, application of rubbing alcohol to foot pads, or immediate release (AZA Canid TAG 2012). If the injured individual is suspected to be a red wolf, based on morphometrics, USFWS staff will be contacted for a decision. In the event that trap caused injuries are determined to be life threatening through use of a trap injury score assessment (Frame and Meier 2007) the individual will be euthanized. In the event that NCWRC personnel cannot be present, trained USFWS personnel may collar and measure captured target animals and will provide data sheets to NCWRC staff. Target animals will not be vaccinated or otherwise treated for diseases, regardless of the presence of disease symptoms.

Non-target animals will be released on site. Captured domestic dogs will be immediately released from the trap set following an injury score assessment and only if no life-threatening

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injuries are present. If a domestic dog has sustained life threatening injuries and owner identification information is present on the dog, then the animal will be held in either a transportable kennel, or at a dog pen on a state game land that is equipped with such facilities, until the owner can retrieve the dog. The costs associated with injuries sustained to the dog will be the responsibility of the animals' owner. Law enforcement may be requested to help communicate with the animal's owner. If the animal does not have an identifiable owner and has incurred substantial life threatening injuries (i.e. compound fracture), the dog will be euthanized on site. Target animals showing signs of disease symptoms such as circling behavior, head tilt, muscle twitches, convulsions with jaw chewing movements and salivation ("chewing gum fits"), disorientation, incoordination, staggering caused by paralysis of the hind legs, seizures, and partial or complete paralysis will be euthanized and tested according to protocol set forth by the agency veterinarian, in order to determine if there may be a public health issue (M. Palamar, personal communication, 2016). USFWS will be contacted in cases of suspected red wolves. Staff involved in animal handling duties will have the pre-exposure rabies vaccination series completed prior to field work inception and will maintain rabies titer records through properly licensed medical services providers.

If staff is bitten and skin is broken by an animal while performing handling duties, they will be advised to immediately visit a local hospital or clinic for evaluation by healthcare professionals. The field coordinator will immediately notify supervisory staff and an injury report and workers' compensation claim will be opened for the incident. The animal will be euthanized and the head will be sent to the state lab for rabies testing; the body may be sent to the Southeastern Cooperative Wildlife Disease Study (SCWDS) laboratory for additional disease investigation.

Capture Processing and Marking

During canid handling, NCWRC personnel will record age class, sex, weight, total body length, head width, ear length, and tail length, visually assess ectoparasite load, look for and disinfect with betadine or iodine as needed any minor trap caused injuries, and affix GPS collars (Knick 1990, Sikes et al. 2011). All captured canids will be fitted with appropriately-sized GPS collars in the field based on morphometrics previously indicated as reliable thresholds for

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species categorization: hind foot length, weight, width of head, and tail length (Hinton 2014); analysis of DNA samples collected during trapping efforts will help to assign captured canids to position along the species continuum post release. Age of individuals will be estimated based on physical characteristics, including weight and tooth replacement (Knick 1990, Hinton 2014, Gier 1968), and captured canids will be aged into one of three classes: > 2 years old as adults, < 2 but > 1 year old as juveniles, and > 6 months but < 12 months old as pups (Hinton 2014). Reproductive status will be determined based on estimated age class and presence of gonadal descent during the breeding season for males and the presence of nipple swelling or previous suckling for females (Hutson and Racey 2004, Magee 2008, Mengel 1971).

Captured individuals will be ear marked using a button tag (model 410, Ketchum Mfg. Co. [or equivalent], PO Box 10, 11 Town Shed Road, Lake Luzerne, NY 12846) placed along the middle of the ear where they are most protected from loss, with a pin-type applicator (485sa Pow-R-ceps plier, Ketchum Mfg. Co. [or equivalent]) (Silvy 2012). The puncture site will be treated with an antiseptic to deter infections. Each sympatric canid will also be marked with an individually-numbered, glass-encapsulated, passive integrated transponder (PIT model HPT12, 12.5 mm, 134.2 kHz, Biomark, Inc., 703 South Americana Blvd., Suite 150, Boise, ID; Gannon et al. 2007), using a syringe-type implanter and replaceable needle (model MK10 [implanter], model N125 [needle], Biomark, Inc.). Successful PIT placement will be verified with a mini portable reader (model GPR Plus, Biomark, Inc.). The implantation site will be prepared by swabbing with 70% alcohol (Mrozek et al. 1995) and a sterilized new needle will be used for each injection. The standard implantation site for transponders is subcutaneously on the dorsal midline of the back, cranial to the shoulder blades (Ingwersen 2000).

A skin biopsy will be taken from all captured target canids by puncturing the pinna of the ear with a biopsy punch in the same location where the ear tag will be placed (Palamar 2014). The biopsied area will be disinfected with alcohol after sampling. The skin biopsy will be placed in a labeled (ID, date, and sample type) cryogenic tube filled with 95% ethanol as buffer and then stored in a freezer until sent out to a lab for genetic analysis (Palamar 2014, Tom 2012). A selection of hairs with the root bulla attached will be pulled from the belly and placed in paper envelopes (Janecka et al. 2007). Hair samples will serve as back up to tissue samples

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for genetic testing. All samples will be sent to the Laboratory for Ecological, Evolutionary and Conservation Genetics, at University of Idaho (875 Perimeter Drive, MS 1136, Moscow, ID 83844) for genotyping to determine species as well as individual identification, hybridization presence, and parentage analysis following previously developed protocols (Adams et al. 2007, Hinton 2014, Miller et al. 2003). The appropriate genetic analyses that examine the coyote-hybrid-wolf species continuum will be performed.

Blood will be collected from all juvenile and adult target canids by venipuncture of the brachial or jugular veins using a 22-28-gauge needle (M. Palamar, NCWRC veterinarian, personal communication, 2016). As per NCWRC veterinarian recommendations, approximately 12 ml of blood will be collected for each animal for possible future testing for diseases of importance to sympatric canid species as well as the humans and domestic animals that they may come into contact with. A minimum of two 6 ml lavender top tube (for whole blood with EDTA) will be filled. Samples should be refrigerated at all times; a cooler with ice will suffice while in the field. Samples should be sent to the NCWRC within 48 hours or frozen for later shipping. Skin scrapes will be collected from animals presenting signs compatible with sarcoptic mange (lesions) for possible future diagnostic purposes. Lesions will be scraped until blood is drawn; the scrapings will be placed onto a slide and covered with a piece of clear tape for later visual confirmation.

Should overheating occur, processing will be performed in the following prioritization order and the first five items will need to be completed before releasing any individuals: 1) trap injury evaluation, 2) collaring, 3) DNA (skin biopsy) sample collection, 4) morphometrics, 5) aging, 6) PIT tagging, 7) weight, 8) ear tagging, 9) reproductive status, 10) ectoparasite evaluation, 11) blood collection, and 12) skin scrape collection.

Collaring

Vertex Plus GPS Collars will be attached to 25 sympatric canids captured on the study area, 10 of which will be equipped with proximity sensors (Vectronic Aerospace GmbH, Carl-Scheele-Str. 12, 12489 Berlin, Germany). Project staff will pilot test proximity sensor technology for utility in analysis of spatial and temporal community dynamics. Proximity sensors trigger increased GPS location acquisition during those time intervals when two collared individuals

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come within a set distance from each other (http://www.vectronic-aerospace.com/wildlife-monitoring/sensors/uhf-id-tags, accessed August 2016).

To avoid instances of collar induced strangulation, only adult (>2 years old) male and female individuals will receive collars (Hinton 2014). ASM guidelines recommends a collar weight of <5-10% of a canids bodyweight, we will observe these guidelines (Sikes et al. 2011). Sympatric canids not releasable at a capture site will not be collared and will not become study animals.

GPS radio-collars will have both VHF and GPS Iridium locational systems as well as store-on-board capabilities. Radio-collar units will be programmed to record GPS coordinates once every 1.75 hours producing approximately 13 locations per day while cycling through the 24-hour time cycle. These settings will allow for a GPS battery life of 300 to 552 days, averaging 431 days. The VHF beacon will be in operation from 0800 – 1600 hours daily. GPS locations will be sent via satellite once per day and each transmission with contain 12 locations. The use of an integrated drop off firing mechanism should allow the collars to drop off within a maximum of approximately 548 days after deployment. The drop off schedule once set cannot be changed. The drop off firing mechanism is wired to a battery unit independent of the collar battery, therefore should the collar battery become depleted, the drop off mechanism will not be affected (C. Akakpo, Vectronic Aerospace GmbH, personal communication, 2016). Unless a collared individual is recaptured before the collar battery dies, the drop off mechanism will fire at the scheduled time frame post collar deployment.

Observation of sympatric canid habitat use and movements will occur through GPS data obtained with combination GPS/VHF radio-collars. VHF relies on triangulation, the process of estimating the location of a transmitter by using two or more compass bearings obtained by using directional antennas at known locations remote from the transmitter's position (White and Garrott 1990), whereas GPS uses a satellite based system to obtain location coordinates. There have been many published studies where one or both of these methods were used, with mixed success for determining various aspects of carnivore ecology throughout the United States (Hinton et al. 2012, Schrecengost et al. 2009, Sparkman et al. 2012). While GPS technology has developed rapidly in recent history, the real time functional advantage of VHF

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cannot be disregarded. When GPS technology falters or malfunctions, VHF can serve as replacement for data collection in addition to its use in real time monitoring of study animals. Canids will be minimally monitored for mortality approximately every 30 days by using VHF aerial telemetry techniques (Whitehouse and Steven 1977) as there may be a delay in satellite transmission of GPS location data due to weather, season, and animal behavior. Transient canids and individuals from breeding pairs that have lost a mate, have been found to use much larger areas versus paired residents, potentially increasing the opportunity for losing track of these individuals when GPS technology reaches its functional capacity or experiences malfunction. VHF data may also provide locations of canids in cover too dense for GPS units to function. Use of VHF telemetry techniques for data collection may be expanded as necessary for project needs.

Spatial Data Analyses

Both minimum convex polygon (MCP) and adaptive kernel (AK) home ranges (95%) and core use areas (50% and 25%) (Seaman and Powell 1996, Seaman et al. 1999) will be calculated from GPS data by using BIOTAS (Ecological Software Solutions LLC, 2016) and Geospatial Modelling Environment (Spatial Ecology, LLC, 2016) for ArcGIS 10.2.2 (Environmental Systems Research Institute, 2016) (Benson et al. 2006, Riley 2006, Tucker et al. 2008, Hinton 2014) for comparison to older studies. These estimations can also be calculated using VHF data, provided data minimum requirements are met. Spatial distribution in relation to habitat will also be estimated by dynamic Brownian bridge movement models as described by Hinton (2014) with R statistical software (R Core Team 2016) using the moveud package with habitat covariates important to each species (Bryne et al. 2014, Collier 2013, Kranstauber and Smolla 2013, C. Proctor, personal communication, 2016). Additionally, recent research into how canids shift their ranges will also be investigated for populations on the AP (Morin and Kelly, in review). Spatial overlap and co-occurrence will be assessed using methods described by Shipley (2012). Habitat and cover types will be estimated from digitized maps created by the SEGAP (Hinton 2014) or ortho files, as available (Shipley 2012). Percent composition of habitat and cover types within home ranges and core areas as well as edge density will be quantified (Shipley 2012). Habitat selection and cover type use effects on spatial distribution will be estimated at both the population (2nd order) and individual (3rd order) spatial scales using resource selection functions

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(Johnson et al. 2006, Manly et al. 2002, Shipley 2012). Effects of seasonality and time of day activity will also be explored. The spatial and temporal patterns of space use by sympatric canids will be studied using data generated from the interaction GPS collar sensors, particularly distance between individuals and duration of proximity.

Den Monitoring

Project staff will attempt to locate den sites for sympatric canids to get pup counts, morphometric measurements, age estimates, and skin biopsies. Project staff will also attempt to monitor pup survival during the pup rearing season by using remote cameras placed around the den site (Harrison and Gilbert 1985, Parks 1979, Way et al. 2001). Pups will be weighed, measured, and PIT tagged during May and June of each year when they become active but are still den-obligated (Gier 1968). We will investigate the use of remote camera traps for monitoring den behavior with a two-camera array around the den (H. Garbe, personal communication, 2016, Kays and Slauson 2008). This method has been successfully used to monitor kit fox pup survival (Kluever et al. 2013). Because coyotes have been found to be sensitive to den site disturbance, there is a general lack of data in the literature regarding this approach for monitoring pup survival. Approaching an experimental methodology systematically will be important for determining which methods are effective and which are not. As a starting point for testing this methodology, remote cameras will be placed two to five meters from main den entrances and set to take photos using a passive infrared sensor trigger (a beam that when broken by movement through it, triggers the camera to take a series of photos) with a time restriction between photo intervals to limit the number of photos taken and maximize the space on the memory card for the time period between camera checks (Kluever et al. 2013). Cameras will be checked six days after deployment and will be redeployed (i.e. new batteries and memory card, if required); cameras will remain at each den site until radio-collar data indicates the den site has been moved (Kluever et al. 2013). Cameras will be not be redeployed to a new coyote den site during a season if that breeding pair has already moved the den once due to the disturbance of camera presence/deployment.

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Mortalities

If a collared animal dies during the project, the carcass will be sent to SCWDS for necropsy. Red wolves will be sent to the SCWDS laboratory for necropsy, unless it is determined to be a law enforcement case. In potential law enforcement cases, the NCWRC Division of Wildlife Management Chief and USFWS Ecological Services Raleigh Field Office Field Supervisor will be contacted and requested to contact the appropriate law enforcement personnel, immediately after determining the need for law enforcement involvement. The carcass and all relevant information will then be turned over to law enforcement; the GPS-collar will be removed and genetic samples will be taken from the individual prior to release to law enforcement.

E. Project Personnel

Andrea Shipley has worked for the North Carolina Wildlife Resources Commission as a Canid Biologist since February 2016. Prior to that, she worked as a Wildlife Biologist for a non-profit located in northeastern Nevada as well as in several different field biologist oriented positions. Andrea has a background in carnivore and spatial ecology, having earned her MS in Biological Sciences from Eastern Kentucky University and BS in Biological Sciences from Rutgers University; Andrea will act as project lead and coordinator.

Brandon Sherrill has worked for the North Carolina Wildlife Resources Commission as a Mammalogist since December 2013. Prior to that, he worked as an educator at the North Carolina Museum of Natural Sciences and as a regional wildlife biologist for the South Carolina Department of Natural Resources. Brandon earned a BS and MS in Fisheries, Wildlife, and Conservation Biology from North Carolina State University; Brandon will act as project supervisor.

Krishna Pacifici, Research Assistant Professor at NCSU, will be the quantitative analysis collaborator on the project. Krishna's background and experience in quantitative ecology makes him well suited to consult and assist with advanced statistical analyses of spatial data.

Lisette Waits, Department Head and Distinguished Professor at the University of Idaho, will be the DNA analysis collaborator for the project, responsible for all DNA related sample processing and subsequent analyses.

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F. Schedule and Estimated Costs

The project will run from soon after December 1, 2017 through June 30, 2020. The estimated timeline for major tasks is as follows:

Year 1: Initiate field work soon after December 1, 2017 with assistance from 1-2 field technicians; 1 technician will be required for trapping and den monitoring efforts. Data collection will begin immediately after collar deployment and data will be managed by Andrea Shipley throughout the life of the project. Data analysis will be initiated after den monitoring season concludes, with guidance and assistance from Krishna Pacifici at North Carolina State University (NCSU). Report, manuscript and presentation production will be initiated concurrently with data analysis.

Year 2: Continue field work and data collection with assistance from 1-2 field technicians. Continue data analysis with guidance and assistance from Krishna Pacifici at NCSU. Continue and finalize report and manuscript production, and presentation at professional working groups and/or meetings.

GPS technology allows researchers to collect locational data at fine spatial and temporal scales through the deployment of collar units on wildlife study subjects. In this project, we propose to study a sample of sympatric canid populations with GPS radio-collars, in order to investigate the population parameters outlined in previous sections as well as species interactions. The purchase and use of this technology is critical to meeting the research objectives set forth in this document as well as in the document included in Attachment 1.

While GPS technology has evolved over the past 20 years, the cost of technology has plateaued. Upfront cost per unit remains relatively high, however project savings occurs at the back end when compared to older telemetry technology such as very high frequency (VHF)

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which require intensive labor to collect data at similar spatial and temporal scales. Pilot testing the proximity sensor enabled GPS-collars will allow investigation of the utility of this relatively new tool for community dynamics analysis by providing an increased locational data acquisition when individuals come within a set distance, or closer, from each other. Additionally, these sensors record the identities of the interacting individuals and the duration of their interactions. Using a trigger to temporarily switch GPS fix schedules will enable us to collect very fine scale data while conserving battery life, achieving project objectives in an efficient manner. Exploring the efficaciousness of this technology has the potential to positively impact future research projects requiring use of GPS-collars for data collection.

Aerial tracking will provide regular study animal surveillance useful to investigate cases of mortality, collar malfunction, or satellite data transmission delays, which can vary seasonally. In some situations, ground tracking could prove less expensive than aerial tracking. However, ground telemetry techniques require more than one biologist working in tandem to acquire accurate location estimates. This often translates to increased labor to collect data, particularly in large study areas. Aerial tracking will provide a more efficient and cost-effective method for surveilling study subjects in this large study area, requiring only one biologist and a contracted pilot. NCWRC personnel will perform aerial tracking along with the NCWRC pilot at a minimum frequency of every 30 days.

Use of local trappers to assist with sampling efforts provides several benefits. Local trappers have established, long-term relationships with private land owners, thereby providing access to private lands that might be otherwise difficult to secure. This will enable project biologists to obtain a representative sample of sympatric canids in the study area, as well as to operate more trap lines concurrently. This is particularly important when using a SCR sample design, as it will have direct implications on the resulting analyses and inferences.

As part of collaboration efforts, the project will contract the services of Krishna Pacifici, Research Assistant Professor in the Applied Ecology department at NCSU. Krishna's expertise is in quantitative ecology; consultation and assistance services provided will allow project biologists to make appropriate statistically relevant inferences from collected data.

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DNA analysis will be contracted to Lisette Wait's lab at the University of Idaho. Lisette's team at The Laboratory for Ecological, Evolutionary and Conservation Genetics has previous experience in analyzing red wolf and coyote hybrid molecular samples and has the most comprehensive DNA methodology for this sympatric canid species continuum in the nation. This expertise will facilitate expedient species identification on collared study animals besides landscape level population dynamics analysis.

	Commission	In-kind	Total
a. Personnel	$ 7,200.00	$ -	$ 7,200.00
b. Fringe Benefits	$ -	$ -	$ -
c. Travel	$ 30,000.00	$ -	$ 30,000.00
d. Equipment	$ 54,000.00	$ -	$ 54,000.00
e. Supplies	$ 61,500.00	$ -	$ 61,500.00
f. Contractual	$ 315,590.00	$ -	$ 315,590.00
g. Construction	$ -	$ -	$ -
h. Other	$ 6,000.00	$ -	$ 6,000.00
i. Total Direct Charges (sum of a – h)	$ 474,290.00	$ -	$ 474,290.00
j. Indirect Charges	$ 4,800.00	$ -	$ 4,800.00
k. Totals (sum of i and j)	$ 479,090.00	$ -	$ 479,090.00
Federal (75%)			$ 359,317.50
State (25%)			$ 119,772.50

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G. Geographic Location

Three counties of the Albemarle Peninsula of North Carolina (Dare, Hyde, and Tyrrell counties).

H. Related Federal Projects

NC-W-F15AF00726 (W-72) NC-Division of Wildlife Management Cooperative Projects

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I. Glossary

Abundance: Species abundance is the number of individuals per species, and relative abundance refers to the evenness of distribution of individuals among species in a community.

Adaptive kernel (AK): A probabilistic home range estimator based on the distribution and density of locations that has been collected over a period of time.

Adverse reactions: In pharmacology, any unexpected or dangerous reaction to a drug.

Aerial: Existing, happening, or operating in the air.

Annually: Once a year; every year.

Anthropogenic: Caused or influenced by humans.

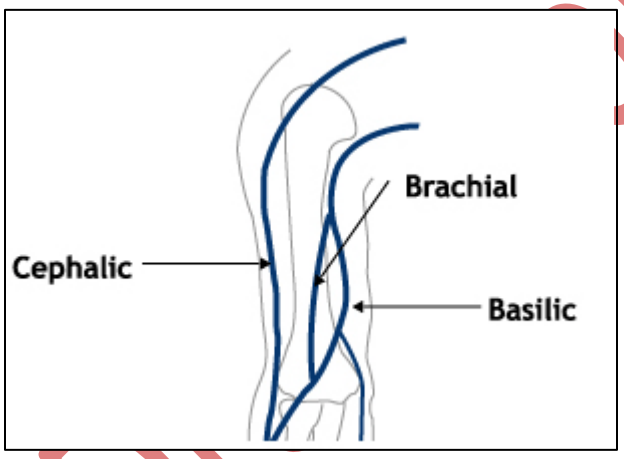
Apex: Having no natural predators in its ecosystem.

Ataxia: The loss of full control of bodily movements.

Beacon: A radio beacon whose purpose is the investigation of the propagation of radio signals.

Biopsy: The removal for diagnostic study of a piece of tissue from a living body.

Brachial vein: One of a pair of veins accompanying the brachial artery and uniting with each other and with the basilic vein to form the axillary vein.



Breeding pair: A pair of animals which cooperate over time to produce offspring with some form of a bond between the individuals.

Carrying capacity: The maximum population size of the species that the environment can sustain indefinitely, given the food, habitat, water, and other necessities available in the environment.

Compensatory immigration: Individuals emigrating from areas with lower mortality to those with higher mortality; filling a deficiency of individuals in a population experiencing higher mortality. The increase in size or activity of one part of an organism or organ that makes up for the loss or dysfunction of another.

Composition: The combining of distinct parts or elements to form a whole.

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Co-occurrence: Refers to observation of the spatial overlap between two (or more) different individuals over a period of time.

Coordinates: Any of the scales or magnitudes that serve to define the position of a point.

Core use areas: An area within a home range exhibited by a dense concentration of location points; commonly estimated at 50% of the location data points.

Covariates: A variable that is possibly predictive of the outcome under study.

Cranial: Pertaining to the cranium or to the anterior (in animals) or superior (in humans) end of the body.

Cryogenic: Very low temperatures, e.g. -80^{o}C.

Den-obligated: Restricted to a particular condition of life, in this case restricted to a den site.

Density: A measure of the number of organisms that make up a population in a defined area.

Deployment: To organize and send out (people or things) to be used for a particular purpose.

Depredation: The act of preying upon.

Depressed respiration: A decrease in the ability to exhale and inhale; respiration that has a rate below 12 breaths per minute or that fails to provide full ventilation and perfusion of the lungs.

Diagnostic: The process of determining by examination the nature and circumstances of a diseased condition.

Disorientation: Loss of one's sense of direction, position, or relationship with one's surroundings.

Distribution: The manner in which a biological taxon is spatially arranged.

DNA: (deoxyribonucleic acid) is a type of macromolecule known as a nucleic acid. It is shaped like a twisted double helix and is composed of long strands of alternating sugars and phosphate groups, along with nitrogenous bases (adenine, thymine, guanine and cytosine).

Dorsal: Situated on or toward the upper side of the body, equivalent to the back, or posterior, in humans; situated on or toward the posterior plane in humans or toward the upper plane in quadrupeds.

Duration: A continuous period of time.

Dynamic Brownian bridge movement models: Incorporates temporal and behavioral characteristics of movement paths into estimation of home range.

Ectoparasite: a parasite that lives on the outside of its host rather than within the hosts body; e.g. fleas and lice.

Effective trap area: Calculated by buffering each trap site by half the mean maximum distance traveled, each of these boundaries are dissolved, creating a measurable area.

Efficacious: Producing or capable of producing a desired effect.

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Efficient: Accomplishment of or ability to accomplish a job with a minimum expenditure of time and effort.

Euthanize: The act of putting to death painlessly or allowing to die, as by withholding extreme medical measures, a person or animal suffering from an incurable, especially a painful, disease or condition.

Expedient: Suitable for achieving a particular end in a given circumstance.

Evaporative cooling: reduction in temperature resulting from the evaporation of a liquid, which removes latent heat from the surface from which evaporation takes place.

Facilitate: Make an action or process easy or easier.

Genotyping: Investigate the genetic constitution of (an individual organism).

Gonadal descent: The act or process of descending from a higher to a lower location; testicular descent occurs during the breeding season annually.

GPS: Global Positioning System, is a radio navigation system that allows land, sea, and airborne users to determine their exact location, velocity, and time 24 hours a day, in all weather conditions, anywhere in the world.

Home range: an area over which an animal or group of animals regularly travels in search of food or mates, and that may overlap with those of neighboring animals or groups of the same species.

Hybridization: The result of mixing, through sexual reproduction, two animals or plants of different breeds, varieties, species or genera.

Immobilization agent: An active force or substance capable of producing an effect.

Implantation: To put or fix firmly.

Inbreeding depression: The reduced biological fitness in a given population as a result of inbreeding, or breeding of related individuals.

Inception: The establishment or starting point of an institution or activity.

Interspecific: Existing or occurring between different species.

Iridium: A satellite constellation providing voice and data coverage to satellite phones, pagers and integrated transceivers over the Earth's entire surface.

Jugular vein: Any of several large veins in the neck, carrying blood from the head and face.

Lacerations: A deep cut or tear in skin or flesh.

Locational: A position or site occupied or available for occupancy or marked by some distinguishing feature.

Malfunction: Fail to operate in the normal or usual manner

Methodology: A system of methods used in a particular area of study or activity.

Midline: A median line or plane of bilateral symmetry, especially that of the body.

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Minimum convex polygon (MCP): Completely enclose all data points by connecting the outer locations in such a way as to create a convex polygon.

Molecular samples: Genetic samples that may be used for investigation of genetic constitution of an individual.

Morphometrics: The process of measuring the external shape and dimensions of landforms, living organisms, or other objects.

Mortality: The state of being subject to death.

Non-target bycatch: Animals caught by accident that are not the target species being sought.

Parameters: A numerical or other measurable factor forming one of a set that defines a system or sets the conditions of its operation.

Parentage: The origin of something; the state or relation of a parent.

Passive integrated transponder: A microchip implant is an identifying integrated circuit placed under the skin of an animal.

Pinna: The external part of the ear in humans and other mammals; the auricle.

Plateaued: A period or state of little or no growth or decline.

Population dynamics: The branch of life sciences that studies the size and age composition of populations as dynamic systems, and the biological and environmental processes driving them (such as birth and death rates, and by immigration and emigration).

Population growth: The increase in the number of individuals in a population.

Population size: A group of organisms of the same species that live in the same area.

Population status:

Population trend: Changes over time and can include changes in ranging behavior and distribution, biogeography and life-history.

Population viability: The process that determines the probability that a population will go extinct within a given number of years.

Proximity: Nearness in space, time, or relationship.

Quantified: Express or measure the quantity of.

Quantitative: Relating to, measuring, or measured by the quantity of something rather than its quality.

Radio-telemetry: The use of radio waves for transmitting information from a distant instrument to a device that indicates or records the measurements.

Recumbency: The state of leaning, resting, or reclining.

Reintegrate: Restore (elements regarded as disparate) to unity.

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Remnant: A small remaining quantity of something.

Reproductive status: Relating to or effecting reproduction.

Spatial: Relating to, occupying, or having the character of space.

Spatial capture-recapture: A method commonly used in ecology to estimate an animal population's size. A portion of the population is captured, marked, and released. Marked animals are either recaptured or are tracked, each tracking location being considered a recapture.

Species Continuum: An aggregate of species capable of interbreeding, resulting in fertile hybrid offspring whose genetic composition may represent a varying array of phenotypes and genotypes from the parental species, at which the extreme ends of the spectrum are distinct.

Standardize: Cause (something) to conform to a standard.

Statistically relevant inferences: the process of deducing properties of an underlying distribution by analysis of data. Inferential statistical analysis infers properties about a population: this includes testing hypotheses and deriving estimates.

Stochastic population models: Ecological population modeling is concerned with the changes in population size and age distribution within a population as a consequence of interactions of organisms with the physical environment, with individuals of their own species, and with organisms of other species; stochasticity possesses some inherent randomness. In stochastic population models, the same set of parameter values and initial conditions will lead to an ensemble of different out puts.

Strangulation: The condition in which circulation of blood to a part of the body is cut off by constriction.

Stratifying: Form or arrange into strata, one of a number of portions or divisions likened to layers or levels.

Surveillance: Continuous observation of a place, person, group, or ongoing activity in order to gather information.

Survival: A living or continuing longer than, or beyond the existence of, another person, thing, or event.

Sympatric: Occurring within the same geographical area; overlapping in distribution.

Tachycardia: A heart rate that exceeds the normal resting rate. In general, a resting heart rate over 100 beats per minute is accepted as tachycardia in human adults.

Telemetry: See radio-telemetry.

Temporal: Of or relating to time.

Tooth replacement: The process of development of two successive sets of teeth, initially the deciduous set and consecutively the permanent set.

Transmitter: A set of equipment used to generate and transmit electromagnetic waves carrying messages or signals, especially those of radio or television.

Transponder: A device for receiving a radio signal and automatically transmitting a different signal.

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Vaccinate: Treat with a vaccine to produce immunity against a disease; inoculate.

Venipuncture: The puncture of a vein as part of a medical procedure, typically to withdraw a blood sample or for an intravenous injection.

VHF: Very high frequency is the ITU designation for the range of radio frequency electromagnetic waves (radio waves) from 30 MHz to 300 MHz, with corresponding wavelengths of ten to one meters.

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Attachment 1: Intra-service Section 7 Biological Evaluation Form

Region 4

INTRA-SERVICE SECTION 7 BIOLOGICAL EVALUATION FORM

[Note: This form provides the outline of information needed for intra-Service consultation. If additional space is needed, attach additional sheets, or set up this form to accommodate your responses.]

Originating Person: Andrea Shipley

Telephone Number: 252.926.0266 **E-Mail:** andrea.shipley@ncwildlife.org

Date: November 8, 2016

PROJECT NAME (Grant Title/Number): NC – Division of Wildlife Management Cooperative Projects / (W-72)

I. Service Program:

_____Ecological Services
__X__Federal Aid
  _____Clean Vessel act
  _____Coastal Wetlands
  _____Endangered Species Section 6
  _____Partners for Fish and Wildlife
  _____Sport Fish Restoration
  __X__Wildlife Restoration
_____Fisheries
_____Refuges/Wildlife

II. State/Agency:

North Carolina / North Carolina Wildlife Resources Commission

III. Station Name:

FWS Raleigh Ecological Services Office

IV. Description of Proposed Action (attach additional pages as needed):

Conduct research project entitled "**Coyotes of the Albemarle: Spatial Ecology, Resource Selection, Demographics, and Interactions with a Sympatric Canid**"

The coyote (*Canis latrans*) is now abundant throughout the 100 counties in North Carolina (NC), where they are managed as nongame with no closed season or bag limit (NC Wildlife Resources Commission 2016). Previously restricted to the West and Midwest regions of the United States, by the early 1990s coyotes had expanded their range into the Albemarle Peninsula (AP), which is situated in the northeast coastal plains region of NC (Hinton et al. 2012, Murray et al. 2014).

Recently described as using "compensatory immigration," coyotes are able to opportunistically fill spatial resource gaps by periodic transiency (Hinton 2016). These periods of transiency can sometimes bring coyotes into conflict with humans and other canids, especially while taking advantage of anthropogenic resources. Though a rural area, human land uses predominate on the AP. The AP is comprised of approximately 30% agricultural fields, 50% forest and coastal marshes, and 20% "other" land cover types on federal, state and private lands (Dellinger 2011).

In 1968, individuals from a remnant population of red wolves were removed from Texas and Louisiana and a captive breeding program was initiated. The United States Fish and Wildlife Service (USFWS) released a non-essential, experimental population of red wolves (*Canis rufus*) on the Alligator River National Wildlife Refuge (ARNWR) in 1987 (Hinton et al. 2013). The red wolf population increased until 2008 and peaked at around 208 individuals (USFWS Red Wolf Recovery Program 2007), a few animals short of the recovery goal of 220 in the wild (USFWS Red Wolf Recovery Program 2013), with an estimated carrying capacity of 140-150 for the AP (Hinton et al. 2013, Kelly et al. 1999, USFWS Red Wolf Recovery Program 2007). Red wolves presently inhabit an approximately 6900 square kilometer recovery area within Beaufort, Dare, Hyde, Tyrrell, and Washington counties (Wildlife Management Institute 2014).
Accurate up-to-date estimates of the population are unavailable, but USFWS staff report a population size of 45-60 individuals with three mortalities in 2016 (https://www.fws.gov/redwolf/index.html July 2016). Hybridization with coyotes, inbreeding depression, and gunshot mortality have all been suspected issues that have affected the population growth and viability since the inception of the Red Wolf Recovery Program (RWRP) (Hinton et al. 2013). In 2013, NCWRC and USFWS established a committee to oversee the collaborative management and conservation of red wolves and other canids on the AP. A USFWS memorandum documented detailed action items for the joint management of canids on the AP, including specific research objectives which this proposal seeks to address (Attachment 1).

As coyotes on the AP increase in number, monitoring coyote movements, particularly in relation to red wolves, will provide important data to NCWRC and USFWS staff for science-based local and landscape-level decisions about coyote population management. Collection of finer temporal scale location data will help to manage interactions of both canid species with humans, as well as to support development of dynamic stochastic population models.

Coyote and red wolves will be live trapped by cooperating NCWRC and USFWS staff, and private trappers using double coil size 3 foothold traps, during the breeding season (Nov-Feb for coyote, Jan-Feb for red wolves) in the tri-county area of Dare, Hyde and Tyrrell. Morphological measurements, incidents of injury, occurrence of ectoparasites, age classification, and reproductive status will be determined; blood and tissue samples will be taken for genetic analysis. All captured individuals that meet the age classification and weight requirements will be collared with GPS collar units. All captured and collared individuals will be released at the capture site. The objectives listed below will be achieved by obtaining measurements, samples and information from the captured, collared, and tracked individuals over the course of three years using GPS location data.

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Objective 1: Use GPS collar and proximity sensor technology to test performance under various conditions and evaluate the frequency and accuracy of the scheduled fix rates.

Objective 2: Use fine scale GPS data collection for investigating annual and seasonal spatial dynamics of sympatric canids: home range and core area sizes, amount of overlap in home range and core areas, movement pathways and daily activity patterns, and cover type selection and preference.

Objective 3: Use fine scale GPS data collection for investigating the number and age structure of offspring for family groups of collared sympatric canids.

Objective 4: Use fine scale GPS data collection for investigating sources of mortality for sympatric canids.

Objective 5: Use fine scale GPS data collection for preventing and mitigating canid conflicts with landowners.

Objective 6: Determine genetic profiles of sympatric canids through DNA identification of all captured individuals, parentage, and presence of hybridization.

V. Pertinent Species and Habitat:

A. Include species/habitat: See section VI

B. Complete the following table:

SPECIES/CRITICAL HABITAT	STATUS[1]
Canis rufus	T

[1]STATUS: E = endangered, T = threatened, PE = proposed endangered, PT =proposed threatened, CH = critical habitat, PC = proposed critical habitat, C = candidate species

VI. Location:

A. Statewide

Albemarle Peninsula (see web address www.ncwildlife.org)

B. Section, township, and range (or latitude and longitude):

Dare, Hyde, Tyrrell counties

C. Distance (miles) and direction to nearest town:

As stated above

D. Species/habitat occurrence:

Canis rufus

VII. Determination of Effects:

A. Explanation of effects of the action on species and critical habitats in item V. B. (attach additional pages as needed):

SPECIES/CRITICAL HABITAT	IMPACTS TO SPECIES/CRITICAL HABITAT
Canis rufus	Trap induced injury is possible

B. Explanation of actions to be implemented to reduce adverse effects:

SPECIES/CRITICAL HABITAT	ACTIONS TO MITIGATE/MINIMIZE IMPACTS
Canis rufus	Use of appropriate trap types, daily trap checks, treatment of minor injuries, trapping season limitations and limitations on environmental conditions for trap operation

VIII. Effect Determination and Response Requested:

Species/ Critical Habitat	Determination[1]			Response[1] Requested
	NE	NA	AA	
Canis rufus		X		Concurrence

[1] Determination/Response Requested:

NE = No Effect. This determination is appropriate when the proposed action will not directly, indirectly, or cumulatively impact, either positively or negatively, any listed, proposed, candidate species or designated/proposed critical habitat. Response Requested is optional but a "Concurrence" is recommended for a complete Administrative Record.

NA = Not Likely To Adversely Affect. The determination is appropriate when the proposed action is not likely to adversely impact any listed, proposed, candidate species or designated/proposed critical habitat or there may be beneficial effects to these resources. Response Requested is a "Concurrence".

AA = Likely To Adversely Affect. This determination is appropriate when the proposed action is likely to adversely impact any listed, proposed, candidate species or designated/proposed critical habitat. Response Requested for listed species is "Formal Consultation". Response Requested for proposed or candidate species is "Conference".

Signature (originating station) **Date**

Title

IX. Reviewing Ecological Services Office Evaluation:

A. Concurrence _____ Non-Concurrence _____

B. Formal consultation required _____

C. Conference required _____

D. Formal conference required _____

E. Remarks (attach additional pages as needed):

_____ _____

Signature **Date**

_____ _____

Title **Office**

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Attachment 2: Joint Memorandum

MEMORANDUM

November 20, 2013

TO: All Interested Parties

FROM: "for" Cynthia K. Dohner, Director, Southeast Region, U.S. Fish and Wildlife Service
Gordon S. Myers, Executive Director, N.C. Wildlife Resources Commission

SUBJECT: Collaborative Conservation of Red Wolves and Other Canids on North Carolina's Albemarle Peninsula

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Recovery of the federally-listed red wolf has been a priority for the U.S. Fish and Wildlife Service (FWS) for more than 20 years and is focused in North Carolina on the Albemarle Peninsula (AP; i.e., Hyde, Tyrrell, Washington, Beaufort, and Dare counties). Comprehensive stakeholder involvement and collaboration with other management agencies is critical to successful recovery of any at-risk species. The North Carolina Wildlife Resources Commission (WRC) is a key collaborator in this regard, as it has jurisdiction over all state-trust wildlife resources in N.C.

Since 2009, the FWS and WRC have worked to broaden our collaboration in the conservation and management of all canid species (including red wolves) on the AP. As these efforts have solidified, specific actions have been jointly identified by our two agencies that will improve conservation outcomes. These actions are categorized into five areas; collaboration, research, outreach, regulatory, and enforcement. Specific action items are outlined and prioritized within each of these categories in Attachment A.

This memo establishes the FWS's and WRC's commitment to initiate, or to continue, the efforts outlined in Attachment A. The common goal in this effort is to establish clear expectations and accountability for collaboration regarding the action items on Attachment A, thus resulting in enhanced and seamless canid conservation and management on the AP. This approach provides the best opportunity to achieve recovery goals for red wolves, while at the same time managing other canids to balance biological variables with social expectations. The dynamics of these canid species are complex and offer unique opportunities for innovation. Appropriate staff from each agency is hereby tasked with immediately developing a timeline to implement these actions. Through this commitment, we will continue to advance our collective conservation goals.

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Attachment A

Action Items for Collaborative Conservation of Canids on North Carolina's Albemarle Peninsula (AP)
(*Note: Action Items are prioritized within category.*)

Collaboration

1. The N.C. Wildlife Resources Commission (WRC) and U.S. Fish and Wildlife Service (FWS) will formalize in writing the collaborative management of canids on the AP. This agreement should:
    a. include a clear mission statement, goals, objectives, and implementation strategies (ask and answer the "Why?");
    b. set a goal to define success regarding canid management on the AP;
    c. espouse a philosophy of canid management operating within the context of a three-legged stool (i.e., federal and state governments and stakeholders);
    d. as available, commit funding and staffing resources for field personnel to contribute to the conservation of the red wolf and management of coyotes;
    e. as available, commit funding to conduct research pertinent to canid management on the AP;
    f. establish polices and goals for developing a collaborative genetic archive for AP canids, a data sharing portal accessible by staff in both agencies, and reciprocal sharing of all historical data (including phenotypic and genotypic data and literature) of the red wolf;
    g. establish a foundation for developing and implementing an adaptive approach to canid management on private lands on the AP;
    h. initiate development of a collaborative canid research program;
    i. describe plans to conduct the next five year Red Wolf Program review;
    j. outline options for holding annual workshops with federal and state enforcement staff;
    k. outline plans to hold semi-annual coordination meetings regarding canid management on the AP; and
    l. develop milestones for future development of a management plan for all canids in the AP.

2. The FWS will initiate a review of the current Red Wolf Recovery Plan to determine if the state-of-our-knowledge or field conditions have changed such as to warrant its revision. Review and comments from the WRC will be considered in this evaluation.

3. The WRC, with support and participation of the FWS, will establish a "Canid Forum" (similar to that established for manatees in Florida) to facilitate communication and discussion regarding canid management and citizen science opportunities on the AP.

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Attachment A

Research

1. The FWS and WRC will provide funding and logistical support for research identified by the Red Wolf Recovery Implementation Team, Red Wolf Program staff, other FWS staff, or the WRC that promote the conservation and recovery of the red wolf and other canids on the AP. Studies could include:
    a. tests of the "placeholder theory" on the AP, including behavior of sympatric canids,
    b. determining carrying capacity of canids on the AP,
    c. determining genetic profiles of canid species on the AP,
    d. evaluating predator-prey dynamics,
    e. studies of canid habitat use,
    f. epidemiology of diseases impacting canids on the AP,
    g. development of stochastic simulation models of sympatric canid population dynamics and habitat use, and
    h. canid dispersal dynamics

2. The FWS and WRC will conduct jointly-supported research to determine the attitudes and opinions of N.C. private landowners and other citizens concerning canids on the AP (i.e., human dimensions studies).

Outreach

1. The FWS and WRC will collaborate with other partners to design and implement broad-based outreach and marketing programs with clear goals, objectives, strategies, and measurable outcomes, including development of consistent agency messages and educating the public about canids on the AP.

Regulatory

1. The FWS and WRC will initiate a review and, if needed, subsequent rule-making to clarify concepts or rectify conflicts in current federal or state rules (including the current 10(J) rule).

2. The WRC will review and evaluate statutory requirements for listing red wolves as state threatened in the five AP counties.

3. As data demonstrating a relationship between coyote hunting and red wolf mortality become available, the FWS and WRC will evaluate, and if appropriate implement, adaptive approaches to regulate of take of coyotes that may result in incidental take of red wolves.

4. The WRC will evaluate the status, management, and regulation of Controlled Fox Hunting Preserves.

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Attachment A

5. The WRC will develop BMPs (due care provisions) for coyote hunting, trapping, and live sale.

6. The WRC will compile, compare, and contrast canid hunting and trapping regulations and programs in other states, including, but not limited to, other states with other species of wolves.

Enforcement

1. The FWS and WRC will develop coordination strategies to improve enforcement of federal regulations protecting red wolves.

Attachment 3: Landowner Agreement Form

NC Wildlife Resources Commission
Wildlife Management Division
Wildlife Diversity Program
Landowner Agreement for Scientific Collection

_____ / _____ / _____
MM DD YYYY

Property Type
Private _____ Federal _____ State _____

NC Wildlife Resources Commission
Address: 1701 Mail Service Center, Raleigh, NC 27699-1701
Phone: 919-707-0010

Cooperator's Name: _____
Last First Middle

Cooperator's Address: _____
Street City, State, Zip

Where will the work be performed? _____

give address or directions if different from above _____

Business, Farm, Property Common Name _____

Owner's or Rep Name _____ _____
If different from Cooperator Telephone Number

Owner's Address: _____
If different from Cooperator Street City, State, Zip

WRC Employee & Work Location	Species
Employee Name	1)
	2)
Duty Area	3)
	4)

I, the cooperator or cooperator's representative, have been informed of the methods and the manner in which research devices will be used, and of the possible hazards associated with their use. I understand that NCWRC, (to include its officers, employees and agents) will: exercise reasonable precautions to safeguard all persons to prevent injury to target and non-target animals; guard against the mishandling of control devices and materials; and exercise due caution and proper judgment in all scientific collection operations. I understand that NCWRC may collect Global Positioning System (GPS) coordinates at the project site as part of component or activity tracking or as wildlife disease monitoring or research data. I, the undersigned cooperator, do hereby give my consent and concurrence to NCWRC, its employees, and its agents, to use, upon lands owned, leased, or otherwise controlled by me, and identified by this document, the following methods and devices (an attachment of additional devices and/or methods may be attached):

Statement of agreement: The landowner, cooperator, or representative, as listed above hereby give permission to NCWRC to perform trap and release of the species listed for scientific collection purposes. In consideration of these understandings, I, the cooperator or cooperator's representative, agree to: assume responsibility for injury to my property under my control, when said injury is not the result of negligence on the part of NCWRC (it's officers, employees, and agents); assist in maintaining such warning signs as NCWRC may place for the purpose of notifying persons entering onto such lands of the possible hazards associated with scientific measures in use thereon; and to give adequate warning of these possible hazards to persons I authorize to enter onto such lands. Further, I, the cooperator or cooperator's representative, agree not to concurrently use or allow to be used upon lands covered by this agreement, any canid depredation efforts during the scientific collection time period.

Landowner Signature/Date _____
Signature Date

WRC Employee Signature/Date _____
Signature Date

Attachment 4: Trapper Service Contract

Contract in development.

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Denton Wildlife Services
Mattamuskeet Ventures Coyote Management Plan

Mattamuskeet Ventures hired Denton Wildlife Services to trap and remove coyote from their property. Denton Wildlife Services hired Terry Marsh with Carolina Predator Control.
I ran 11 trail cameras before we started trapping, and during our time there. Two weeks before and two while we were there for a total of 4 weeks. The best we could tell there was less than 10 canines on MMV properties. I am sure there are more but we trapped, did track counts, scat, and ran cameras. That was the best number we could come up with.

Of the canines I got pictures of, there was one pair of collard wolves, one single wolf with a collar in generally the same area as the pair. There was one other single collard wolf on the other side of the property. That made four USFWS collard wolves.

There was also one collared canine that appeared to be a normal size coyote wearing a FWS collar. I think it might have been one of the sterilized coyotes.
I also have a picture of NCWRC collared coyote. It had an uncollared mate. The mate was a normal size coyote.
I gave Mike Morris with USFWS a copy of all collard canines that had USFWS collars and a Map of their locations. Mike gave us two holding cages and a chip scanner in case we caught a Red Wolf or a collared animal.

I will include a USB with pictures and videos with the required collected information when I turn it into Andrea Shipley.

In the areas where I was picking up just wolf pictures off the trail cameras and their track sign on a regular basis we did not set traps. We thought it would be best to not catch a collared wolf.

In the area where we caught two wolves last year, both were collared and released back on the property.
I was told last year by the USFWS that after testing both were Red wolves. This year we were told by the USFWS that the blood work came back as 75% wolf. USFWS told us if we caught one of those canines they would remove the collars and put the animal down. The USFWS now considers a pure Red Wolf at **92% and higher.**
In this same area where we caught the two 75% canines, we caught two more this trip (Oct/18) that looked identical to the 75% canines we caught in April.
We met with Mike Morris (USFWS) and were told by Mike they were coyotes. Both were females.

We only kept 3 canines, two females and one male. Of those, we collected DNA Hair samples, hock and tail measurements and a lower canine for aging. We also recorded GPS coordinates for each capture site. Since April we have removed 17 canines from

the property. Two were returned, the two that were thought to be wolves. Nine were females with only one being bred.
On incidentals we caught 7 raccoon, 3 opossums, and two bobcats. All were released unharmed except for one opossum and one raccoon that were killed by bear. We had 14 traps set off by deer and 23 by bear. We did catch and hold two bear that were big enough to pull free and a third one in the 250 lb range, a sow we had to release.

I have asked Andrea, when she gets the DNA results from the canines samples I turned in, in April, I would like to get a copy of the results. Also I would like the same information with the ages on the samples I turned in from Oct/18.

Thanks
David
Denton Wildlife services


Page 2; 51: Maybe a short discussion on specifically what types of property damage is being referred to here? There are very few livestock operations on the AP, so depredation rates on livestock is relatively low. Wolves have been involved in very few depredation incidents over the years, and I'm not sure what other types of property damage sympatric canids would potentially cause? Most of the complaints we receive tend to be simple presence of canids on private property or a perceived reduction in observed game populations, which of course are not property.

Page 2; 54-55: Has there been any research done to analyze direct predation of canids on at risk ground nesting species as compared to potential benefits of canids through the control of other known nest predators?

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I would prefer to see a research proposal more limited in scope with a clearer objective, and to use equipment and protocols consistent with equipment and protocols already in place on the A.P. Target animals in current zones of ignorance (which is now the majority of the A.P.) instead of targeting known wolf packs. While I think it is preferable in theory for the two agencies to collaboratively conserve and manage red wolves and other canids on the A.P., it is problematic when their respective objectives are polar opposites of one another. It is quite clear now, after exhaustive and repetitive reviews on the taxonomy and historical range of the red wolf, that the best available science indicates that this is indeed a valid listable species native to northeast NC. If the two agencies are to realistically work towards the conservation and management of canids on the A.P., the WRC needs to, at minimum, rescind their resolution requesting that red wolves be removed from the state of NC and declared extinct in the wild, and move towards listing the red wolf as a state listed threatened species. Then, in addition to collaborative research, we can explore joint regulatory efforts to reduce anthropogenic causes of red wolf mortality on the A.P. Until then I am not comfortable handing over this level of monitoring and management of red wolves on the A.P. to WRC.

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STATE: North Carolina

GRANT TITLE: W79-Wildlife Management

PROJECT TITLE: Pilot Study – Using Fine Scale GPS Technology to Research Sympatric Canid Population Dynamics (Job 2.0?)

A. Problem and Need

The coyote (*Canis latrans*) is now abundant throughout the 100 counties in North Carolina (NC), and is managed as nongame with no closed season or bag limit (NC Wildlife Resources Commission 2016). Previously restricted to the West and Midwest regions of the United States, by the early 1990s coyotes had expanded their range into the Albemarle Peninsula (AP), which is situated in the northeast coastal plain region of NC (Hinton et al. 2012, Murray et al. 2014). In recent years as coyotes have increased their population, some have begun to make use of the Outer Banks region.

The United States Fish and Wildlife Service (USFWS) released a non-essential, experimental population of captive-bred red wolves (*Canis rufus*) on the Alligator River National Wildlife Refuge (ARNWR) in 1987 (Hinton et al. 2013). This population increased until 2008 and peaked at around 130 individuals (Group Solutions, Inc. 2016), short of the recovery goal of 220 in the wild (USFWS Red Wolf Recovery Program 2013). The AP has an estimated carrying capacity of 140-150 wolves (Hinton et al. 2013, Kelly et al. 1999, USFWS Red Wolf Recovery Program 2007). The exact number of red wolves is not known, but USFWS staff report a population estimate of 45-60 individuals with eight mortalities to date in 2016 (https://www.fws.gov/redwolf/index.html August 2016). Hybridization with coyotes and inbreeding depression are suspected factors that have affected red wolf population growth and viability since the inception of the Red Wolf Recovery Program (RWRP), while vehicular and gunshot mortality are known factors (Hinton et al. 2013). Because of hybridization between red wolves and coyotes, the AP supports a continuum of sympatric canids, hereafter referred to as "sympatric canids."

As part of a recent program review, the USFWS halted many aspects of the RWRP in 2015 and discontinued the coyote sterilization program, potentially affecting the spatial

Commented [OSE1]: Citation! How abundant?

Commented [JM2]: Morse - The 220 animals in the wild was to be a total population number devided into 2-3 mainland sites.

Commented [JM3]: Morse - The actual estimate for carrying capacity in the NEP is more like 175 animals.

Commented [OSE4]: This information is obviously out of date and invalid.

Commented [OSE5]: Hybridization has not been an issue since the beginning of the program as there were no coyotes out here in the beginning.

Commented [JM6]: Morse - Gunshot mortality is known to be the number one and most critical factor affecting population growth.

Commented [JM7]: Morse - The coyote sterilization program needs to be part of the NCWRC research proposal. (Deal breaker)

Draft - Confidential

distribution and population dynamics of sympatric canids. Telemetry data from coyotes on the AP suggests that about 70% of coyotes are residents (i.e., those that defend set territories) while the other 30% are transients, with most being dispersing juveniles (Hinton et al. 2015). Transient coyotes do not defend set territories. Coyotes can travel long distances and become transient even as adults, especially when they lose their mate. Recently described as using "compensatory immigration," coyotes opportunistically fill spatial resource gaps by periodic transiency; when spots come open, individuals that do not yet have permanent territories and have been roaming in the area, are able to inhabit the new openings (Hinton 2016). These periods of transiency can sometimes bring coyotes into conflict with other canids and humans, especially when they are utilizing of anthropogenic resources.

Though a rural area, human land uses occupy a significant portion of space on the AP. The AP is comprised of approximately 30% agricultural fields, 50% forest and coastal marshes, and 20% "other" land cover types on federal, state and private lands (Dellinger 2011). Concerns about fear of attacks on humans and domestic pets, the effects of sympatric canids on white-tailed deer and other game populations, and homeowner property damage comprise many of the conflict calls regarding sympatric canids on the AP (Responsive Management, forthcoming data). Wildlife managers in this region frequently receive requests for information on canid management (C. Turner, personal communication, 2016).

The changes in state and federal canid management rules have resulted in confusion regarding residents' rights and options for management of property damage by sympatric canids. As a result, some citizens are unsure of the legal and most effective methods for canid conflict management. Adding to management complexity is the need to manage canids for conservation purposes, such as reducing predation on at-risk ground nesting species or reducing hybridization of sympatric canids.

In 2013, NCWRC and USFWS established a committee to oversee the collaborative management and conservation of sympatric canids on the AP. A USFWS and NCWRC joint memorandum documented detailed action items for the joint management of sympatric canids on the AP, including specific research objectives which this proposal seeks to address (Attachment 2). As sympatric canids on the AP increase in number, monitoring their

Commented [JM8]: Morse - Need to see the forthcoming data to comment on it. No predator/prey relationship studies have been conducted in the NEP for red wolves or coyotes and whitetail deer or any other game species. This should be part of the study proposal.

Commented [JM9]: Morse - Need information on information request to FWS by Chris Turner. Not sure of any to date.

Commented [JM10]: Morse - The current law/reg. is clear: it is legal to take or harass a red wolf in defense of human life or to protect pets and livestock.

Commented [JM11]: See Ryan's comment.

Commented [OSE12]: Does this mean that they are going to trap at Pea Island or any other state and federal land that occurs in Dare county that's not on the peninsula?

Commented [JM13]: Morse - Need examples of at-risk, ground nesting species to be able to comment adequately.

Commented [JM14]: See Ryan's comment.

Commented [JM15]: See Ryan's comment.

Commented [JM16]: Does not acknowledge dramatic decrease of red wolves because of lumping as sympatric canids.

Commented [OSE17]: As stated on page one "the AP supports a continuum of sympatric canids" this means coyotes, hybrids and wolves. I guarantee that wolf numbers are declining while others on the continuum are increasing; thus making this statement false. It implies that all variations are increasing.

This sentiment is explained more clearly on page 33 paragraph 3. They refer to coyotes and wolves separately.

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movements, particularly in relation to individuals of differing ancestry, could provide important data to NCWRC and USFWS staff for science-based local and landscape-level decisions about sympatric canid populations and conflict management. Collection of finer temporal scale location data would help to manage interactions of sympatric canids with humans, as well as to support development of dynamic stochastic population models.

B. Objectives (after December 1, 2016-November 30, 2018)

Objective 1: Use GPS collar and proximity sensor technology to test performance under various conditions and evaluate the frequency and accuracy of the scheduled fix rates.

Objective 2: Use fine scale GPS data collection for investigating annual and seasonal spatial dynamics of sympatric canids: home range and core area sizes, amount of overlap in home range and core areas, movement pathways and daily activity patterns, and cover type selection and preference.

Objective 3: Use fine scale GPS data collection for investigating the number and age structure of offspring for family groups of collared sympatric canids.

Objective 4: Use fine scale GPS data collection for investigating sources of mortality for sympatric canids.

Objective 5: Use fine scale GPS data collection for preventing and mitigating canid conflicts with landowners.

Objective 6: Determine genetic profiles of sympatric canids through DNA identification of all captured individuals, parentage, and presence of hybridization.

At the end of this two-year pilot study, we will deliver an observational summary detailing the use of the GPS and sensor technology for spatial and population dynamics research on sympatric canids on the AP.

C. Expected Results and Benefits

As part of a pilot study, we will monitor the status of collared individuals by using a finer scale assessment of space and habitat use than previous studies. Earlier research focused on many of the same objectives we suggest investigating here, but during a time of intense, active

Commented [OSE18]: Don't see how this would work, unless they are talking about human dimensions.

Commented [JM19]: Morse - Need description on how this data will help manage interactions of sympatric canids with humans.

Commented [JM20]: Objectives talk about GPS'd animals but don't take into account any data from the existing 23 radio-collared red wolves and 29 collared coyotes.

Commented [OSE21]: Is this list a weighted list? I would hate to think that this was the objective with the highest priority.

Commented [JM22]: Morse - This testing should be conducted with coyotes, not wolves until performance levels are confirmed. Coyotes should be sterilized to assist with gaining private landowner permissions.

Commented [JM23]: Morse - There is currently no area on ARNWR where this level of wolf/coyote interaction occurs. Where will this investigation be conducted?

Commented [OSE24]: Why do they need location data for number of animals and age?

Commented [JM25]: Morse -The number and age of wolf offspring in breeding groups is already known using conventional VHF data collection and USFWS den work.

Commented [OSE26]: As stated later in this proposal no target animals will be treated for disease. Not treating wolves for visible or known disease is contrary to the recovery program, whether that be for recovery in the wild or increasing numbers in captivity. By continuing treating any wolves we would be compromising the validity of any conclusions from the data. Additionally, are they talking about actual source locations, as in disease originating locus, or causes of mortality?

Commented [JM27]: Morse - FWS already conducts ~100 telemetry flight/year to access red wolf and radio-collared coyote mortality sources.

Commented [JM28]: Morse - Need description of how this will happen and what data is to be shared with private landowners.

Commented [OSE29]: How do they propose to accomplish this? Which specific conflicts? How does knowing exact location help?

Commented [JM30]: Morse - This needs to be a separate and ongoing project conducted with ASU or a different university.

Commented [OSE31]: Their section 7 attachment state 3 years. Granted they state they will be tracking over the course of 3 years. Did they mean 2 years of trapping with a ...

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management. Specific management techniques are no longer being carried out and dynamics between sympatric canids are expected to have changed substantially. The uncertainty regarding current dynamics presents a need for additional research in order to inform actions for the management of sympatric canids. Information gained from research may impact management rules and landowner's abilities to manage canids in some areas. Additionally, GPS technology has improved since earlier research was conducted allowing for more temporally detailed data collection and more nuanced analyses. Understanding how sympatric canids collectively use resources in areas of human-dominated landscapes will allow wildlife managers to tailor management options to local conditions. On the AP, row crop agriculture and hunting represent the primary and secondary land uses, respectively. Row crop agriculture is a significant nutrient resource on the landscape and, as opportunists, canids take advantage of such resources when they are available. Non-consumptive wildlife-driven tourism persists in all seasons and wildlife watching is a main draw for tourists in this area. For many tourists, the opportunity to see or hear large carnivores is the sole attraction for traveling to the AP. Information from this study will be provided to local constituents to establish a knowledge base regarding how sympatric canids use resources on private lands. Management and guidance could serve to prevent or minimize conflict while maximizing positive wildlife interaction opportunities for constituents. Development of a common understanding between wildlife managers and landowners based upon factual information is paramount for collaboratively achieving successful management of sympatric canids. The data collected in this pilot study is the foundation upon which this understanding and future management actions will be built.

The current level of hybridization between sympatric canids on the AP will be characterized using DNA gathered during this study. Body size exists as a continuum between coyotes and red wolves and has been documented as the most important factor for successful interspecific breeding pairs of these canids (Hinton 2014). Though both species have been found to use resources in similar manners, red wolves generally have more expansive home ranges and therefore may not use local resources as intensively as coyotes, depending on body size. Obtaining individual identification of study animals will allow managers, armed with spatial information, to infer how and why individuals in the canid species continuum exploit

Commented [JM32]: Morse - Do not rule out the possibility of more intense, active management techniques as described in the RW adaptive management plan.

Commented [JM33]: See Ryan's comment.

Commented [OSE34]: I would like to see a citation for everything in this sentence. Additionally, how do they take advantage of the resources? Are they eating part of it? Primary hunting area?

Commented [JM35]: Morse -What does this mean?

Commented [JM36]: See Ryan's comment.

Commented [OSE37]: Who are these local constituents? One of the main results that I can think of is that landowner requests for wolf removal will increase. Wasteful spending of federal and state money on removal efforts of coyotes, just like the failed removal effort of a coyote in 2016.

Commented [OSE38]: Is a wolf breeding with a hybrid considered hybridization?

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anthropogenic resources considering their life history traits.

In conjunction with prior research, data collected will contribute to knowledge on sympatric canid population dynamics on the AP. Estimating population size will allow managers to monitor population trends of sympatric canids and to examine the long and short-term impacts of different management strategies on their populations. While it is unknown whether sample size will allow for population estimation, obtaining population estimates for coyotes would provide wildlife managers with baseline data, when paired with annual mortality estimates, for monitoring changes in population abundance over time. Information on changes in abundance, reproductive dynamics, and habitat use could impact management strategies to influence long-term conservation outcomes. Results of this pilot study will allow managers to determine if future work will be necessary, what amount of effort will be required to achieve each objective, and whether or not population estimates will be an attainable goal.

D. Approach

The official Red Wolf Recovery Area (RWRA) covers approximately 6,900 square kilometers within Beaufort, Dare, Hyde, Tyrrell, and Washington counties (Wildlife Management Institute 2014). However, the USFWS has proposed the RWRA be constricted to the ARNWR and the Dare County Bombing Range in Dare county by the end of 2017. Due to these proposed RWRA changes, this study proposes to capture and radio-collar 25 sympatric canids within Dare, Hyde, and Tyrrell counties (hereafter referred to as "study area"); those counties being within and directly adjacent to the proposed new RWRA. The thematic subheadings below provide detailed descriptions of the approaches required for achieving the pilot study objectives.

Sampling Efforts

Trained NCWRC personnel will conduct live trapping of sympatric canids, with assistance from the USFWS RWRP biologists, and trained, experienced local trappers. NCWRC and USFWS wildlife personnel will select local trappers based on their past performance in trapping sympatric canids, but may also select trappers from the NCWRC coyote trappers list. NCWRC staff will train contracted trappers on specific trapping procedures before every trapping

Commented [OSE39]: What? They are opportunistic animals and will use any resources that they are able to, or is there something in the literature that states that coyote and wolves don't use anthropogenic resources. They even stated earlier that canids take advantage of row crops which would imply anthropogenic resources are an integral part of their life history. They are implying that the use of anthropogenic resources is abnormal behavior.

Commented [JM40]: Morse - This aspect of a coyote population size estimate would best be done in an area with no other sympatric canids.

Commented [JM41]: I don't believe technically a "recovery area" has been delineated, just an NEP boundary.

Commented [JM42]: See Ryan's comment.

Commented [OSE43]: Are we really going to let them trap on the refuge?? Needless to say this would hand over significant control of the program over to the State. I would dare say an illegal hand over at this point.

Loss of control 1.

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season. The project lead will supervise and coordinate all trapping activities including locations for installation and the operation of trap lines and handling of captured animals. Simultaneous personal trapping activities by contracted trappers will not be permitted while performing contracted trapping services, as specified in the draft service contract (Attachment 4).

Trapping efforts will follow a spatial capture-recapture (SCR) framework with a systematic targeted sampling design, focusing on areas that contain resources previously found to be used by sympatric canids (e.g. edge, agricultural fields, secondary roads, etc.) (Harris et al. 2013, Ivan et al. 2013), while attempting to sample a diversity of habitat types. This effort will allow us to increase the probability of detection of sympatric canids on the landscape (Tom 2012). While it is important to sample a wide range of habitats, the most important requirement for SCR is the number of collared individuals; this requirement provides flexibility in the other requirements for field sampling as needed (K. Pacifici, personal communication, 2016). We will initially focus trapping in areas of known red wolf packs, as advised by RWRP.

Trapping will take place during the breeding season when the likelihood of capturing females in the later stages of gestation or whelping females will be low. Capture efforts will be conducted from soon after 1 December 2017 – February 2018 and December 2018 – February 2019. Captured sympatric canids will be surrendered to NCWRC or the USFWS at capture sites. Trapping should occur on both public and private lands to obtain sampling coverage of the study area. Ideally, all federal and state lands would be accessible for trap and release (hereafter referred to as "capture") of sympatric canids, but it is most important to be able to trap and release on Alligator River NWR and the Dare County Bombing Range as those encompass the newly proposed RWRP recovery area and comprise the majority of land area for Dare county. Unlike Dare county, there are ample private lands that surround Pocosin Lakes NWR and Lake Mattamuskeet NWR in both Tyrrell and Hyde counties that may be utilized to effectively sample individuals who may use those federal lands, should they be excluded from capture activities. Capture on federal lands may require USFWS take permits and proposed activities may be subject to a compatibility assessment (P. Benjamin, personal communication, 2016). Scientific collection activities that take place on private lands will require agreements outlining conditions mutually decided by NCWRC and landowners (Attachment 3).

Commented [OSE44]: Another level of lost control.

Loss of control 2

Commented [OSE45]: Trap shy animals will be difficult to recapture, thus biasing their results.

Commented [OSE46]: There are only two known wolf packs left in their proposed study area.

Commented [JM47]: See Ryan's comment.

Commented [OSE48]: Breeding disruption is a possibility. Higher chance of trapping too many animals too young, as per their protocol, to collar.

In the Section 7 attachment they specifically state that coyote trapping will commence in Nov and end in Feb, while wolf trapping will start in Dec and end in Feb.

Commented [JM49]: Morse - Not for red wolves (deal breaker).

Commented [JM50]: See Ryan's comment.

Commented [JM51]: See Ryan's comment.

Commented [JM52]: Is it appropriate for NCWRC personnel and contract trappers to be trapping on the Refuge vice highly trained and experienced FWS personnel?

Commented [OSE53]: This sentence is a little vague. Do they mean that will have the opportunity to trap private land if the public land is excluded?

Commented [OSE54]: Compatibility assessment?. If this study goes through, it would effectively give the State full control of the wild population. At the bare minimum this would constitute a 10j rule change.

Where is the assessment?

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To increase probability of detection of sympatric canids, the accessible study area will be partitioned by a grid, the cell size of which will based on the average annual home range size of resident coyotes previously reported for the AP, approximately 23 km^2 (Hinton et al. 2015). As a system of sampling, trap lines will be referred here as "traps," and the number of trap sets (i.e. the actual trapping device) and number of each trap set size may vary between traps as necessary. Sampling will be standardized within each grid cell by use of equal number of traps per cell, on average 3 per cell, each at an approximate length of 10 km (Andelt and Gipson 1979, Way et al. 2004).

Target canids will be captured by using Softcatch #3 Coyote 4x4 (Oneida Victor Inc. Ltd., P.O. Box 32398, Euclid, Ohio 44132, Hinton 2014, Schemnitz 1994), the EZ Grip #7 (Livestock Protection Company, P.O. Box 725, Alpine, Texas 79831, Frame and Meier 2007), or equivalent. Various lures and baits will be used to increase trapping efficiency (Frederick et al. 1989, Shipley 2012). Traps will be laid on the Monday of each week and will be opened at the time of deployment. Traps will be checked once daily at dawn, to reduce potential stress to trapped individuals and will not be operated on days where the temperature is expected to reach or exceed 80° F (R. Nordsven, personal communication, 2016) or during times of predicted inclement weather (e.g. snow, hail, high wind, etc., Sikes et al. 2011). To standardize effort and remain logistically realistic, traps should be open for three trap nights in a row before being removed. Trap sets that have been closed due to non-target bycatch or other circumstances may be reopened and all traps should be re-baited and lured as appropriate.

Trap set locations will be marked by NCWRC or USFWS personnel using handheld GPS units (Garmin GPSMAP 64S, 1200 E. 151st St., Olathe, KS 66062-3426) and given a sequential identification number. Traps will also be given an identification number and trap set points will be documented in ArcMap 10.4. Trappers will keep detailed records on trap set operation, non-target species trapped, and other relevant details. Non-target species will be released from traps after an in-field assessment of injuries, if any, and animals with life threatening injuries will be euthanized by the trap operator. Targeted recapture of collared canids will occur annually during the same months, to replace GPS collar batteries and drop-off collar release units in field. Trapping effort will be quantified (trap nights), the effective sample area will be

Commented [JM55]: See Ryan's comment.

Commented [JM56]: See Ryan's comment.

Commented [OSE57]: What about freezing or below freezing temps. This concern might be covered by their inclement weather statement. The temperature range should be spelled out and private trappers would have to be explicitly told not to trap.

Commented [OSE58]: Why only 3 nights

Commented [OSE59]: Loss of control 3. Implied.

Commented [OSE60]: Good luck capturing trap shy animals. Additionally wont this interfere with subsequent trapping years of the study, or are they planning on not trapping for new animals in the same locations the following year.

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estimated, the encounter (detection) probability will be estimated using a Gaussian detection model (Amundson et al. 2014), and an estimate of density for coyotes will be calculated using a modified Huggins closed-capture estimator in program MARK, if sample size allows (Harris et al. 2013, Ivan et al. 2013).

Animal Handling

Handling of canids will follow American Society of Mammalogists (ASM) guidelines (Sikes et al. 2011) and will be performed at the capture site. Chemical immobilization agents may be used depending on the number of field staff during processing (i.e., three or more staff required during non-chemical immobilizations, Craft 2007, M. Morse, personal communication, 2016).

Chemical Immobilization

Unless adequate numbers of personnel are available to safely employ mechanical restraint techniques, target animals will be anesthetized with the chemical immobilization agent BAM (Wildlife Pharmaceuticals, Inc., Windsor, CO 80550). BAM, a combination of Butorphanol tartrate, Azaperone tartrate and Medetomidine HCl., will be delivered by intramuscular injection by syringe pole to the hip. Dosage for canids is based on field trails performed by Wildlife Pharmaceuticals (Wildlife Pharmaceuticals, Inc. 2016) and the recommended dose for coyotes is 0.2CC and red wolves is 0.3CC, with adjunct doses of 0.1-0.2CC delivered if initial dosages do not cause induction (S. Kirschner, personal communication, 2017). Induction times for coyotes and wolves ranged from 5 to 10 minutes after initial and/or adjunct dosages (Wildlife Pharmaceuticals, Inc. 2016). After field handling is concluded the anesthesia will be reversed using two reversal agents, Atipamezole and Naltrexone, at double the CC of Atipamezole to BAM that was delivered (including adjunct doses, if given) and 0.5CC of Naltrexone. Recovery time from the reversal agents ranged from 10 to 25 minutes during field trails (Wildlife Pharmaceuticals, Inc. 2016). Field personnel will observe animals for signs of adverse effects for up to 30 minutes after reversal agents are delivered.

Mechanical Immobilization

Unlike other carnivore families, the submissive behavioral response of canids to

Commented [OSE61]: Why is the sample area going to be estimated when they stated earlier that they were going to grid out accessible areas?

Commented [OSE62]: This probability is comprised of two factors. 1) Availability "which is the probability that an animal is present in the survey area and signaling its presence to the observer" and 2) Perceptibility "which is the probability that an animal available for detection (e.g., a bird sings) is detected by the observer" This is taken directly form the Amundson paper. I understand how the collars will help with determining availability, but I am curious how they will determine perceptibility. Is the perceptibility tied to the number of traps or ear tags?

Commented [OSE63]: Are they talking about immobilization while the animal is in the trap or are they talking about after the animal is out of the trap? Lots of possible implications when dealing with contract trappers if it is the former. What about total animal process time vs checking trap lines.

Commented [JM64]: Morse - Wolves will be turned over to FWS for processing and radio-collaring at the RWEC (Columbia, NC) with support from NCWRC biologists. (deal breaker).

Commented [JM65]: Morse - Two biologists and one note taker (if available). If not, two biologists can do the processing with no problems.

Commented [JM66]: Morse - We have a better, cleaner and safer chemical immobilization protocol developed specifically for red wolves by the NCSU Vet School. Butorphanol @ 0.4mg/kg w/ Dexmedetomide @ 0.04mg/kg
Antagonist: Naloxone @ 0.02mg/kg w/ atipamizole @ 0.2mg/kg

Commented [JM67]: See Ryan's comment.

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perceived dominance reduces the need to use immobilization agents. Appropriate mechanical restraint techniques can reduce handling time of animals, allowing animals to reintegrate into social groups more quickly, subsequently reducing overall stress to the individual (Powell and Proulx 2003). Target canids will be mechanically restrained with a restraint pole, until two muzzles can be placed around the snout. While pinned with the restraint pole by one person, a second person will restrain the set of legs not in the trap against the ground and a third person will release the foot from the trap. This set of legs will then be restrained by the 3rd person as the restraint pole is removed. Once the restraint pole is removed the person restraining the front legs will also then restrain the head. The first person will then move forward with processing the captured animal.

Each animal will be placed on a towel or blanket to provide thermal protection from the ground, with eyes covered and lubricated with eye ointment; temperature will be monitored with a rectal thermometer. Overheating occurs at approximately 104-105°F for canids (AZA Canid TAG 2012) and the animal handling crew will monitor temperature at 5-minute intervals; if a temperature reading reaches 104°F, corrective actions will be taken and temperature will be monitored at 1-minute intervals. Should overheating occur, the individual will be removed from insulation to expedite the natural evaporative cooling process. During days that approach 80°F in temperature, measures will be taken to reduce heat stress, such as: wetting the animal with water, application of a cold pack to the groin area between the back legs, application of rubbing alcohol to foot pads, or immediate release (AZA Canid TAG 2012). If the injured individual is suspected to be a red wolf, based on morphometrics, USFWS staff will be contacted for a decision. In the event that trap caused injuries are determined to be life threatening through use of a trap injury score assessment (Frame and Meier 2007) the individual will be euthanized. In the event that NCWRC personnel cannot be present, trained USFWS personnel may collar and measure captured target animals and will provide data sheets to NCWRC staff. Target animals will not be vaccinated or otherwise treated for diseases, regardless of the presence of disease symptoms.

Non-target animals will be released on site. Captured domestic dogs will be immediately released from the trap set following an injury score assessment and only if no life-threatening

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Commented [OSE68]: This is not always a guarantee that the animal is a wolf or not

Commented [OSE69]: Loss of control 4. Implied.

Commented [JM70]: See Ryan's comment.

Commented [OSE71]: FWS will be "allowed" to do this?! This statement plus several others would seem to indicate a takeover of the red wolf program by the NCWRC.

Loss of control 5. Implied.

Commented [JM72]: This seems like an unnecessary statement, as FWS personnel have the authority to handle red wolves.

Commented [JM73]: Why would we not vaccinate the capture animals, especially red wolves given the high value of each individual within a population so low?

Commented [OSE74]: Not treating wolves for visible or known disease is contrary to the recovery program, whether that be for recovery in the wild or increasing numbers in captivity. These wolves would be integral for population increase in the wild or for the "SSP meta-population"

Commented [JM75]: See Ryan's comment.

injuries are present. If a domestic dog has sustained life threatening injuries and owner identification information is present on the dog, then the animal will be held in either a transportable kennel, or at a dog pen on a state game land that is equipped with such facilities, until the owner can retrieve the dog. The costs associated with injuries sustained to the dog will be the responsibility of the animals' owner. Law enforcement may be requested to help communicate with the animal's owner. If the animal does not have an identifiable owner and has incurred substantial life threatening injuries (i.e. compound fracture), the dog will be euthanized on site. Target animals showing signs of disease symptoms such as circling behavior, head tilt, muscle twitches, convulsions with jaw chewing movements and salivation ("chewing gum fits"), disorientation, incoordination, staggering caused by paralysis of the hind legs, seizures, and partial or complete paralysis will be euthanized and tested according to protocol set forth by the agency veterinarian, in order to determine if there may be a public health issue (M. Palamar, personal communication, 2016). USFWS will be contacted in cases of suspected red wolves. Staff involved in animal handling duties will have the pre-exposure rabies vaccination series completed prior to field work inception and will maintain rabies titer records through properly licensed medical services providers.

If staff is bitten and skin is broken by an animal while performing handling duties, they will be advised to immediately visit a local hospital or clinic for evaluation by healthcare professionals. The field coordinator will immediately notify supervisory staff and an injury report and workers' compensation claim will be opened for the incident. The animal will be euthanized and the head will be sent to the state lab for rabies testing; the body may be sent to the Southeastern Cooperative Wildlife Disease Study (SCWDS) laboratory for additional disease investigation.

Capture Processing and Marking

During canid handling, NCWRC personnel will record age class, sex, weight, total body length, head width, ear length, and tail length, visually assess ectoparasite load, look for and disinfect with betadine or iodine as needed any minor trap caused injuries, and affix GPS collars (Knick 1990, Sikes et al. 2011). All captured canids will be fitted with appropriately-sized GPS collars in the field based on morphometrics previously indicated as reliable thresholds for

Commented [OSE76]: Loss of control 6. Implied.

Commented [OSE77]: Do they not have facilities to hold the animal for observation? They are going to unilaterally euthanize a wolf??

Commented [JM78]: I disagree that staff being bitten during a capture should result in a red wolf being euthanized, particularly if that animal is displaying no signs of disease. We can't afford to lose any more individuals in such a low population. And no euthanasia of a red wolf should occur without FWS involvement in the decision making process.

Commented [JM79]: See Ryan's comment.

Commented [OSE80]: This whole section gives state complete control of the program. Additionally are they going to remove our collars and put their own on?

Commented [OSE81]: Loss of control 7. Implied.

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species categorization: hind foot length, weight, width of head, and tail length (Hinton 2014); analysis of DNA samples collected during trapping efforts will help to assign captured canids to position along the species continuum post release. Age of individuals will be estimated based on physical characteristics, including weight and tooth replacement (Knick 1990, Hinton 2014, Gier 1968), and captured canids will be aged into one of three classes: > 2 years old as adults, < 2 but > 1 year old as juveniles, and > 6 months but < 12 months old as pups (Hinton 2014). Reproductive status will be determined based on estimated age class and presence of gonadal descent during the breeding season for males and the presence of nipple swelling or previous suckling for females (Hutson and Racey 2004, Magee 2008, Mengel 1971).

Captured individuals will be ear marked using a button tag (model 410, Ketchum Mfg. Co. [or equivalent], PO Box 10, 11 Town Shed Road, Lake Luzerne, NY 12846) placed along the middle of the ear where they are most protected from loss, with a pin-type applicator (485sa Pow-R-ceps plier, Ketchum Mfg. Co. [or equivalent]) (Silvy 2012). The puncture site will be treated with an antiseptic to deter infections. Each sympatric canid will also be marked with an individually-numbered, glass-encapsulated, passive integrated transponder (PIT model HPT12, 12.5 mm, 134.2 kHz, Biomark, Inc., 703 South Americana Blvd., Suite 150, Boise, ID; Gannon et al. 2007), using a syringe-type implanter and replaceable needle (model MK10 [implanter], model N125 [needle], Biomark, Inc.). Successful PIT placement will be verified with a mini portable reader (model GPR Plus, Biomark, Inc.). The implantation site will be prepared by swabbing with 70% alcohol (Mrozek et al. 1995) and a sterilized new needle will be used for each injection. The standard implantation site for transponders is subcutaneously on the dorsal midline of the back, cranial to the shoulder blades (Ingwersen 2000).

A skin biopsy will be taken from all captured target canids by puncturing the pinna of the ear with a biopsy punch in the same location where the ear tag will be placed (Palamar 2014). The biopsied area will be disinfected with alcohol after sampling. The skin biopsy will be placed in a labeled (ID, date, and sample type) cryogenic tube filled with 95% ethanol as buffer and then stored in a freezer until sent out to a lab for genetic analysis (Palamar 2014, Tom 2012). A selection of hairs with the root bulla attached will be pulled from the belly and placed in paper envelopes (Janecka et al. 2007). Hair samples will serve as back up to tissue samples

Commented [OSE82]: What is the point of this if they are going to have a collar on them. Would this be used for mark/recapture purposes for any animal in excess of the 25 collars? Or is this for continued identification after the collars fall off. Collars falling off of wolves does us no good for continued tracking after the study.

I have conflicting thoughts on this. Makes it easier to identify while in a trap prior to release but makes it easier for someone to see and shoot the animal. Alternatively it could stop someone from shooting and thus biasing mortality results.

Commented [JM83]: Morse - Why - no need. the ear tags are not needed and are a constant source of infection and irritation. In addition, when we,ve used them in the past - the animals tear them out.

Commented [OSE84]: Are we going to give them our tags or will they use their own. Either way is a loss of control of the program.

Commented [JM85]: Morse - Continue to use PIT tags by Trovan to keep consistency with animals already deployed.

Commented [JM86]: Concerns over PIT tag not being compatible with our reader

Commented [JM87]: See Ryan's comment.

Commented [OSE88]: What is the point of this and how does it help them achieve any of their stated goals? Are they proposing to make a hole in the ear first using this method and then place the tag in the hole?

Commented [JM89]: Morse - genetic analysis can be done with blood serum.

Commented [JM90]: See Ryan's comment.

Commented [OSE91]: Not opposed to this but again, why? Can they get more info from this than from blood samples? They are proposing 3 separate DNA samples.

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for genetic testing. All samples will be sent to the Laboratory for Ecological, Evolutionary and Conservation Genetics, at University of Idaho (875 Perimeter Drive, MS 1136, Moscow, ID 83844) for genotyping to determine species as well as individual identification, hybridization presence, and parentage analysis following previously developed protocols (Adams et al. 2007, Hinton 2014, Miller et al. 2003). The appropriate genetic analyses that examine the coyote-hybrid-wolf species continuum will be performed.

Blood will be collected from all juvenile and adult target canids by venipuncture of the brachial or jugular veins using a 22-28-gauge needle (M. Palamar, NCWRC veterinarian, personal communication, 2016). As per NCWRC veterinarian recommendations, approximately 12 ml of blood will be collected for each animal for possible future testing for diseases of importance to sympatric canid species as well as the humans and domestic animals that they may come into contact with. A minimum of two 6 ml lavender top tube (for whole blood with EDTA) will be filled. Samples should be refrigerated at all times; a cooler with ice will suffice while in the field. Samples should be sent to the NCWRC within 48 hours or frozen for later shipping. Skin scrapes will be collected from animals presenting signs compatible with sarcoptic mange (lesions) for possible future diagnostic purposes. Lesions will be scraped until blood is drawn; the scrapings will be placed onto a slide and covered with a piece of clear tape for later visual confirmation.

Should overheating occur, processing will be performed in the following prioritization order and the first five items will need to be completed before releasing any individuals: 1) trap injury evaluation, 2) collaring, 3) DNA (skin biopsy) sample collection, 4) morphometrics, 5) aging, 6) PIT tagging, 7) weight, 8) ear tagging, 9) reproductive status, 10) ectoparasite evaluation, 11) blood collection, and 12) skin scrape collection.

Collaring

Vertex Plus GPS Collars will be attached to 25 sympatric canids captured on the study area, 10 of which will be equipped with proximity sensors (Vectronic Aerospace GmbH, Carl-Scheele-Str. 12, 12489 Berlin, Germany). Project staff will pilot test proximity sensor technology for utility in analysis of spatial and temporal community dynamics. Proximity sensors trigger increased GPS location acquisition during those time intervals when two collared individuals

Commented [JM92]: Morse - Pull one red top tube to spin for serum collection. Why 2 - 6 mm purple top tubes (isn't 1 enough)? Also, FWS is going to need to maintain additional blood samples for database.

Commented [JM93]: See Ryan's comment.

Commented [JM94]: Morse - define overheating temp. range and cooling procedures. In the event of overheating, the first thing to do is to immediately cool the animal. Collar then blood draw (omit the rest).

Commented [OSE95]: Given our concerns over many aspects of tissue collection, I feel that this list should be revisited.

Commented [JM96]: See Ryan's comment.

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come within a set distance from each other (http://www.vectronic-aerospace.com/wildlife-monitoring/sensors/uhf-id-tags, accessed August 2016).

To avoid instances of collar induced strangulation, only adult (>2 years old) male and female individuals will receive collars (Hinton 2014). ASM guidelines recommends a collar weight of <5-10% of a canids bodyweight, we will observe these guidelines (Sikes et al. 2011). Sympatric canids not releasable at a capture site will not be collared and will not become study animals.

GPS radio-collars will have both VHF and GPS Iridium locational systems as well as store-on-board capabilities. Radio-collar units will be programmed to record GPS coordinates once every 1.75 hours producing approximately 13 locations per day while cycling through the 24-hour time cycle. These settings will allow for a GPS battery life of 300 to 552 days, averaging 431 days. The VHF beacon will be in operation from 0800 – 1600 hours daily. GPS locations will be sent via satellite once per day and each transmission with contain 12 locations. The use of an integrated drop off firing mechanism should allow the collars to drop off within a maximum of approximately 548 days after deployment. The drop off schedule once set cannot be changed. The drop off firing mechanism is wired to a battery unit independent of the collar battery, therefore should the collar battery become depleted, the drop off mechanism will not be affected (C. Akakpo, Vectronic Aerospace GmbH, personal communication, 2016). Unless a collared individual is recaptured before the collar battery dies, the drop off mechanism will fire at the scheduled time frame post collar deployment.

Observation of sympatric canid habitat use and movements will occur through GPS data obtained with combination GPS/VHF radio-collars. VHF relies on triangulation, the process of estimating the location of a transmitter by using two or more compass bearings obtained by using directional antennas at known locations remote from the transmitter's position (White and Garrott 1990), whereas GPS uses a satellite based system to obtain location coordinates. There have been many published studies where one or both of these methods were used, with mixed success for determining various aspects of carnivore ecology throughout the United States (Hinton et al. 2012, Schrecengost et al. 2009, Sparkman et al. 2012). While GPS technology has developed rapidly in recent history, the real time functional advantage of VHF

Commented [JM97]: So in theory they could catch a one year old red wolf and by their protocol they would not collar it because it is less than 2 and they would release it without a collar. So basically the effort to trap a red wolf and the potential for injury has already occurred, but we do not take advantage of that by placing a collar on it to be able to monitor as much of the population as possible. Doesn't make sense.

Commented [OSE98]: I have a feeling that there is going to be many animals that fall into this category especially considering the prevalent landowner attitude towards carnivores in general and coyotes specifically. Additionally this constitutes a double standard in regards to releasing animals. We have landowner authorization in many cases but the State still will not allow us to use those lands for release, but are they going to allow themselves to do that? Also I feel that they should have all landowner agreements in place and the study/trapping areas well defined prior to any trapping effort. I have serious doubts that they can get this in place prior to Dec 1st.

Commented [JM99]: Needs clarification. Are they trying to say that if a landowner won't let them release a captured canid on their property then they won't collar it and release it? The context of the paragraph doesn't jive with that.

Commented [OSE100]: What frequency range?

Commented [JM101]: See Ryan's comment.

Commented [JM102]: See Ryan's comment.

Commented [JM103]: Morse -What happens to ability to monitor animals with no collars?

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cannot be disregarded. When GPS technology falters or malfunctions, VHF can serve as replacement for data collection in addition to its use in real time monitoring of study animals. Canids will be minimally monitored for mortality approximately every 30 days by using VHF aerial telemetry techniques (Whitehouse and Steven 1977) as there may be a delay in satellite transmission of GPS location data due to weather, season, and animal behavior. Transient canids and individuals from breeding pairs that have lost a mate, have been found to use much larger areas versus paired residents, potentially increasing the opportunity for losing track of these individuals when GPS technology reaches its functional capacity or experiences malfunction. VHF data may also provide locations of canids in cover too dense for GPS units to function. Use of VHF telemetry techniques for data collection may be expanded as necessary for project needs.

Commented [OSE104]: Can the GPS collars transmit through water? If not and you have an animal that tumbles into water right after mortality you've lost data.

Commented [JM105]: See Ryan's comment.

Commented [JM106]: They are proposing monitoring for dead canids every 30 days. For any collared red wolf, we would like to add those frequencies to our flights so they can be monitored much more frequently. Which is another reason the frequencies of their collars should be in the same range as the existing collars.

Spatial Data Analyses

Both minimum convex polygon (MCP) and adaptive kernel (AK) home ranges (95%) and core use areas (50% and 25%) (Seaman and Powell 1996, Seaman et al. 1999) will be calculated from GPS data by using BIOTAS (Ecological Software Solutions LLC, 2016) and Geospatial Modelling Environment (Spatial Ecology, LLC, 2016) for ArcGIS 10.2.2 (Environmental Systems Research Institute, 2016) (Benson et al. 2006, Riley 2006, Tucker et al. 2008, Hinton 2014) for comparison to older studies. These estimations can also be calculated using VHF data, provided data minimum requirements are met. Spatial distribution in relation to habitat will also be estimated by dynamic Brownian bridge movement models as described by Hinton (2014) with R statistical software (R Core Team 2016) using the moveud package with habitat covariates important to each species (Bryne et al. 2014, Collier 2013, Kranstauber and Smolla 2013, C. Proctor, personal communication, 2016). Additionally, recent research into how canids shift their ranges will also be investigated for populations on the AP (Morin and Kelly, in review). Spatial overlap and co-occurrence will be assessed using methods described by Shipley (2012). Habitat and cover types will be estimated from digitized maps created by the SEGAP (Hinton 2014) or ortho files, as available (Shipley 2012). Percent composition of habitat and cover types within home ranges and core areas as well as edge density will be quantified (Shipley 2012). Habitat selection and cover type use effects on spatial distribution will be estimated at both the population (2nd order) and individual (3rd order) spatial scales using resource selection functions

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(Johnson et al. 2006, Manly et al. 2002, Shipley 2012). Effects of seasonality and time of day activity will also be explored. The spatial and temporal patterns of space use by sympatric canids will be studied using data generated from the interaction GPS collar sensors, particularly distance between individuals and duration of proximity.

Den Monitoring

Project staff will attempt to locate den sites for sympatric canids to get pup counts, morphometric measurements, age estimates, and skin biopsies. Project staff will also attempt to monitor pup survival during the pup rearing season by using remote cameras placed around the den site (Harrison and Gilbert 1985, Parks 1979, Way et al. 2001). Pups will be weighed, measured, and PIT tagged during May and June of each year when they become active but are still den-obligated (Gier 1968). We will investigate the use of remote camera traps for monitoring den behavior with a two-camera array around the den (H. Garbe, personal communication, 2016, Kays and Slauson 2008). This method has been successfully used to monitor kit fox pup survival (Kluever et al. 2013). Because coyotes have been found to be sensitive to den site disturbance, there is a general lack of data in the literature regarding this approach for monitoring pup survival. Approaching an experimental methodology systematically will be important for determining which methods are effective and which are not. As a starting point for testing this methodology, remote cameras will be placed two to five meters from main den entrances and set to take photos using a passive infrared sensor trigger (a beam that when broken by movement through it, triggers the camera to take a series of photos) with a time restriction between photo intervals to limit the number of photos taken and maximize the space on the memory card for the time period between camera checks (Kluever et al. 2013). Cameras will be checked six days after deployment and will be redeployed (i.e. new batteries and memory card, if required); cameras will remain at each den site until radio-collar data indicates the den site has been moved (Kluever et al. 2013). Cameras will be not be redeployed to a new coyote den site during a season if that breeding pair has already moved the den once due to the disturbance of camera presence/deployment.

Commented [OSE107]: No mention USFWS personnel in conjunction with this phrase.

Loss of control 8. Implied in conjunction with Project Personnel section.

Commented [JM108]: Morse – A minimum number of biologists will attend a den (2-3).

Commented [JM109]: See Ryan's comment.

Commented [OSE110]: No need for biopsies. Again, why do they need this? We already draw blood.

Commented [JM111]: Morse – No skin biopsies on pups.

Commented [JM112]: Morse – No. Best if not at all. Cameras set no closer than 7 m. to den entrance

Commented [OSE113]: Getting this close to dens in order to set up the cameras will cause high enough disturbance that the mother will move the pups or will abandon the pups all together. Even if by some miracle they were not moved or abandoned after first deployment, good luck with that not occurring after your first 6 day revisit. Looking at the Kluever paper I noticed 2 major differences between the Kluever study and this one.

The first is terrain. The Kluever study was conducted in the Great Basin in NE Utah. The area as described in the paper is very open and lacks dense vegetation. Lines of site were not an issue. Often times canid dens in SE will be located in dense vegetation. Not to say that this issue cannot be overcome, but it may be impractical to deploy cameras effectively, or site modification, i.e. clearing out veg, could be enough to cause den abandonment or den relocation.

The second issue is animal behavior is quite different. Kluever et al. were observing kit foxes. Camera deployment was done in the afternoons when the foxes were underground in their dens. The foxes most likely had no clue that the researchers were ever there. In fact the authors attributed the lack of den abandonment to this probable factor. There would never be a time where a pack would not be aware of, or disturbed by camera deployment here in NC.

Commented [JM114]: Morse - 6 days is too often to disturb a den

Commented [JM115]: See Ryan's comment.

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Mortalities

If a collared animal dies during the project, the carcass will be sent to SCWDS for necropsy. Red wolves will be sent to the SCWDS laboratory for necropsy, unless it is determined to be a law enforcement case. In potential law enforcement cases, the NCWRC Division of Wildlife Management Chief and USFWS Ecological Services Raleigh Field Office Field Supervisor will be contacted and requested to contact the appropriate law enforcement personnel, immediately after determining the need for law enforcement involvement. The carcass and all relevant information will then be turned over to law enforcement; the GPS-collar will be removed and genetic samples will be taken from the individual prior to release to law enforcement.

Commented [JM116]: Morse - Coyotes will be sent to SCWDS

Commented [JM117]: See Ryan's comment.

Commented [JM118]: Morse - Red Wolf Carcasses will be sent of the National Wildlife Health Lab in Madison, WI.

Commented [OSE119]: We have our own facility for this. This would be another point of lost control.

Loss of control 9.

Commented [OSE120]: Why? Just contact LE and then inform the Chief and Field Supervisor

Commented [JM121]: See Ryan's comment.

E. Project Personnel

Andrea Shipley has worked for the North Carolina Wildlife Resources Commission as a Canid Biologist since February 2016. Prior to that, she worked as a Wildlife Biologist for a non-profit located in northeastern Nevada as well as in several different field biologist oriented positions. Andrea has a background in carnivore and spatial ecology, having earned her MS in Biological Sciences from Eastern Kentucky University and BS in Biological Sciences from Rutgers University; Andrea will act as project lead and coordinator.

Brandon Sherrill has worked for the North Carolina Wildlife Resources Commission as a Mammalogist since December 2013. Prior to that, he worked as an educator at the North Carolina Museum of Natural Sciences and as a regional wildlife biologist for the South Carolina Department of Natural Resources. Brandon earned a BS and MS in Fisheries, Wildlife, and Conservation Biology from North Carolina State University; Brandon will act as project supervisor.

Krishna Pacifici, Research Assistant Professor at NCSU, will be the quantitative analysis collaborator on the project. Krishna's background and experience in quantitative ecology makes him well suited to consult and assist with advanced statistical analyses of spatial data.

Lisette Waits, Department Head and Distinguished Professor at the University of Idaho, will be the DNA analysis collaborator for the project, responsible for all DNA related sample processing and subsequent analyses.

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F. Schedule and Estimated Costs

The project will run from soon after December 1, 2017 through June 30, 2020. The estimated timeline for major tasks is as follows:

Year 1: Initiate field work soon after December 1, 2017 with assistance from 1-2 field technicians; 1 technician will be required for trapping and den monitoring efforts. Data collection will begin immediately after collar deployment and data will be managed by Andrea Shipley throughout the life of the project. Data analysis will be initiated after den monitoring season concludes, with guidance and assistance from Krishna Pacifici at North Carolina State University (NCSU). Report, manuscript and presentation production will be initiated concurrently with data analysis.

Year 2: Continue field work and data collection with assistance from 1-2 field technicians. Continue data analysis with guidance and assistance from Krishna Pacifici at NCSU. Continue and finalize report and manuscript production, and presentation at professional working groups and/or meetings.

Commented [OSE122]: Where are these techs coming from? Are we going to be paying for them?

Commented [OSE123]: Will we have any access to these data or only receive what the State is willing to give us? How will these data be used? Will the state cherry pick data and use it as a claim that the wolf is not a species?

Loss of control 10.

Commented [OSE124]: Where is year 3; as stated in their section 7 attachment?

GPS technology allows researchers to collect locational data at fine spatial and temporal scales through the deployment of collar units on wildlife study subjects. In this project, we propose to study a sample of sympatric canid populations with GPS radio-collars, in order to investigate the population parameters outlined in previous sections as well as species interactions. The purchase and use of this technology is critical to meeting the research objectives set forth in this document as well as in the document included in Attachment 1.

While GPS technology has evolved over the past 20 years, the cost of technology has plateaued. Upfront cost per unit remains relatively high, however project savings occurs at the back end when compared to older telemetry technology such as very high frequency (VHF)

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which require intensive labor to collect data at similar spatial and temporal scales. Pilot testing the proximity sensor enabled GPS-collars will allow investigation of the utility of this relatively new tool for community dynamics analysis by providing an increased locational data acquisition when individuals come within a set distance, or closer, from each other. Additionally, these sensors record the identities of the interacting individuals and the duration of their interactions. Using a trigger to temporarily switch GPS fix schedules will enable us to collect very fine scale data while conserving battery life, achieving project objectives in an efficient manner. Exploring the efficaciousness of this technology has the potential to positively impact future research projects requiring use of GPS-collars for data collection.

Aerial tracking will provide regular study animal surveillance useful to investigate cases of mortality, collar malfunction, or satellite data transmission delays, which can vary seasonally. In some situations, ground tracking could prove less expensive than aerial tracking. However, ground telemetry techniques require more than one biologist working in tandem to acquire accurate location estimates. This often translates to increased labor to collect data, particularly in large study areas. Aerial tracking will provide a more efficient and cost-effective method for surveilling study subjects in this large study area, requiring only one biologist and a contracted pilot. NCWRC personnel will perform aerial tracking along with the NCWRC pilot at a minimum frequency of every 30 days.

Use of local trappers to assist with sampling efforts provides several benefits. Local trappers have established, long-term relationships with private land owners, thereby providing access to private lands that might be otherwise difficult to secure. This will enable project biologists to obtain a representative sample of sympatric canids in the study area, as well as to operate more trap lines concurrently. This is particularly important when using a SCR sample design, as it will have direct implications on the resulting analyses and inferences.

As part of collaboration efforts, the project will contract the services of Krishna Pacifici, Research Assistant Professor in the Applied Ecology department at NCSU. Krishna's expertise is in quantitative ecology; consultation and assistance services provided will allow project biologists to make appropriate statistically relevant inferences from collected data.

Commented [JM125]: Morse - why the need for 12 more flights if using GPS collars for location/mortality?

Commented [OSE126]: Access does not necessarily denote cooperation. A land owner may say it's okay to trap but nay not agree to releasing the animal back on to the property.

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DNA analysis will be contracted to Lisette Wait's lab at the University of Idaho. Lisette's team at The Laboratory for Ecological, Evolutionary and Conservation Genetics has previous experience in analyzing red wolf and coyote hybrid molecular samples and has the most comprehensive DNA methodology for this sympatric canid species continuum in the nation. This expertise will facilitate expedient species identification on collared study animals besides landscape level population dynamics analysis.

	Commission	In-kind	Total
a. Personnel	$ 7,200.00	$ -	$ 7,200.00
b. Fringe Benefits	$ -	$ -	$ -
c. Travel	$ 30,000.00	$ -	$ 30,000.00
d. Equipment	$ 54,000.00	$ -	$ 54,000.00
e. Supplies	$ 61,500.00	$ -	$ 61,500.00
f. Contractual	$315,590.00	$ -	$315,590.00
g. Construction	$ -	$ -	$ -
h. Other	$ 6,000.00	$ -	$ 6,000.00
i. Total Direct Charges (sum of a – h)	$474,290.00	$ -	$474,290.00
j. Indirect Charges	$ 4,800.00	$ -	$ 4,800.00
k. Totals (sum of i and j)	$479,090.00	$ -	$479,090.00
Federal (75%)			$359,317.50
State (25%)			$119,772.50

Commented [OSE127]: Do they even work with hair or biopsy samples?

Commented [OSE128]: 30k for travel? Where are they going? Vegas?
300k for contracts? How many trappers are they going to use? All of them?

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G. Geographic Location

Three counties of the Albemarle Peninsula of North Carolina (Dare, Hyde, and Tyrrell counties).

Commented [JM129]: Morse - add Washington & Beaufort Counties

H. Related Federal Projects

NC-W-F15AF00726 (W-72) NC-Division of Wildlife Management Cooperative Projects

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I. Glossary

Abundance: Species abundance is the number of individuals per species, and relative abundance refers to the evenness of distribution of individuals among species in a community.

Adaptive kernel (AK): A probabilistic home range estimator based on the distribution and density of locations that has been collected over a period of time.

Adverse reactions: In pharmacology, any unexpected or dangerous reaction to a drug.

Aerial: Existing, happening, or operating in the air.

Annually: Once a year; every year.

Anthropogenic: Caused or influenced by humans.

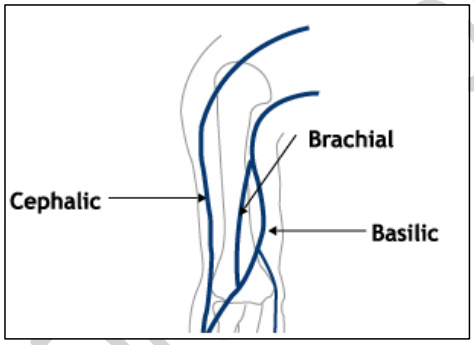
Apex: Having no natural predators in its ecosystem.

Ataxia: The loss of full control of bodily movements.

Beacon: A radio beacon whose purpose is the investigation of the propagation of radio signals.

Biopsy: The removal for diagnostic study of a piece of tissue from a living body.

Brachial vein: One of a pair of veins accompanying the brachial artery and uniting with each other and with the basilic vein to form the axillary vein.



Breeding pair: A pair of animals which cooperate over time to produce offspring with some form of a bond between the individuals.

Carrying capacity: The maximum population size of the species that the environment can sustain indefinitely, given the food, habitat, water, and other necessities available in the environment.

Compensatory immigration: Individuals emigrating from areas with lower mortality to those with higher mortality; filling a deficiency of individuals in a population experiencing higher mortality. The increase in size or activity of one part of an organism or organ that makes up for the loss or dysfunction of another.

Composition: The combining of distinct parts or elements to form a whole.

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Co-occurrence: Refers to observation of the spatial overlap between two (or more) different individuals over a period of time.

Coordinates: Any of the scales or magnitudes that serve to define the position of a point.

Core use areas: An area within a home range exhibited by a dense concentration of location points; commonly estimated at 50% of the location data points.

Covariates: A variable that is possibly predictive of the outcome under study.

Cranial: Pertaining to the cranium or to the anterior (in animals) or superior (in humans) end of the body.

Cryogenic: Very low temperatures, e.g. -80ºC.

Den-obligated: Restricted to a particular condition of life, in this case restricted to a den site.

Density: A measure of the number of organisms that make up a population in a defined area.

Deployment: To organize and send out (people or things) to be used for a particular purpose.

Depredation: The act of preying upon.

Depressed respiration: A decrease in the ability to exhale and inhale; respiration that has a rate below 12 breaths per minute or that fails to provide full ventilation and perfusion of the lungs.

Diagnostic: The process of determining by examination the nature and circumstances of a diseased condition.

Disorientation: Loss of one's sense of direction, position, or relationship with one's surroundings.

Distribution: The manner in which a biological taxon is spatially arranged.

DNA: (deoxyribonucleic acid) is a type of macromolecule known as a nucleic acid. It is shaped like a twisted double helix and is composed of long strands of alternating sugars and phosphate groups, along with nitrogenous bases (adenine, thymine, guanine and cytosine).

Dorsal: Situated on or toward the upper side of the body, equivalent to the back, or posterior, in humans; situated on or toward the posterior plane in humans or toward the upper plane in quadrupeds.

Duration: A continuous period of time.

Dynamic Brownian bridge movement models: Incorporates temporal and behavioral characteristics of movement paths into estimation of home range.

Ectoparasite: a parasite that lives on the outside of its host rather than within the hosts body; e.g. fleas and lice.

Effective trap area: Calculated by buffering each trap site by half the mean maximum distance traveled, each of these boundaries are dissolved, creating a measurable area.

Efficacious: Producing or capable of producing a desired effect.

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Efficient: Accomplishment of or ability to accomplish a job with a minimum expenditure of time and effort.

Euthanize: The act of putting to death painlessly or allowing to die, as by withholding extreme medical measures, a person or animal suffering from an incurable, especially a painful, disease or condition.

Expedient: Suitable for achieving a particular end in a given circumstance.

Evaporative cooling: reduction in temperature resulting from the evaporation of a liquid, which removes latent heat from the surface from which evaporation takes place.

Facilitate: Make an action or process easy or easier.

Genotyping: Investigate the genetic constitution of (an individual organism).

Gonadal descent: The act or process of descending from a higher to a lower location; testicular descent occurs during the breeding season annually.

GPS: Global Positioning System, is a radio navigation system that allows land, sea, and airborne users to determine their exact location, velocity, and time 24 hours a day, in all weather conditions, anywhere in the world.

Home range: an area over which an animal or group of animals regularly travels in search of food or mates, and that may overlap with those of neighboring animals or groups of the same species.

Hybridization: The result of mixing, through sexual reproduction, two animals or plants of different breeds, varieties, species or genera.

Immobilization agent: An active force or substance capable of producing an effect.

Implantation: To put or fix firmly.

Inbreeding depression: The reduced biological fitness in a given population as a result of inbreeding, or breeding of related individuals.

Inception: The establishment or starting point of an institution or activity.

Interspecific: Existing or occurring between different species.

Iridium: A satellite constellation providing voice and data coverage to satellite phones, pagers and integrated transceivers over the Earth's entire surface.

Jugular vein: Any of several large veins in the neck, carrying blood from the head and face.

Lacerations: A deep cut or tear in skin or flesh.

Locational: A position or site occupied or available for occupancy or marked by some distinguishing feature.

Malfunction: Fail to operate in the normal or usual manner

Methodology: A system of methods used in a particular area of study or activity.

Midline: A median line or plane of bilateral symmetry, especially that of the body.

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Minimum convex polygon (MCP): Completely enclose all data points by connecting the outer locations in such a way as to create a convex polygon.

Molecular samples: Genetic samples that may be used for investigation of genetic constitution of an individual.

Morphometrics: The process of measuring the external shape and dimensions of landforms, living organisms, or other objects.

Mortality: The state of being subject to death.

Non-target bycatch: Animals caught by accident that are not the target species being sought.

Parameters: A numerical or other measurable factor forming one of a set that defines a system or sets the conditions of its operation.

Parentage: The origin of something; the state or relation of a parent.

Passive integrated transponder: A microchip implant is an identifying integrated circuit placed under the skin of an animal.

Pinna: The external part of the ear in humans and other mammals; the auricle.

Plateaued: A period or state of little or no growth or decline.

Population dynamics: The branch of life sciences that studies the size and age composition of populations as dynamic systems, and the biological and environmental processes driving them (such as birth and death rates, and by immigration and emigration).

Population growth: The increase in the number of individuals in a population.

Population size: A group of organisms of the same species that live in the same area.

Population status:

Population trend: Changes over time and can include changes in ranging behavior and distribution, biogeography and life-history.

Population viability: The process that determines the probability that a population will go extinct within a given number of years.

Proximity: Nearness in space, time, or relationship.

Quantified: Express or measure the quantity of.

Quantitative: Relating to, measuring, or measured by the quantity of something rather than its quality.

Radio-telemetry: The use of radio waves for transmitting information from a distant instrument to a device that indicates or records the measurements.

Recumbency: The state of leaning, resting, or reclining.

Reintegrate: Restore (elements regarded as disparate) to unity.

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Remnant: A small remaining quantity of something.

Reproductive status: Relating to or effecting reproduction.

Spatial: Relating to, occupying, or having the character of space.

Spatial capture-recapture: A method commonly used in ecology to estimate an animal population's size. A portion of the population is captured, marked, and released. Marked animals are either recaptured or are tracked, each tracking location being considered a recapture.

Species Continuum: An aggregate of species capable of interbreeding, resulting in fertile hybrid offspring whose genetic composition may represent a varying array of phenotypes and genotypes from the parental species, at which the extreme ends of the spectrum are distinct.

Standardize: Cause (something) to conform to a standard.

Statistically relevant inferences: the process of deducing properties of an underlying distribution by analysis of data. Inferential statistical analysis infers properties about a population: this includes testing hypotheses and deriving estimates.

Stochastic population models: Ecological population modeling is concerned with the changes in population size and age distribution within a population as a consequence of interactions of organisms with the physical environment, with individuals of their own species, and with organisms of other species; stochasticity possesses some inherent randomness. In stochastic population models, the same set of parameter values and initial conditions will lead to an ensemble of different out puts.

Strangulation: The condition in which circulation of blood to a part of the body is cut off by constriction.

Stratifying: Form or arrange into strata, one of a number of portions or divisions likened to layers or levels.

Surveillance: Continuous observation of a place, person, group, or ongoing activity in order to gather information.

Survival: A living or continuing longer than, or beyond the existence of, another person, thing, or event.

Sympatric: Occurring within the same geographical area; overlapping in distribution.

Tachycardia: A heart rate that exceeds the normal resting rate. In general, a resting heart rate over 100 beats per minute is accepted as tachycardia in human adults.

Telemetry: See radio-telemetry.

Temporal: Of or relating to time.

Tooth replacement: The process of development of two successive sets of teeth, initially the deciduous set and consecutively the permanent set.

Transmitter: A set of equipment used to generate and transmit electromagnetic waves carrying messages or signals, especially those of radio or television.

Transponder: A device for receiving a radio signal and automatically transmitting a different signal.

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Vaccinate: Treat with a vaccine to produce immunity against a disease; inoculate.

Venipuncture: The puncture of a vein as part of a medical procedure, typically to withdraw a blood sample or for an intravenous injection.

VHF: Very high frequency is the ITU designation for the range of radio frequency electromagnetic waves (radio waves) from 30 MHz to 300 MHz, with corresponding wavelengths of ten to one meters.

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Attachment 1: Intra-service Section 7 Biological Evaluation Form

Region 4
INTRA-SERVICE SECTION 7 BIOLOGICAL EVALUATION FORM

[Note: This form provides the outline of information needed for intra-Service consultation. If additional space is needed, attach additional sheets, or set up this form to accommodate your responses.]

Originating Person: Andrea Shipley
Telephone Number: 252.926.0266 **E-Mail:** andrea.shipley@ncwildlife.org
Date: November 8, 2016

PROJECT NAME (Grant Title/Number): NC – Division of Wildlife Management Cooperative Projects / (W-72)

I. Service Program:

_____**Ecological Services**
__X__**Federal Aid**
_____**Clean Vessel act**
_____**Coastal Wetlands**
_____**Endangered Species Section 6**
_____**Partners for Fish and Wildlife**
_____**Sport Fish Restoration**
__X__**Wildlife Restoration**
_____**Fisheries**
_____**Refuges/Wildlife**

II. State/Agency:

NORTH CAROLINA / NORTH CAROLINA WILDLIFE RESOURCES COMMISSION

III. Station Name:

FWS RALEIGH ECOLOGICAL SERVICES OFFICE

IV. Description of Proposed Action (attach additional pages as needed):

Conduct research project entitled "**Coyotes of the Albemarle: Spatial Ecology, Resource Selection, Demographics, and Interactions with a Sympatric Canid"**

The coyote (*Canis latrans*) is now abundant throughout the 100 counties in North Carolina (NC), where they are managed as nongame with no closed season or bag limit (NC Wildlife Resources Commission 2016). Previously restricted to the West and Midwest regions of the United States, by the early 1990s coyotes had expanded their range into the Albemarle Peninsula (AP), which is situated in the northeast coastal plains region of NC (Hinton et al. 2012, Murray et al. 2014).

Recently described as using "compensatory immigration," coyotes are able to opportunistically fill spatial resource gaps by periodic transiency (Hinton 2016). These periods of transiency can sometimes bring coyotes into conflict with humans and other canids, especially while taking advantage of anthropogenic resources. Though a rural area, human land uses predominate on the AP. The AP is comprised of approximately 30% agricultural fields, 50% forest and coastal marshes, and 20% "other" land cover types on federal, state and private lands (Dellinger 2011).

In 1968, individuals from a remnant population of red wolves were removed from Texas and Louisiana and a captive breeding program was initiated. The United States Fish and Wildlife Service (USFWS) released a non-essential, experimental population of red wolves (*Canis rufus*) on the Alligator River National Wildlife Refuge (ARNWR) in 1987 (Hinton et al. 2013). The red wolf population increased until 2008 and peaked at around 208 individuals (USFWS Red Wolf Recovery Program 2007), a few animals short of the recovery goal of 220 in the wild (USFWS Red Wolf Recovery Program 2013), with an estimated carrying capacity of 140-150 for the AP (Hinton et al. 2013, Kelly et al. 1999, USFWS Red Wolf Recovery Program 2007). Red wolves presently inhabit an approximately 6900 square kilometer recovery area within Beaufort, Dare, Hyde, Tyrrell, and Washington counties (Wildlife Management Institute 2014).
Accurate up-to-date estimates of the population are unavailable, but USFWS staff report a population size of 45-60 individuals with three mortalities in 2016 (https://www.fws.gov/redwolf/index.html July 2016). Hybridization with coyotes, inbreeding depression, and gunshot mortality have all been suspected issues that have affected the population growth and viability since the inception of the Red Wolf Recovery Program (RWRP) (Hinton et al. 2013). In 2013, NCWRC and USFWS established a committee to oversee the collaborative management and conservation of red wolves and other canids on the AP. A USFWS memorandum documented detailed action items for the joint management of canids on the AP, including specific research objectives which this proposal seeks to address (Attachment 1).

As coyotes on the AP increase in number, monitoring coyote movements, particularly in relation to red wolves, will provide important data to NCWRC and USFWS staff for science-based local and landscape-level decisions about coyote population management. Collection of finer temporal scale location data will help to manage interactions of both canid species with humans, as well as to support development of dynamic stochastic population models.

Coyote and red wolves will be live trapped by cooperating NCWRC and USFWS staff, and private trappers using double coil size 3 foothold traps, during the breeding season (Nov-Feb for coyote, Jan-Feb for red wolves) in the tri-county area of Dare, Hyde and Tyrrell. Morphological measurements, incidents of injury, occurrence of ectoparasites, age classification, and reproductive status will be determined; blood and tissue samples will be taken for genetic analysis. All captured individuals that meet the age classification and weight requirements will be collared with GPS collar units. All captured and collared individuals will be released at the capture site. The objectives listed below will be achieved by obtaining measurements, samples and information from the captured, collared, and tracked individuals over the course of three years using GPS location data.

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Commented [JM130]: Morse - 11 mortalities in 2016 (insert current pop. estimate

Not trapping during breeding season (February).
No tissue samples from live wolves.
Will coyotes be sterilized?

Objective 1: Use GPS collar and proximity sensor technology to test performance under various conditions and evaluate the frequency and accuracy of the scheduled fix rates.

Objective 2: Use fine scale GPS data collection for investigating annual and seasonal spatial dynamics of sympatric canids: home range and core area sizes, amount of overlap in home range and core areas, movement pathways and daily activity patterns, and cover type selection and preference.

Objective 3: Use fine scale GPS data collection for investigating the number and age structure of offspring for family groups of collared sympatric canids.

Objective 4: Use fine scale GPS data collection for investigating sources of mortality for sympatric canids.

Objective 5: Use fine scale GPS data collection for preventing and mitigating canid conflicts with landowners.

Objective 6: Determine genetic profiles of sympatric canids through DNA identification of all captured individuals, parentage, and presence of hybridization.

V. Pertinent Species and Habitat:

A. Include species/habitat: See section VI

B. Complete the following table:

SPECIES/CRITICAL HABITAT	STATUS[1]
Canis rufus	T

[1]STATUS: E = endangered, T = threatened, PE = proposed endangered, PT =proposed threatened, CH = critical habitat, PC = proposed critical habitat, C = candidate species

VI. Location:

A. Statewide

Albemarle Peninsula (see web address www.ncwildlife.org)

B. Section, township, and range (or latitude and longitude):

Dare, Hyde, Tyrrell counties

C. Distance (miles) and direction to nearest town:

As stated above

D. Species/habitat occurrence:

Canis rufus

VII. Determination of Effects:

A. Explanation of effects of the action on species and critical habitats in item V. B. (attach additional pages as needed):

SPECIES/CRITICAL HABITAT	IMPACTS TO SPECIES/CRITICAL HABITAT
Canis rufus	Trap induced injury is possible

B. Explanation of actions to be implemented to reduce adverse effects:

SPECIES/CRITICAL HABITAT	ACTIONS TO MITIGATE/MINIMIZE IMPACTS
Canis rufus	Use of appropriate trap types, daily trap checks, treatment of minor injuries, trapping season limitations and limitations on environmental conditions for trap operation

Commented [JM131]: Morse – VI B. Include Washington and Beaufort Counties

Section VII. B. Include early morning trap checks.

VIII. Effect Determination and Response Requested:

Species/ Critical Habitat	Determination[1]			Response[1] Requested
	NE	NA	AA	
Canis rufus		X		Concurrence

[1] Determination/Response Requested:

NE = No Effect. This determination is appropriate when the proposed action will not directly, indirectly, or cumulatively impact, either positively or negatively, any listed, proposed, candidate species or designated/proposed critical habitat. Response Requested is optional but a "Concurrence" is recommended for a complete Administrative Record.

NA = Not Likely To Adversely Affect. The determination is appropriate when the proposed action is not likely to adversely impact any listed, proposed, candidate species or designated/proposed critical habitat or there may be beneficial effects to these resources. Response Requested is a "Concurrence".

AA = Likely To Adversely Affect. This determination is appropriate when the proposed action is likely to adversely impact any listed, proposed, candidate species or designated/proposed critical habitat. Response Requested for listed species is "Formal Consultation". Response Requested for proposed or candidate species is "Conference".

Signature (originating station) **Date**

Title

IX. Reviewing Ecological Services Office Evaluation:

A. Concurrence _____ Non-Concurrence _____

B. Formal consultation required _____

C. Conference required _____

D. Formal conference required _____

E. Remarks (attach additional pages as needed):

_____ _____
Signature **Date**

_____ _____
Title **Office**

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Attachment 2: Joint Memorandum

MEMORANDUM

November 20, 2013

TO: All Interested Parties

FROM: "for"
Cynthia K. Dohner, Director, Southeast Region, U.S. Fish and Wildlife Service
Gordon S. Myers, Executive Director, N.C. Wildlife Resources Commission

SUBJECT: Collaborative Conservation of Red Wolves and Other Canids on North Carolina's Albemarle Peninsula

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Recovery of the federally-listed red wolf has been a priority for the U.S. Fish and Wildlife Service (FWS) for more than 20 years and is focused in North Carolina on the Albemarle Peninsula (AP; i.e., Hyde, Tyrrell, Washington, Beaufort, and Dare counties). Comprehensive stakeholder involvement and collaboration with other management agencies is critical to successful recovery of any at-risk species. The North Carolina Wildlife Resources Commission (WRC) is a key collaborator in this regard, as it has jurisdiction over all state-trust wildlife resources in N.C.

Since 2009, the FWS and WRC have worked to broaden our collaboration in the conservation and management of all canid species (including red wolves) on the AP. As these efforts have solidified, specific actions have been jointly identified by our two agencies that will improve conservation outcomes. These actions are categorized into five areas; collaboration, research, outreach, regulatory, and enforcement. Specific action items are outlined and prioritized within each of these categories in Attachment A.

This memo establishes the FWS's and WRC's commitment to initiate, or to continue, the efforts outlined in Attachment A. The common goal in this effort is to establish clear expectations and accountability for collaboration regarding the action items on Attachment A, thus resulting in enhanced and seamless canid conservation and management on the AP. This approach provides the best opportunity to achieve recovery goals for red wolves, while at the same time managing other canids to balance biological variables with social expectations. The dynamics of these canid species are complex and offer unique opportunities for innovation. Appropriate staff from each agency is hereby tasked with immediately developing a timeline to implement these actions. Through this commitment, we will continue to advance our collective conservation goals.

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Attachment A

Action Items for Collaborative Conservation of Canids on North Carolina's Albemarle Peninsula (AP)
(*Note: Action Items are prioritized within category.*)

Collaboration

1. The N.C. Wildlife Resources Commission (WRC) and U.S. Fish and Wildlife Service (FWS) will formalize in writing the collaborative management of canids on the AP. This agreement should:
    a. include a clear mission statement, goals, objectives, and implementation strategies (ask and answer the "Why?");
    b. set a goal to define success regarding canid management on the AP;
    c. espouse a philosophy of canid management operating within the context of a three-legged stool (i.e., federal and state governments and stakeholders);
    d. as available, commit funding and staffing resources for field personnel to contribute to the conservation of the red wolf and management of coyotes;
    e. as available, commit funding to conduct research pertinent to canid management on the AP;
    f. establish polices and goals for developing a collaborative genetic archive for AP canids, a data sharing portal accessible by staff in both agencies, and reciprocal sharing of all historical data (including phenotypic and genotypic data and literature) of the red wolf;
    g. establish a foundation for developing and implementing an adaptive approach to canid management on private lands on the AP;
    h. initiate development of a collaborative canid research program;
    i. describe plans to conduct the next five year Red Wolf Program review;
    j. outline options for holding annual workshops with federal and state enforcement staff;
    k. outline plans to hold semi-annual coordination meetings regarding canid management on the AP; and
    l. develop milestones for future development of a management plan for all canids in the AP.

2. The FWS will initiate a review of the current Red Wolf Recovery Plan to determine if the state-of-our-knowledge or field conditions have changed such as to warrant its revision. Review and comments from the WRC will be considered in this evaluation.

3. The WRC, with support and participation of the FWS, will establish a "Canid Forum" (similar to that established for manatees in Florida) to facilitate communication and discussion regarding canid management and citizen science opportunities on the AP.

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Attachment A

Research

1. The FWS and WRC will provide funding and logistical support for research identified by the Red Wolf Recovery Implementation Team, Red Wolf Program staff, other FWS staff, or the WRC that promote the conservation and recovery of the red wolf and other canids on the AP. Studies could include:
    a. tests of the "placeholder theory" on the AP, including behavior of sympatric canids,
    b. determining carrying capacity of canids on the AP,
    c. determining genetic profiles of canid species on the AP,
    d. evaluating predator-prey dynamics,
    e. studies of canid habitat use,
    f. epidemiology of diseases impacting canids on the AP,
    g. development of stochastic simulation models of sympatric canid population dynamics and habitat use, and
    h. canid dispersal dynamics

2. The FWS and WRC will conduct jointly-supported research to determine the attitudes and opinions of N.C. private landowners and other citizens concerning canids on the AP (i.e., human dimensions studies).

Outreach

1. The FWS and WRC will collaborate with other partners to design and implement broad-based outreach and marketing programs with clear goals, objectives, strategies, and measurable outcomes, including development of consistent agency messages and educating the public about canids on the AP.

Regulatory

1. The FWS and WRC will initiate a review and, if needed, subsequent rule-making to clarify concepts or rectify conflicts in current federal or state rules (including the current 10(J) rule).

2. The WRC will review and evaluate statutory requirements for listing red wolves as state threatened in the five AP counties.

3. As data demonstrating a relationship between coyote hunting and red wolf mortality become available, the FWS and WRC will evaluate, and if appropriate implement, adaptive approaches to regulate of take of coyotes that may result in incidental take of red wolves.

4. The WRC will evaluate the status, management, and regulation of Controlled Fox Hunting Preserves.

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5. The WRC will develop BMPs (due care provisions) for coyote hunting, trapping, and live sale.

6. The WRC will compile, compare, and contrast canid hunting and trapping regulations and programs in other states, including, but not limited to, other states with other species of wolves.

Enforcement

1. The FWS and WRC will develop coordination strategies to improve enforcement of federal regulations protecting red wolves.

Attachment 3: Landowner Agreement Form

NC Wildlife Resources Commission
Wildlife Management Division
Wildlife Diversity Program
Landowner Agreement for Scientific Collection

_____ / _____ / _____
MM DD YYYY

Property Type
Private _____ Federal _____ State _____

NC Wildlife Resources Commission
Address: 1701 Mail Service Center, Raleigh, NC 27699-1701
Phone: 919-707-0010

Cooperator's Name: _____
Last First Middle

Cooperator's Address: _____
Street City, State, Zip

Where will the work be performed? _____

give address or directions if different from above _____

Business, Farm, Property Common Name _____

Owner's or Rep Name _____ _____
If different from Cooperator Telephone Number

Owner's Address: _____
If different from Cooperator Street City, State, Zip

WRC Employee & Work Location	Species
	1)
Employee Name	2)
	3)
Duty Area	4)

I, the cooperator or cooperator's representative, have been informed of the methods and the manner in which research devices will be used, and of the possible hazards associated with their use. I understand that NCWRC, (to include its officers, employees and agents) will: exercise reasonable precautions to safeguard all persons to prevent injury to target and non-target animals; guard against the mishandling of control devices and materials; and exercise due caution and proper judgment in all scientific collection operations. I understand that NCWRC may collect Global Positioning System (GPS) coordinates at the project site as part of component or activity tracking or as wildlife disease monitoring or research data. I, the undersigned cooperator, do hereby give my consent and concurrence to NCWRC, its employees, and its agents, to use, upon lands owned, leased, or otherwise controlled by me, and identified by this document, the following methods and devices (an attachment of additional devices and/or methods may be attached):

Statement of agreement: The landowner, cooperator, or representative, as listed above hereby give permission to NCWRC to perform trap and release of the species listed for scientific collection purposes. In consideration of these understandings, I, the cooperator or cooperator's representative, agree to: assume responsibility for injury to my property under my control, when said injury is not the result of negligence on the part of NCWRC (it's officers, employees, and agents); assist in maintaining such warning signs as NCWRC may place for the purpose of notifying persons entering onto such lands of the possible hazards associated with scientific measures in use thereon; and to give adequate warning of these possible hazards to persons I authorize to enter onto such lands. Further, I, the cooperator or cooperator's representative, agree not to concurrently use or allow to be used upon lands covered by this agreement, any canid depredation efforts during the scientific collection time period.

Landowner Signature/Date _____
Signature Date

WRC Employee Signature/Date _____
Signature Date

Attachment 4: Trapper Service Contract

Contract in development.

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STATE: North Carolina

GRANT TITLE: W79-Wildlife Management

PROJECT TITLE: Pilot Study – Using Fine Scale GPS Technology to Research Sympatric Canid Population Dynamics (Job 2.0?)

A. Problem and Need

The coyote (*Canis latrans*) is now abundant throughout the 100 counties in North Carolina (NC), and is managed as nongame with no closed season or bag limit (NC Wildlife Resources Commission 2016). Previously restricted to the West and Midwest regions of the United States, by the early 1990s coyotes had expanded their range into the Albemarle Peninsula (AP), which is situated in the northeast coastal plain region of NC (Hinton et al. 2012, Murray et al. 2014). In recent years as coyotes have increased their population, some have begun to make use of the Outer Banks region.

The United States Fish and Wildlife Service (USFWS) released a non-essential, experimental population of captive-bred red wolves (*Canis rufus*) on the Alligator River National Wildlife Refuge (ARNWR) in 1987 (Hinton et al. 2013). This population increased until 2008 and peaked at around 130 individuals (Group Solutions, Inc. 2016), short of the recovery goal of 220 in the wild (USFWS Red Wolf Recovery Program 2013). The AP has an estimated carrying capacity of 140-150 wolves (Hinton et al. 2013, Kelly et al. 1999, USFWS Red Wolf Recovery Program 2007). The exact number of red wolves is not known, but USFWS staff report a population estimate of 45-60 individuals with eight mortalities to date in 2016 (https://www.fws.gov/redwolf/index.html August 2016). Hybridization with coyotes and inbreeding depression are suspected factors that have affected red wolf population growth and viability since the inception of the Red Wolf Recovery Program (RWRP), while vehicular and gunshot mortality are known factors (Hinton et al. 2013). Because of hybridization between red wolves and coyotes, the AP supports a continuum of sympatric canids, hereafter referred to as "sympatric canids."

As part of a recent program review, the USFWS halted many aspects of the RWRP in 2015 and discontinued the coyote sterilization program, potentially affecting the spatial

Commented [OSE1]: Citation! How abundant?

Commented [JM2]: Morse - The 220 animals in the wild was to be a total population number devided into 2-3 mainland sites.

Commented [JM3]: Morse - The actual estimate for carrying capacity in the NEP is more like 175 animals.

Commented [OSE4]: This information is obviously out of date and invalid.

Commented [OSE5]: Hybridization has not been an issue since the beginning of the program as there were no coyotes out here in the beginning.

Commented [JM6]: Morse - Gunshot mortality is known to be the number one and most critical factor affecting population growth.

Commented [JM7]: Morse - The coyote sterilization program needs to be part of the NCWRC research proposal. (Deal breaker)

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distribution and population dynamics of sympatric canids. Telemetry data from coyotes on the AP suggests that about 70% of coyotes are residents (i.e., those that defend set territories) while the other 30% are transients, with most being dispersing juveniles (Hinton et al. 2015). Transient coyotes do not defend set territories. Coyotes can travel long distances and become transient even as adults, especially when they lose their mate. Recently described as using "compensatory immigration," coyotes opportunistically fill spatial resource gaps by periodic transiency; when spots come open, individuals that do not yet have permanent territories and have been roaming in the area, are able to inhabit the new openings (Hinton 2016). These periods of transiency can sometimes bring coyotes into conflict with other canids and humans, especially when they are utilizing of anthropogenic resources.

Though a rural area, human land uses occupy a significant portion of space on the AP. The AP is comprised of approximately 30% agricultural fields, 50% forest and coastal marshes, and 20% "other" land cover types on federal, state and private lands (Dellinger 2011). Concerns about fear of attacks on humans and domestic pets, the effects of sympatric canids on white-tailed deer and other game populations, and homeowner property damage comprise many of the conflict calls regarding sympatric canids on the AP (Responsive Management, forthcoming data). Wildlife managers in this region frequently receive requests for information on canid management (C. Turner, personal communication, 2016).

The changes in state and federal canid management rules have resulted in confusion regarding residents' rights and options for management of property damage by sympatric canids. As a result, some citizens are unsure of the legal and most effective methods for canid conflict management. Adding to management complexity is the need to manage canids for conservation purposes, such as reducing predation on at-risk ground nesting species or reducing hybridization of sympatric canids.

In 2013, NCWRC and USFWS established a committee to oversee the collaborative management and conservation of sympatric canids on the AP. A USFWS and NCWRC joint memorandum documented detailed action items for the joint management of sympatric canids on the AP, including specific research objectives which this proposal seeks to address (Attachment 2). As sympatric canids on the AP increase in number, monitoring their

Commented [JM8]: Morse - Need to see the forthcoming data to comment on it. No predator/prey relationship studies have been conducted in the NEP for red wolves or coyotes and whitetail deer or any other game species. This should be part of the study proposal.

Commented [JM9]: Morse - Need information on information request to FWS by Chris Turner. Not sure of any to date.

Commented [JM10]: Morse - The current law/reg. is clear: it is legal to take or harass a red wolf in defense of human life or to protect pets and livestock.

Commented [JM11]: See Ryan's comment.

Commented [OSE12]: Does this mean that they are going to trap at Pea Island or any other state and federal land that occurs in Dare county that's not on the peninsula?

Commented [JM13]: Morse - Need examples of at-risk, ground nesting species to be able to comment adequately.

Commented [JM14]: See Ryan's comment.

Commented [JM15]: See Ryan's comment.

Commented [JM16]: Does not acknowledge dramatic decrease of red wolves because of lumping as sympatric canids.

Commented [OSE17]: As stated on page one "the AP supports a continuum of sympatric canids" this means coyotes, hybrids and wolves. I guarantee that wolf numbers are declining while others on the continuum are increasing; thus making this statement false. It implies that all variations are increasing.

This sentiment is explained more clearly on page 33 paragraph 3. They refer to coyotes and wolves separately.

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movements, particularly in relation to individuals of differing ancestry, could provide important data to NCWRC and USFWS staff for science-based local and landscape-level decisions about sympatric canid populations and conflict management. Collection of finer temporal scale location data would help to manage interactions of sympatric canids with humans, as well as to support development of dynamic stochastic population models.

B. Objectives (after December 1, 2016-November 30, 2018)

Objective 1: Use GPS collar and proximity sensor technology to test performance under various conditions and evaluate the frequency and accuracy of the scheduled fix rates.

Objective 2: Use fine scale GPS data collection for investigating annual and seasonal spatial dynamics of sympatric canids: home range and core area sizes, amount of overlap in home range and core areas, movement pathways and daily activity patterns, and cover type selection and preference.

Objective 3: Use fine scale GPS data collection for investigating the number and age structure of offspring for family groups of collared sympatric canids.

Objective 4: Use fine scale GPS data collection for investigating sources of mortality for sympatric canids.

Objective 5: Use fine scale GPS data collection for preventing and mitigating canid conflicts with landowners.

Objective 6: Determine genetic profiles of sympatric canids through DNA identification of all captured individuals, parentage, and presence of hybridization.

At the end of this two-year pilot study, we will deliver an observational summary detailing the use of the GPS and sensor technology for spatial and population dynamics research on sympatric canids on the AP.

C. Expected Results and Benefits

As part of a pilot study, we will monitor the status of collared individuals by using a finer scale assessment of space and habitat use than previous studies. Earlier research focused on many of the same objectives we suggest investigating here, but during a time of intense, active

Commented [OSE18]: Don't see how this would work, unless they are talking about human dimensions.

Commented [JM19]: Morse - Need description on how this data will help manage interactions of sympatric canids with humans.

Commented [JM20]: Objectives talk about GPS'd animals but don't take into account any data from the existing 23 radio-collared red wolves and 29 collared coyotes.

Commented [OSE21]: Is this list a weighted list? I would hate to think that this was the objective with the highest priority.

Commented [JM22]: Morse - This testing should be conducted with coyotes, not wolves until performance levels are confirmed. Coyotes should be sterilized to assist with gaining private landowner permissions.

Commented [JM23]: Morse - There is currently no area on ARNWR where this level of wolf/coyote interaction occurs. Where will this investigation be conducted?

Commented [OSE24]: Why do they need location data for number of animals and age?

Commented [JM25]: Morse -The number and age of wolf offspring in breeding groups is already known using conventional VHF data collection and USFWS den work.

Commented [OSE26]: As stated later in this proposal no target animals will be treated for disease. Not treating wolves for visible or known disease is contrary to the recovery program, whether that be for recovery in the wild or increasing numbers in captivity. By continuing treating any wolves we would be compromising the validity of any conclusions from the data. Additionally, are they talking about actual source locations, as in disease originating locus, or causes of mortality?

Commented [JM27]: Morse - FWS already conducts ~100 telemetry flight/year to access red wolf and radio-collared coyote mortality sources.

Commented [JM28]: Morse - Need description of how this will happen and what data is to be shared with private landowners.

Commented [OSE29]: How do they propose to accomplish this? Which specific conflicts? How does knowing exact location help?

Commented [JM30]: Morse - This needs to be a separate and ongoing project conducted with ASU or a different university.

Commented [OSE31]: Their section 7 attachment state 3 years. Granted they state they will be tracking over the course of 3 years. Did they mean 2 years of trapping with a ...

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management. Specific management techniques are no longer being carried out and dynamics between sympatric canids are expected to have changed substantially. The uncertainty regarding current dynamics presents a need for additional research in order to inform actions for the management of sympatric canids. Information gained from research may impact management rules and landowner's abilities to manage canids in some areas. Additionally, GPS technology has improved since earlier research was conducted allowing for more temporally detailed data collection and more nuanced analyses. Understanding how sympatric canids collectively use resources in areas of human-dominated landscapes will allow wildlife managers to tailor management options to local conditions. On the AP, row crop agriculture and hunting represent the primary and secondary land uses, respectively. Row crop agriculture is a significant nutrient resource on the landscape and, as opportunists, canids take advantage of such resources when they are available. Non-consumptive wildlife-driven tourism persists in all seasons and wildlife watching is a main draw for tourists in this area. For many tourists, the opportunity to see or hear large carnivores is the sole attraction for traveling to the AP. Information from this study will be provided to local constituents to establish a knowledge base regarding how sympatric canids use resources on private lands. Management and guidance could serve to prevent or minimize conflict while maximizing positive wildlife interaction opportunities for constituents. Development of a common understanding between wildlife managers and landowners based upon factual information is paramount for collaboratively achieving successful management of sympatric canids. The data collected in this pilot study is the foundation upon which this understanding and future management actions will be built.

The current level of hybridization between sympatric canids on the AP will be characterized using DNA gathered during this study. Body size exists as a continuum between coyotes and red wolves and has been documented as the most important factor for successful interspecific breeding pairs of these canids (Hinton 2014). Though both species have been found to use resources in similar manners, red wolves generally have more expansive home ranges and therefore may not use local resources as intensively as coyotes, depending on body size. Obtaining individual identification of study animals will allow managers, armed with spatial information, to infer how and why individuals in the canid species continuum exploit

Commented [JM32]: Morse - Do not rule out the possibility of more intense, active management techniques as described in the RW adaptive management plan.

Commented [JM33]: See Ryan's comment.

Commented [OSE34]: I would like to see a citation for everything in this sentence. Additionally, how do they take advantage of the resources? Are they eating part of it? Primary hunting area?

Commented [JM35]: Morse -What does this mean?

Commented [JM36]: See Ryan's comment.

Commented [OSE37]: Who are these local constituents? One of the main results that I can think of is that landowner requests for wolf removal will increase. Wasteful spending of federal and state money on removal efforts of coyotes, just like the failed removal effort of a coyote in 2016.

Commented [OSE38]: Is a wolf breeding with a hybrid considered hybridization?

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anthropogenic resources considering their life history traits.

In conjunction with prior research, data collected will contribute to knowledge on sympatric canid population dynamics on the AP. Estimating population size will allow managers to monitor population trends of sympatric canids and to examine the long and short-term impacts of different management strategies on their populations. While it is unknown whether sample size will allow for population estimation, obtaining population estimates for coyotes would provide wildlife managers with baseline data, when paired with annual mortality estimates, for monitoring changes in population abundance over time. Information on changes in abundance, reproductive dynamics, and habitat use could impact management strategies to influence long-term conservation outcomes. Results of this pilot study will allow managers to determine if future work will be necessary, what amount of effort will be required to achieve each objective, and whether or not population estimates will be an attainable goal.

D. Approach

The official Red Wolf Recovery Area (RWRA) covers approximately 6,900 square kilometers within Beaufort, Dare, Hyde, Tyrrell, and Washington counties (Wildlife Management Institute 2014). However, the USFWS has proposed the RWRA be constricted to the ARNWR and the Dare County Bombing Range in Dare county by the end of 2017. Due to these proposed RWRA changes, this study proposes to capture and radio-collar 25 sympatric canids within Dare, Hyde, and Tyrrell counties (hereafter referred to as "study area"); those counties being within and directly adjacent to the proposed new RWRA. The thematic subheadings below provide detailed descriptions of the approaches required for achieving the pilot study objectives.

Sampling Efforts

Trained NCWRC personnel will conduct live trapping of sympatric canids, with assistance from the USFWS RWRP biologists, and trained, experienced local trappers. NCWRC and USFWS wildlife personnel will select local trappers based on their past performance in trapping sympatric canids, but may also select trappers from the NCWRC coyote trappers list. NCWRC staff will train contracted trappers on specific trapping procedures before every trapping

Commented [OSE39]: What? They are opportunistic animals and will use any resources that they are able to, or is there something in the literature that states that coyote and wolves don't use anthropogenic resources. They even stated earlier that canids take advantage of row crops which would imply anthropogenic resources are an integral part of their life history. They are implying that the use of anthropogenic resources is abnormal behavior.

Commented [JM40]: Morse - This aspect of a coyote population size estimate would best be done in an area with no other sympatric canids.

Commented [JM41]: I don't believe technically a "recovery area" has been delineated, just an NEP boundary.

Commented [JM42]: See Ryan's comment.

Commented [OSE43]: Are we really going to let them trap on the refuge?? Needless to say this would hand over significant control of the program over to the State. I would dare say an illegal hand over at this point.

Loss of control 1.

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season. The project lead will supervise and coordinate all trapping activities including locations for installation and the operation of trap lines and handling of captured animals. Simultaneous personal trapping activities by contracted trappers will not be permitted while performing contracted trapping services, as specified in the draft service contract (Attachment 4).

Trapping efforts will follow a spatial capture-recapture (SCR) framework with a systematic targeted sampling design, focusing on areas that contain resources previously found to be used by sympatric canids (e.g. edge, agricultural fields, secondary roads, etc.) (Harris et al. 2013, Ivan et al. 2013), while attempting to sample a diversity of habitat types. This effort will allow us to increase the probability of detection of sympatric canids on the landscape (Tom 2012). While it is important to sample a wide range of habitats, the most important requirement for SCR is the number of collared individuals; this requirement provides flexibility in the other requirements for field sampling as needed (K. Pacifici, personal communication, 2016). We will initially focus trapping in areas of known red wolf packs, as advised by RWRP.

Trapping will take place during the breeding season when the likelihood of capturing females in the later stages of gestation or whelping females will be low. Capture efforts will be conducted from soon after 1 December 2017 – February 2018 and December 2018 – February 2019. Captured sympatric canids will be surrendered to NCWRC or the USFWS at capture sites. Trapping should occur on both public and private lands to obtain sampling coverage of the study area. Ideally, all federal and state lands would be accessible for trap and release (hereafter referred to as "capture") of sympatric canids, but it is most important to be able to trap and release on Alligator River NWR and the Dare County Bombing Range as those encompass the newly proposed RWRP recovery area and comprise the majority of land area for Dare county. Unlike Dare county, there are ample private lands that surround Pocosin Lakes NWR and Lake Mattamuskeet NWR in both Tyrrell and Hyde counties that may be utilized to effectively sample individuals who may use those federal lands, should they be excluded from capture activities. Capture on federal lands may require USFWS take permits and proposed activities may be subject to a compatibility assessment (P. Benjamin, personal communication, 2016). Scientific collection activities that take place on private lands will require agreements outlining conditions mutually decided by NCWRC and landowners (Attachment 3).

Commented [OSE44]: Another level of lost control.

Loss of control 2

Commented [OSE45]: Trap shy animals will be difficult to recapture, thus biasing their results.

Commented [OSE46]: There are only two known wolf packs left in their proposed study area.

Commented [JM47]: See Ryan's comment.

Commented [OSE48]: Breeding disruption is a possibility. Higher chance of trapping too many animals too young, as per their protocol, to collar.

In the Section 7 attachment they specifically state that coyote trapping will commence in Nov and end in Feb, while wolf trapping will start in Dec and end in Feb.

Commented [JM49]: Morse - Not for red wolves (deal breaker).

Commented [JM50]: See Ryan's comment.

Commented [JM51]: See Ryan's comment.

Commented [JM52]: Is it appropriate for NCWRC personnel and contract trappers to be trapping on the Refuge vice highly trained and experienced FWS personnel?

Commented [OSE53]: This sentence is a little vague. Do they mean that will have the opportunity to trap private land if the public land is excluded?

Commented [OSE54]: Compatibility assessment?. If this study goes through, it would effectively give the State full control of the wild population. At the bare minimum this would constitute a 10j rule change.

Where is the assessment?

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To increase probability of detection of sympatric canids, the accessible study area will be partitioned by a grid, the cell size of which will based on the average annual home range size of resident coyotes previously reported for the AP, approximately 23 km^2 (Hinton et al. 2015). As a system of sampling, trap lines will be referred here as "traps," and the number of trap sets (i.e. the actual trapping device) and number of each trap set size may vary between traps as necessary. Sampling will be standardized within each grid cell by use of equal number of traps per cell, on average 3 per cell, each at an approximate length of 10 km (Andelt and Gipson 1979, Way et al. 2004).

Target canids will be captured by using Softcatch #3 Coyote 4x4 (Oneida Victor Inc. Ltd., P.O. Box 32398, Euclid, Ohio 44132, Hinton 2014, Schemnitz 1994), the EZ Grip #7 (Livestock Protection Company, P.O. Box 725, Alpine, Texas 79831, Frame and Meier 2007), or equivalent. Various lures and baits will be used to increase trapping efficiency (Frederick et al. 1989, Shipley 2012). Traps will be laid on the Monday of each week and will be opened at the time of deployment. Traps will be checked once daily at dawn, to reduce potential stress to trapped individuals and will not be operated on days where the temperature is expected to reach or exceed 80° F (R. Nordsven, personal communication, 2016) or during times of predicted inclement weather (e.g. snow, hail, high wind, etc., Sikes et al. 2011). To standardize effort and remain logistically realistic, traps should be open for three trap nights in a row before being removed. Trap sets that have been closed due to non-target bycatch or other circumstances may be reopened and all traps should be re-baited and lured as appropriate.

Trap set locations will be marked by NCWRC or USFWS personnel using handheld GPS units (Garmin GPSMAP 64S, 1200 E. 151st St., Olathe, KS 66062-3426) and given a sequential identification number. Traps will also be given an identification number and trap set points will be documented in ArcMap 10.4. Trappers will keep detailed records on trap set operation, non-target species trapped, and other relevant details. Non-target species will be released from traps after an in-field assessment of injuries, if any, and animals with life threatening injuries will be euthanized by the trap operator. Targeted recapture of collared canids will occur annually during the same months, to replace GPS collar batteries and drop-off collar release units in field. Trapping effort will be quantified (trap nights), the effective sample area will be

Commented [JM55]: See Ryan's comment.

Commented [JM56]: See Ryan's comment.

Commented [OSE57]: What about freezing or below freezing temps. This concern might be covered by their inclement weather statement. The temperature range should be spelled out and private trappers would have to be explicitly told not to trap.

Commented [OSE58]: Why only 3 nights

Commented [OSE59]: Loss of control 3. Implied.

Commented [OSE60]: Good luck capturing trap shy animals. Additionally wont this interfere with subsequent trapping years of the study, or are they planning on not trapping for new animals in the same locations the following year.

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estimated, the encounter (detection) probability will be estimated using a Gaussian detection model (Amundson et al. 2014), and an estimate of density for coyotes will be calculated using a modified Huggins closed-capture estimator in program MARK, if sample size allows (Harris et al. 2013, Ivan et al. 2013).

Animal Handling

Handling of canids will follow American Society of Mammalogists (ASM) guidelines (Sikes et al. 2011) and will be performed at the capture site. Chemical immobilization agents may be used depending on the number of field staff during processing (i.e., three or more staff required during non-chemical immobilizations, Craft 2007, M. Morse, personal communication, 2016).

Chemical Immobilization

Unless adequate numbers of personnel are available to safely employ mechanical restraint techniques, target animals will be anesthetized with the chemical immobilization agent BAM (Wildlife Pharmaceuticals, Inc., Windsor, CO 80550). BAM, a combination of Butorphanol tartrate, Azaperone tartrate and Medetomidine HCl., will be delivered by intramuscular injection by syringe pole to the hip. Dosage for canids is based on field trails performed by Wildlife Pharmaceuticals (Wildlife Pharmaceuticals, Inc. 2016) and the recommended dose for coyotes is 0.2CC and red wolves is 0.3CC, with adjunct doses of 0.1-0.2CC delivered if initial dosages do not cause induction (S. Kirschner, personal communication, 2017). Induction times for coyotes and wolves ranged from 5 to 10 minutes after initial and/or adjunct dosages (Wildlife Pharmaceuticals, Inc. 2016). After field handling is concluded the anesthesia will be reversed using two reversal agents, Atipamezole and Naltrexone, at double the CC of Atipamezole to BAM that was delivered (including adjunct doses, if given) and 0.5CC of Naltrexone. Recovery time from the reversal agents ranged from 10 to 25 minutes during field trails (Wildlife Pharmaceuticals, Inc. 2016). Field personnel will observe animals for signs of adverse effects for up to 30 minutes after reversal agents are delivered.

Mechanical Immobilization

Unlike other carnivore families, the submissive behavioral response of canids to

Commented [OSE61]: Why is the sample area going to be estimated when they stated earlier that they were going to grid out accessible areas?

Commented [OSE62]: This probability is comprised of two factors. 1) Availability "which is the probability that an animal is present in the survey area and signaling its presence to the observer" and 2) Perceptibility "which is the probability that an animal available for detection (e.g., a bird sings) is detected by the observer" This is taken directly form the Amundson paper. I understand how the collars will help with determining availability, but I am curious how they will determine perceptibility. Is the perceptibility tied to the number of traps or ear tags?

Commented [OSE63]: Are they talking about immobilization while the animal is in the trap or are they talking about after the animal is out of the trap? Lots of possible implications when dealing with contract trappers if it is the former. What about total animal process time vs checking trap lines.

Commented [JM64]: Morse - Wolves will be turned over to FWS for processing and radio-collaring at the RWEC (Columbia, NC) with support from NCWRC biologists. (deal breaker).

Commented [JM65]: Morse - Two biologists and one note taker (if available). If not, two biologists can do the processing with no problems.

Commented [JM66]: Morse - We have a better, cleaner and safer chemical immobilization protocol developed specifically for red wolves by the NCSU Vet School. Butorphanol @ 0.4mg/kg w/ Dexmedetomide @ 0.04mg/kg
Antagonist: Naloxone @ 0.02mg/kg w/ atipamizole @ 0.2mg/kg

Commented [JM67]: See Ryan's comment.

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perceived dominance reduces the need to use immobilization agents. Appropriate mechanical restraint techniques can reduce handling time of animals, allowing animals to reintegrate into social groups more quickly, subsequently reducing overall stress to the individual (Powell and Proulx 2003). Target canids will be mechanically restrained with a restraint pole, until two muzzles can be placed around the snout. While pinned with the restraint pole by one person, a second person will restrain the set of legs not in the trap against the ground and a third person will release the foot from the trap. This set of legs will then be restrained by the 3rd person as the restraint pole is removed. Once the restraint pole is removed the person restraining the front legs will also then restrain the head. The first person will then move forward with processing the captured animal.

Each animal will be placed on a towel or blanket to provide thermal protection from the ground, with eyes covered and lubricated with eye ointment; temperature will be monitored with a rectal thermometer. Overheating occurs at approximately 104-105°F for canids (AZA Canid TAG 2012) and the animal handling crew will monitor temperature at 5-minute intervals; if a temperature reading reaches 104°F, corrective actions will be taken and temperature will be monitored at 1-minute intervals. Should overheating occur, the individual will be removed from insulation to expedite the natural evaporative cooling process. During days that approach 80°F in temperature, measures will be taken to reduce heat stress, such as: wetting the animal with water, application of a cold pack to the groin area between the back legs, application of rubbing alcohol to foot pads, or immediate release (AZA Canid TAG 2012). If the injured individual is suspected to be a red wolf, based on morphometrics, USFWS staff will be contacted for a decision. In the event that trap caused injuries are determined to be life threatening through use of a trap injury score assessment (Frame and Meier 2007) the individual will be euthanized. In the event that NCWRC personnel cannot be present, trained USFWS personnel may collar and measure captured target animals and will provide data sheets to NCWRC staff. Target animals will not be vaccinated or otherwise treated for diseases, regardless of the presence of disease symptoms.

Non-target animals will be released on site. Captured domestic dogs will be immediately released from the trap set following an injury score assessment and only if no life-threatening

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Commented [OSE68]: This is not always a guarantee that the animal is a wolf or not

Commented [OSE69]: Loss of control 4. Implied.

Commented [JM70]: See Ryan's comment.

Commented [OSE71]: FWS will be "allowed" to do this?! This statement plus several others would seem to indicate a takeover of the red wolf program by the NCWRC.

Loss of control 5. Implied.

Commented [JM72]: This seems like an unnecessary statement, as FWS personnel have the authority to handle red wolves.

Commented [JM73]: Why would we not vaccinate the capture animals, especially red wolves given the high value of each individual within a population so low?

Commented [OSE74]: Not treating wolves for visible or known disease is contrary to the recovery program, whether that be for recovery in the wild or increasing numbers in captivity. These wolves would be integral for population increase in the wild or for the "SSP meta-population"

Commented [JM75]: See Ryan's comment.

injuries are present. If a domestic dog has sustained life threatening injuries and owner identification information is present on the dog, then the animal will be held in either a transportable kennel, or at a dog pen on a state game land that is equipped with such facilities, until the owner can retrieve the dog. The costs associated with injuries sustained to the dog will be the responsibility of the animals' owner. Law enforcement may be requested to help communicate with the animal's owner. If the animal does not have an identifiable owner and has incurred substantial life threatening injuries (i.e. compound fracture), the dog will be euthanized on site. Target animals showing signs of disease symptoms such as circling behavior, head tilt, muscle twitches, convulsions with jaw chewing movements and salivation ("chewing gum fits"), disorientation, incoordination, staggering caused by paralysis of the hind legs, seizures, and partial or complete paralysis will be euthanized and tested according to protocol set forth by the agency veterinarian, in order to determine if there may be a public health issue (M. Palamar, personal communication, 2016). USFWS will be contacted in cases of suspected red wolves. Staff involved in animal handling duties will have the pre-exposure rabies vaccination series completed prior to field work inception and will maintain rabies titer records through properly licensed medical services providers.

If staff is bitten and skin is broken by an animal while performing handling duties, they will be advised to immediately visit a local hospital or clinic for evaluation by healthcare professionals. The field coordinator will immediately notify supervisory staff and an injury report and workers' compensation claim will be opened for the incident. The animal will be euthanized and the head will be sent to the state lab for rabies testing; the body may be sent to the Southeastern Cooperative Wildlife Disease Study (SCWDS) laboratory for additional disease investigation.

Capture Processing and Marking

During canid handling, NCWRC personnel will record age class, sex, weight, total body length, head width, ear length, and tail length, visually assess ectoparasite load, look for and disinfect with betadine or iodine as needed any minor trap caused injuries, and affix GPS collars (Knick 1990, Sikes et al. 2011). All captured canids will be fitted with appropriately-sized GPS collars in the field based on morphometrics previously indicated as reliable thresholds for

Commented [OSE76]: Loss of control 6. Implied.

Commented [OSE77]: Do they not have facilities to hold the animal for observation? They are going to unilaterally euthanize a wolf??

Commented [JM78]: I disagree that staff being bitten during a capture should result in a red wolf being euthanized, particularly if that animal is displaying no signs of disease. We can't afford to lose any more individuals in such a low population. And no euthanasia of a red wolf should occur without FWS involvement in the decision making process.

Commented [JM79]: See Ryan's comment.

Commented [OSE80]: This whole section gives state complete control of the program. Additionally are they going to remove our collars and put their own on?

Commented [OSE81]: Loss of control 7. Implied.

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species categorization: hind foot length, weight, width of head, and tail length (Hinton 2014); analysis of DNA samples collected during trapping efforts will help to assign captured canids to position along the species continuum post release. Age of individuals will be estimated based on physical characteristics, including weight and tooth replacement (Knick 1990, Hinton 2014, Gier 1968), and captured canids will be aged into one of three classes: > 2 years old as adults, < 2 but > 1 year old as juveniles, and > 6 months but < 12 months old as pups (Hinton 2014). Reproductive status will be determined based on estimated age class and presence of gonadal descent during the breeding season for males and the presence of nipple swelling or previous suckling for females (Hutson and Racey 2004, Magee 2008, Mengel 1971).

Captured individuals will be ear marked using a button tag (model 410, Ketchum Mfg. Co. [or equivalent], PO Box 10, 11 Town Shed Road, Lake Luzerne, NY 12846) placed along the middle of the ear where they are most protected from loss, with a pin-type applicator (485sa Pow-R-ceps plier, Ketchum Mfg. Co. [or equivalent]) (Silvy 2012). The puncture site will be treated with an antiseptic to deter infections. Each sympatric canid will also be marked with an individually-numbered, glass-encapsulated, passive integrated transponder (PIT model HPT12, 12.5 mm, 134.2 kHz, Biomark, Inc., 703 South Americana Blvd., Suite 150, Boise, ID; Gannon et al. 2007), using a syringe-type implanter and replaceable needle (model MK10 [implanter], model N125 [needle], Biomark, Inc.). Successful PIT placement will be verified with a mini portable reader (model GPR Plus, Biomark, Inc.). The implantation site will be prepared by swabbing with 70% alcohol (Mrozek et al. 1995) and a sterilized new needle will be used for each injection. The standard implantation site for transponders is subcutaneously on the dorsal midline of the back, cranial to the shoulder blades (Ingwersen 2000).

A skin biopsy will be taken from all captured target canids by puncturing the pinna of the ear with a biopsy punch in the same location where the ear tag will be placed (Palamar 2014). The biopsied area will be disinfected with alcohol after sampling. The skin biopsy will be placed in a labeled (ID, date, and sample type) cryogenic tube filled with 95% ethanol as buffer and then stored in a freezer until sent out to a lab for genetic analysis (Palamar 2014, Tom 2012). A selection of hairs with the root bulla attached will be pulled from the belly and placed in paper envelopes (Janecka et al. 2007). Hair samples will serve as back up to tissue samples

Commented [OSE82]: What is the point of this if they are going to have a collar on them. Would this be used for mark/recapture purposes for any animal in excess of the 25 collars? Or is this for continued identification after the collars fall off. Collars falling off of wolves does us no good for continued tracking after the study.

I have conflicting thoughts on this. Makes it easier to identify while in a trap prior to release but makes it easier for someone to see and shoot the animal. Alternatively it could stop someone from shooting and thus biasing mortality results.

Commented [JM83]: Morse - Why - no need. the ear tags are not needed and are a constant source of infection and irritation. In addition, when we,ve used them in the past - the animals tear them out.

Commented [OSE84]: Are we going to give them our tags or will they use their own. Either way is a loss of control of the program.

Commented [JM85]: Morse - Continue to use PIT tags by Trovan to keep consistency with animals already deployed.

Commented [JM86]: Concerns over PIT tag not being compatible with our reader

Commented [JM87]: See Ryan's comment.

Commented [OSE88]: What is the point of this and how does it help them achieve any of their stated goals? Are they proposing to make a hole in the ear first using this method and then place the tag in the hole?

Commented [JM89]: Morse - genetic analysis can be done with blood serum.

Commented [JM90]: See Ryan's comment.

Commented [OSE91]: Not opposed to this but again, why? Can they get more info from this than from blood samples? They are proposing 3 separate DNA samples.

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for genetic testing. All samples will be sent to the Laboratory for Ecological, Evolutionary and Conservation Genetics, at University of Idaho (875 Perimeter Drive, MS 1136, Moscow, ID 83844) for genotyping to determine species as well as individual identification, hybridization presence, and parentage analysis following previously developed protocols (Adams et al. 2007, Hinton 2014, Miller et al. 2003). The appropriate genetic analyses that examine the coyote-hybrid-wolf species continuum will be performed.

Blood will be collected from all juvenile and adult target canids by venipuncture of the brachial or jugular veins using a 22-28-gauge needle (M. Palamar, NCWRC veterinarian, personal communication, 2016). As per NCWRC veterinarian recommendations, approximately 12 ml of blood will be collected for each animal for possible future testing for diseases of importance to sympatric canid species as well as the humans and domestic animals that they may come into contact with. A minimum of two 6 ml lavender top tube (for whole blood with EDTA) will be filled. Samples should be refrigerated at all times; a cooler with ice will suffice while in the field. Samples should be sent to the NCWRC within 48 hours or frozen for later shipping. Skin scrapes will be collected from animals presenting signs compatible with sarcoptic mange (lesions) for possible future diagnostic purposes. Lesions will be scraped until blood is drawn; the scrapings will be placed onto a slide and covered with a piece of clear tape for later visual confirmation.

Should overheating occur, processing will be performed in the following prioritization order and the first five items will need to be completed before releasing any individuals: 1) trap injury evaluation, 2) collaring, 3) DNA (skin biopsy) sample collection, 4) morphometrics, 5) aging, 6) PIT tagging, 7) weight, 8) ear tagging, 9) reproductive status, 10) ectoparasite evaluation, 11) blood collection, and 12) skin scrape collection.

Collaring

Vertex Plus GPS Collars will be attached to 25 sympatric canids captured on the study area, 10 of which will be equipped with proximity sensors (Vectronic Aerospace GmbH, Carl-Scheele-Str. 12, 12489 Berlin, Germany). Project staff will pilot test proximity sensor technology for utility in analysis of spatial and temporal community dynamics. Proximity sensors trigger increased GPS location acquisition during those time intervals when two collared individuals

Commented [JM92]: Morse - Pull one red top tube to spin for serum collection. Why 2 - 6 mm purple top tubes (isn't 1 enough)? Also, FWS is going to need to maintain additional blood samples for database.

Commented [JM93]: See Ryan's comment.

Commented [JM94]: Morse - define overheating temp. range and cooling procedures. In the event of overheating, the first thing to do is to immediately cool the animal. Collar then blood draw (omit the rest).

Commented [OSE95]: Given our concerns over many aspects of tissue collection, I feel that this list should be revisited.

Commented [JM96]: See Ryan's comment.

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come within a set distance from each other (http://www.vectronic-aerospace.com/wildlife-monitoring/sensors/uhf-id-tags, accessed August 2016).

To avoid instances of collar induced strangulation, only adult (>2 years old) male and female individuals will receive collars (Hinton 2014). ASM guidelines recommends a collar weight of <5-10% of a canids bodyweight, we will observe these guidelines (Sikes et al. 2011). Sympatric canids not releasable at a capture site will not be collared and will not become study animals.

GPS radio-collars will have both VHF and GPS Iridium locational systems as well as store-on-board capabilities. Radio-collar units will be programmed to record GPS coordinates once every 1.75 hours producing approximately 13 locations per day while cycling through the 24-hour time cycle. These settings will allow for a GPS battery life of 300 to 552 days, averaging 431 days. The VHF beacon will be in operation from 0800 – 1600 hours daily. GPS locations will be sent via satellite once per day and each transmission with contain 12 locations. The use of an integrated drop off firing mechanism should allow the collars to drop off within a maximum of approximately 548 days after deployment. The drop off schedule once set cannot be changed. The drop off firing mechanism is wired to a battery unit independent of the collar battery, therefore should the collar battery become depleted, the drop off mechanism will not be affected (C. Akakpo, Vectronic Aerospace GmbH, personal communication, 2016). Unless a collared individual is recaptured before the collar battery dies, the drop off mechanism will fire at the scheduled time frame post collar deployment.

Observation of sympatric canid habitat use and movements will occur through GPS data obtained with combination GPS/VHF radio-collars. VHF relies on triangulation, the process of estimating the location of a transmitter by using two or more compass bearings obtained by using directional antennas at known locations remote from the transmitter's position (White and Garrott 1990), whereas GPS uses a satellite based system to obtain location coordinates. There have been many published studies where one or both of these methods were used, with mixed success for determining various aspects of carnivore ecology throughout the United States (Hinton et al. 2012, Schrecengost et al. 2009, Sparkman et al. 2012). While GPS technology has developed rapidly in recent history, the real time functional advantage of VHF

Commented [JM97]: So in theory they could catch a one year old red wolf and by their protocol they would not collar it because it is less than 2 and they would release it without a collar. So basically the effort to trap a red wolf and the potential for injury has already occurred, but we do not take advantage of that by placing a collar on it to be able to monitor as much of the population as possible. Doesn't make sense.

Commented [OSE98]: I have a feeling that there is going to be many animals that fall into this category especially considering the prevalent landowner attitude towards carnivores in general and coyotes specifically. Additionally this constitutes a double standard in regards to releasing animals. We have landowner authorization in many cases but the State still will not allow us to use those lands for release, but are they going to allow themselves to do that? Also I feel that they should have all landowner agreements in place and the study/trapping areas well defined prior to any trapping effort. I have serious doubts that they can get this in place prior to Dec 1st.

Commented [JM99]: Needs clarification. Are they trying to say that if a landowner won't let them release a captured canid on their property then they won't collar it and release it? The context of the paragraph doesn't jive with that.

Commented [OSE100]: What frequency range?

Commented [JM101]: See Ryan's comment.

Commented [JM102]: See Ryan's comment.

Commented [JM103]: Morse -What happens to ability to monitor animals with no collars?

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cannot be disregarded. When GPS technology falters or malfunctions, VHF can serve as replacement for data collection in addition to its use in real time monitoring of study animals. Canids will be minimally monitored for mortality approximately every 30 days by using VHF aerial telemetry techniques (Whitehouse and Steven 1977) as there may be a delay in satellite transmission of GPS location data due to weather, season, and animal behavior. Transient canids and individuals from breeding pairs that have lost a mate, have been found to use much larger areas versus paired residents, potentially increasing the opportunity for losing track of these individuals when GPS technology reaches its functional capacity or experiences malfunction. VHF data may also provide locations of canids in cover too dense for GPS units to function. Use of VHF telemetry techniques for data collection may be expanded as necessary for project needs.

Commented [OSE104]: Can the GPS collars transmit through water? If not and you have an animal that tumbles into water right after mortality you've lost data.

Commented [JM105]: See Ryan's comment.

Commented [JM106]: They are proposing monitoring for dead canids every 30 days. For any collared red wolf, we would like to add those frequencies to our flights so they can be monitored much more frequently. Which is another reason the frequencies of their collars should be in the same range as the existing collars.

Spatial Data Analyses

Both minimum convex polygon (MCP) and adaptive kernel (AK) home ranges (95%) and core use areas (50% and 25%) (Seaman and Powell 1996, Seaman et al. 1999) will be calculated from GPS data by using BIOTAS (Ecological Software Solutions LLC, 2016) and Geospatial Modelling Environment (Spatial Ecology, LLC, 2016) for ArcGIS 10.2.2 (Environmental Systems Research Institute, 2016) (Benson et al. 2006, Riley 2006, Tucker et al. 2008, Hinton 2014) for comparison to older studies. These estimations can also be calculated using VHF data, provided data minimum requirements are met. Spatial distribution in relation to habitat will also be estimated by dynamic Brownian bridge movement models as described by Hinton (2014) with R statistical software (R Core Team 2016) using the moveud package with habitat covariates important to each species (Bryne et al. 2014, Collier 2013, Kranstauber and Smolla 2013, C. Proctor, personal communication, 2016). Additionally, recent research into how canids shift their ranges will also be investigated for populations on the AP (Morin and Kelly, in review). Spatial overlap and co-occurrence will be assessed using methods described by Shipley (2012). Habitat and cover types will be estimated from digitized maps created by the SEGAP (Hinton 2014) or ortho files, as available (Shipley 2012). Percent composition of habitat and cover types within home ranges and core areas as well as edge density will be quantified (Shipley 2012). Habitat selection and cover type use effects on spatial distribution will be estimated at both the population (2nd order) and individual (3rd order) spatial scales using resource selection functions

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(Johnson et al. 2006, Manly et al. 2002, Shipley 2012). Effects of seasonality and time of day activity will also be explored. The spatial and temporal patterns of space use by sympatric canids will be studied using data generated from the interaction GPS collar sensors, particularly distance between individuals and duration of proximity.

Den Monitoring

Project staff will attempt to locate den sites for sympatric canids to get pup counts, morphometric measurements, age estimates, and skin biopsies. Project staff will also attempt to monitor pup survival during the pup rearing season by using remote cameras placed around the den site (Harrison and Gilbert 1985, Parks 1979, Way et al. 2001). Pups will be weighed, measured, and PIT tagged during May and June of each year when they become active but are still den-obligated (Gier 1968). We will investigate the use of remote camera traps for monitoring den behavior with a two-camera array around the den (H. Garbe, personal communication, 2016, Kays and Slauson 2008). This method has been successfully used to monitor kit fox pup survival (Kluever et al. 2013). Because coyotes have been found to be sensitive to den site disturbance, there is a general lack of data in the literature regarding this approach for monitoring pup survival. Approaching an experimental methodology systematically will be important for determining which methods are effective and which are not. As a starting point for testing this methodology, remote cameras will be placed two to five meters from main den entrances and set to take photos using a passive infrared sensor trigger (a beam that when broken by movement through it, triggers the camera to take a series of photos) with a time restriction between photo intervals to limit the number of photos taken and maximize the space on the memory card for the time period between camera checks (Kluever et al. 2013). Cameras will be checked six days after deployment and will be redeployed (i.e. new batteries and memory card, if required); cameras will remain at each den site until radio-collar data indicates the den site has been moved (Kluever et al. 2013). Cameras will be not be redeployed to a new coyote den site during a season if that breeding pair has already moved the den once due to the disturbance of camera presence/deployment.

Commented [OSE107]: No mention USFWS personnel in conjunction with this phrase.

Loss of control 8. Implied in conjunction with Project Personnel section.

Commented [JM108]: Morse – A minimum number of biologists will attend a den (2-3).

Commented [JM109]: See Ryan's comment.

Commented [OSE110]: No need for biopsies. Again, why do they need this? We already draw blood.

Commented [JM111]: Morse – No skin biopsies on pups.

Commented [JM112]: Morse – No. Best if not at all. Cameras set no closer than 7 m. to den entrance

Commented [OSE113]: Getting this close to dens in order to set up the cameras will cause high enough disturbance that the mother will move the pups or will abandon the pups all together. Even if by some miracle they were not moved or abandoned after first deployment, good luck with that not occurring after your first 6 day revisit. Looking at the Kluever paper I noticed 2 major differences between the Kluever study and this one.

The first is terrain. The Kluever study was conducted in the Great Basin in NE Utah. The area as described in the paper is very open and lacks dense vegetation. Lines of site were not an issue. Often times canid dens in SE will be located in dense vegetation. Not to say that this issue cannot be overcome, but it may be impractical to deploy cameras effectively, or site modification, i.e. clearing out veg, could be enough to cause den abandonment or den relocation.

The second issue is animal behavior is quite different. Kluever et al. were observing kit foxes. Camera deployment was done in the afternoons when the foxes were underground in their dens. The foxes most likely had no clue that the researchers were ever there. In fact the authors attributed the lack of den abandonment to this probable factor. There would never be a time where a pack would not be aware of, or disturbed by camera deployment here in NC.

Commented [JM114]: Morse - 6 days is too often to disturb a den

Commented [JM115]: See Ryan's comment.

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Mortalities

If a collared animal dies during the project, the carcass will be sent to SCWDS for necropsy. Red wolves will be sent to the SCWDS laboratory for necropsy, unless it is determined to be a law enforcement case. In potential law enforcement cases, the NCWRC Division of Wildlife Management Chief and USFWS Ecological Services Raleigh Field Office Field Supervisor will be contacted and requested to contact the appropriate law enforcement personnel, immediately after determining the need for law enforcement involvement. The carcass and all relevant information will then be turned over to law enforcement; the GPS-collar will be removed and genetic samples will be taken from the individual prior to release to law enforcement.

Commented [JM116]: Morse - Coyotes will be sent to SCWDS

Commented [JM117]: See Ryan's comment.

Commented [JM118]: Morse - Red Wolf Carcasses will be sent of the National Wildlife Health Lab in Madison, WI.

Commented [OSE119]: We have our own facility for this. This would be another point of lost control.

Loss of control 9.

Commented [OSE120]: Why? Just contact LE and then inform the Chief and Field Supervisor

Commented [JM121]: See Ryan's comment.

E. Project Personnel

Andrea Shipley has worked for the North Carolina Wildlife Resources Commission as a Canid Biologist since February 2016. Prior to that, she worked as a Wildlife Biologist for a non-profit located in northeastern Nevada as well as in several different field biologist oriented positions. Andrea has a background in carnivore and spatial ecology, having earned her MS in Biological Sciences from Eastern Kentucky University and BS in Biological Sciences from Rutgers University; Andrea will act as project lead and coordinator.

Brandon Sherrill has worked for the North Carolina Wildlife Resources Commission as a Mammalogist since December 2013. Prior to that, he worked as an educator at the North Carolina Museum of Natural Sciences and as a regional wildlife biologist for the South Carolina Department of Natural Resources. Brandon earned a BS and MS in Fisheries, Wildlife, and Conservation Biology from North Carolina State University; Brandon will act as project supervisor.

Krishna Pacifici, Research Assistant Professor at NCSU, will be the quantitative analysis collaborator on the project. Krishna's background and experience in quantitative ecology makes him well suited to consult and assist with advanced statistical analyses of spatial data.

Lisette Waits, Department Head and Distinguished Professor at the University of Idaho, will be the DNA analysis collaborator for the project, responsible for all DNA related sample processing and subsequent analyses.

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F. Schedule and Estimated Costs

The project will run from soon after December 1, 2017 through June 30, 2020. The estimated timeline for major tasks is as follows:

Year 1: Initiate field work soon after December 1, 2017 with assistance from 1-2 field technicians; 1 technician will be required for trapping and den monitoring efforts. Data collection will begin immediately after collar deployment and data will be managed by Andrea Shipley throughout the life of the project. Data analysis will be initiated after den monitoring season concludes, with guidance and assistance from Krishna Pacifici at North Carolina State University (NCSU). Report, manuscript and presentation production will be initiated concurrently with data analysis.

Year 2: Continue field work and data collection with assistance from 1-2 field technicians. Continue data analysis with guidance and assistance from Krishna Pacifici at NCSU. Continue and finalize report and manuscript production, and presentation at professional working groups and/or meetings.

Commented [OSE122]: Where are these techs coming from? Are we going to be paying for them?

Commented [OSE123]: Will we have any access to these data or only receive what the State is willing to give us? How will these data be used? Will the state cherry pick data and use it as a claim that the wolf is not a species?

Loss of control 10.

Commented [OSE124]: Where is year 3; as stated in their section 7 attachment?

GPS technology allows researchers to collect locational data at fine spatial and temporal scales through the deployment of collar units on wildlife study subjects. In this project, we propose to study a sample of sympatric canid populations with GPS radio-collars, in order to investigate the population parameters outlined in previous sections as well as species interactions. The purchase and use of this technology is critical to meeting the research objectives set forth in this document as well as in the document included in Attachment 1.

While GPS technology has evolved over the past 20 years, the cost of technology has plateaued. Upfront cost per unit remains relatively high, however project savings occurs at the back end when compared to older telemetry technology such as very high frequency (VHF)

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which require intensive labor to collect data at similar spatial and temporal scales. Pilot testing the proximity sensor enabled GPS-collars will allow investigation of the utility of this relatively new tool for community dynamics analysis by providing an increased locational data acquisition when individuals come within a set distance, or closer, from each other. Additionally, these sensors record the identities of the interacting individuals and the duration of their interactions. Using a trigger to temporarily switch GPS fix schedules will enable us to collect very fine scale data while conserving battery life, achieving project objectives in an efficient manner. Exploring the efficaciousness of this technology has the potential to positively impact future research projects requiring use of GPS-collars for data collection.

Aerial tracking will provide regular study animal surveillance useful to investigate cases of mortality, collar malfunction, or satellite data transmission delays, which can vary seasonally. In some situations, ground tracking could prove less expensive than aerial tracking. However, ground telemetry techniques require more than one biologist working in tandem to acquire accurate location estimates. This often translates to increased labor to collect data, particularly in large study areas. Aerial tracking will provide a more efficient and cost-effective method for surveilling study subjects in this large study area, requiring only one biologist and a contracted pilot. NCWRC personnel will perform aerial tracking along with the NCWRC pilot at a minimum frequency of every 30 days.

Use of local trappers to assist with sampling efforts provides several benefits. Local trappers have established, long-term relationships with private land owners, thereby providing access to private lands that might be otherwise difficult to secure. This will enable project biologists to obtain a representative sample of sympatric canids in the study area, as well as to operate more trap lines concurrently. This is particularly important when using a SCR sample design, as it will have direct implications on the resulting analyses and inferences.

As part of collaboration efforts, the project will contract the services of Krishna Pacifici, Research Assistant Professor in the Applied Ecology department at NCSU. Krishna's expertise is in quantitative ecology; consultation and assistance services provided will allow project biologists to make appropriate statistically relevant inferences from collected data.

Commented [JM125]: Morse - why the need for 12 more flights if using GPS collars for location/mortality?

Commented [OSE126]: Access does not necessarily denote cooperation. A land owner may say it's okay to trap but nay not agree to releasing the animal back on to the property.

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DNA analysis will be contracted to Lisette Wait's lab at the University of Idaho. Lisette's team at The Laboratory for Ecological, Evolutionary and Conservation Genetics has previous experience in analyzing red wolf and coyote hybrid molecular samples and has the most comprehensive DNA methodology for this sympatric canid species continuum in the nation. This expertise will facilitate expedient species identification on collared study animals besides landscape level population dynamics analysis.

	Commission	In-kind	Total
a. Personnel	$ 7,200.00	$ -	$ 7,200.00
b. Fringe Benefits	$ -	$ -	$ -
c. Travel	$ 30,000.00	$ -	$ 30,000.00
d. Equipment	$ 54,000.00	$ -	$ 54,000.00
e. Supplies	$ 61,500.00	$ -	$ 61,500.00
f. Contractual	$315,590.00	$ -	$315,590.00
g. Construction	$ -	$ -	$ -
h. Other	$ 6,000.00	$ -	$ 6,000.00
i. Total Direct Charges (sum of a – h)	$474,290.00	$ -	$474,290.00
j. Indirect Charges	$ 4,800.00	$ -	$ 4,800.00
k. Totals (sum of i and j)	$479,090.00	$ -	$479,090.00
Federal (75%)			$359,317.50
State (25%)			$119,772.50

Commented [OSE127]: Do they even work with hair or biopsy samples?

Commented [OSE128]: 30k for travel? Where are they going? Vegas?
300k for contracts? How many trappers are they going to use? All of them?

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G. Geographic Location

Three counties of the Albemarle Peninsula of North Carolina (Dare, Hyde, and Tyrrell counties).

Commented [JM129]: Morse - add Washington & Beaufort Counties

H. Related Federal Projects

NC-W-F15AF00726 (W-72) NC-Division of Wildlife Management Cooperative Projects

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I. Glossary

Abundance: Species abundance is the number of individuals per species, and relative abundance refers to the evenness of distribution of individuals among species in a community.

Adaptive kernel (AK): A probabilistic home range estimator based on the distribution and density of locations that has been collected over a period of time.

Adverse reactions: In pharmacology, any unexpected or dangerous reaction to a drug.

Aerial: Existing, happening, or operating in the air.

Annually: Once a year; every year.

Anthropogenic: Caused or influenced by humans.

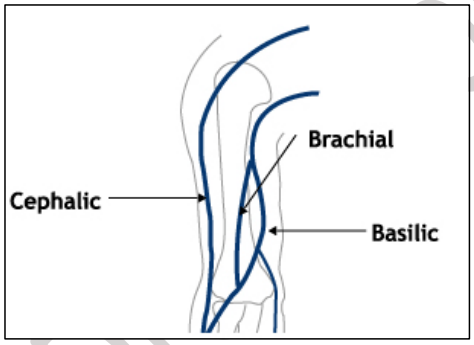
Apex: Having no natural predators in its ecosystem.

Ataxia: The loss of full control of bodily movements.

Beacon: A radio beacon whose purpose is the investigation of the propagation of radio signals.

Biopsy: The removal for diagnostic study of a piece of tissue from a living body.

Brachial vein: One of a pair of veins accompanying the brachial artery and uniting with each other and with the basilic vein to form the axillary vein.



Breeding pair: A pair of animals which cooperate over time to produce offspring with some form of a bond between the individuals.

Carrying capacity: The maximum population size of the species that the environment can sustain indefinitely, given the food, habitat, water, and other necessities available in the environment.

Compensatory immigration: Individuals emigrating from areas with lower mortality to those with higher mortality; filling a deficiency of individuals in a population experiencing higher mortality. The increase in size or activity of one part of an organism or organ that makes up for the loss or dysfunction of another.

Composition: The combining of distinct parts or elements to form a whole.

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Co-occurrence: Refers to observation of the spatial overlap between two (or more) different individuals over a period of time.

Coordinates: Any of the scales or magnitudes that serve to define the position of a point.

Core use areas: An area within a home range exhibited by a dense concentration of location points; commonly estimated at 50% of the location data points.

Covariates: A variable that is possibly predictive of the outcome under study.

Cranial: Pertaining to the cranium or to the anterior (in animals) or superior (in humans) end of the body.

Cryogenic: Very low temperatures, e.g. -80ºC.

Den-obligated: Restricted to a particular condition of life, in this case restricted to a den site.

Density: A measure of the number of organisms that make up a population in a defined area.

Deployment: To organize and send out (people or things) to be used for a particular purpose.

Depredation: The act of preying upon.

Depressed respiration: A decrease in the ability to exhale and inhale; respiration that has a rate below 12 breaths per minute or that fails to provide full ventilation and perfusion of the lungs.

Diagnostic: The process of determining by examination the nature and circumstances of a diseased condition.

Disorientation: Loss of one's sense of direction, position, or relationship with one's surroundings.

Distribution: The manner in which a biological taxon is spatially arranged.

DNA: (deoxyribonucleic acid) is a type of macromolecule known as a nucleic acid. It is shaped like a twisted double helix and is composed of long strands of alternating sugars and phosphate groups, along with nitrogenous bases (adenine, thymine, guanine and cytosine).

Dorsal: Situated on or toward the upper side of the body, equivalent to the back, or posterior, in humans; situated on or toward the posterior plane in humans or toward the upper plane in quadrupeds.

Duration: A continuous period of time.

Dynamic Brownian bridge movement models: Incorporates temporal and behavioral characteristics of movement paths into estimation of home range.

Ectoparasite: a parasite that lives on the outside of its host rather than within the hosts body; e.g. fleas and lice.

Effective trap area: Calculated by buffering each trap site by half the mean maximum distance traveled, each of these boundaries are dissolved, creating a measurable area.

Efficacious: Producing or capable of producing a desired effect.

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Efficient: Accomplishment of or ability to accomplish a job with a minimum expenditure of time and effort.

Euthanize: The act of putting to death painlessly or allowing to die, as by withholding extreme medical measures, a person or animal suffering from an incurable, especially a painful, disease or condition.

Expedient: Suitable for achieving a particular end in a given circumstance.

Evaporative cooling: reduction in temperature resulting from the evaporation of a liquid, which removes latent heat from the surface from which evaporation takes place.

Facilitate: Make an action or process easy or easier.

Genotyping: Investigate the genetic constitution of (an individual organism).

Gonadal descent: The act or process of descending from a higher to a lower location; testicular descent occurs during the breeding season annually.

GPS: Global Positioning System, is a radio navigation system that allows land, sea, and airborne users to determine their exact location, velocity, and time 24 hours a day, in all weather conditions, anywhere in the world.

Home range: an area over which an animal or group of animals regularly travels in search of food or mates, and that may overlap with those of neighboring animals or groups of the same species.

Hybridization: The result of mixing, through sexual reproduction, two animals or plants of different breeds, varieties, species or genera.

Immobilization agent: An active force or substance capable of producing an effect.

Implantation: To put or fix firmly.

Inbreeding depression: The reduced biological fitness in a given population as a result of inbreeding, or breeding of related individuals.

Inception: The establishment or starting point of an institution or activity.

Interspecific: Existing or occurring between different species.

Iridium: A satellite constellation providing voice and data coverage to satellite phones, pagers and integrated transceivers over the Earth's entire surface.

Jugular vein: Any of several large veins in the neck, carrying blood from the head and face.

Lacerations: A deep cut or tear in skin or flesh.

Locational: A position or site occupied or available for occupancy or marked by some distinguishing feature.

Malfunction: Fail to operate in the normal or usual manner

Methodology: A system of methods used in a particular area of study or activity.

Midline: A median line or plane of bilateral symmetry, especially that of the body.

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Minimum convex polygon (MCP): Completely enclose all data points by connecting the outer locations in such a way as to create a convex polygon.

Molecular samples: Genetic samples that may be used for investigation of genetic constitution of an individual.

Morphometrics: The process of measuring the external shape and dimensions of landforms, living organisms, or other objects.

Mortality: The state of being subject to death.

Non-target bycatch: Animals caught by accident that are not the target species being sought.

Parameters: A numerical or other measurable factor forming one of a set that defines a system or sets the conditions of its operation.

Parentage: The origin of something; the state or relation of a parent.

Passive integrated transponder: A microchip implant is an identifying integrated circuit placed under the skin of an animal.

Pinna: The external part of the ear in humans and other mammals; the auricle.

Plateaued: A period or state of little or no growth or decline.

Population dynamics: The branch of life sciences that studies the size and age composition of populations as dynamic systems, and the biological and environmental processes driving them (such as birth and death rates, and by immigration and emigration).

Population growth: The increase in the number of individuals in a population.

Population size: A group of organisms of the same species that live in the same area.

Population status:

Population trend: Changes over time and can include changes in ranging behavior and distribution, biogeography and life-history.

Population viability: The process that determines the probability that a population will go extinct within a given number of years.

Proximity: Nearness in space, time, or relationship.

Quantified: Express or measure the quantity of.

Quantitative: Relating to, measuring, or measured by the quantity of something rather than its quality.

Radio-telemetry: The use of radio waves for transmitting information from a distant instrument to a device that indicates or records the measurements.

Recumbency: The state of leaning, resting, or reclining.

Reintegrate: Restore (elements regarded as disparate) to unity.

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Remnant: A small remaining quantity of something.

Reproductive status: Relating to or effecting reproduction.

Spatial: Relating to, occupying, or having the character of space.

Spatial capture-recapture: A method commonly used in ecology to estimate an animal population's size. A portion of the population is captured, marked, and released. Marked animals are either recaptured or are tracked, each tracking location being considered a recapture.

Species Continuum: An aggregate of species capable of interbreeding, resulting in fertile hybrid offspring whose genetic composition may represent a varying array of phenotypes and genotypes from the parental species, at which the extreme ends of the spectrum are distinct.

Standardize: Cause (something) to conform to a standard.

Statistically relevant inferences: the process of deducing properties of an underlying distribution by analysis of data. Inferential statistical analysis infers properties about a population: this includes testing hypotheses and deriving estimates.

Stochastic population models: Ecological population modeling is concerned with the changes in population size and age distribution within a population as a consequence of interactions of organisms with the physical environment, with individuals of their own species, and with organisms of other species; stochasticity possesses some inherent randomness. In stochastic population models, the same set of parameter values and initial conditions will lead to an ensemble of different out puts.

Strangulation: The condition in which circulation of blood to a part of the body is cut off by constriction.

Stratifying: Form or arrange into strata, one of a number of portions or divisions likened to layers or levels.

Surveillance: Continuous observation of a place, person, group, or ongoing activity in order to gather information.

Survival: A living or continuing longer than, or beyond the existence of, another person, thing, or event.

Sympatric: Occurring within the same geographical area; overlapping in distribution.

Tachycardia: A heart rate that exceeds the normal resting rate. In general, a resting heart rate over 100 beats per minute is accepted as tachycardia in human adults.

Telemetry: See radio-telemetry.

Temporal: Of or relating to time.

Tooth replacement: The process of development of two successive sets of teeth, initially the deciduous set and consecutively the permanent set.

Transmitter: A set of equipment used to generate and transmit electromagnetic waves carrying messages or signals, especially those of radio or television.

Transponder: A device for receiving a radio signal and automatically transmitting a different signal.

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Vaccinate: Treat with a vaccine to produce immunity against a disease; inoculate.

Venipuncture: The puncture of a vein as part of a medical procedure, typically to withdraw a blood sample or for an intravenous injection.

VHF: Very high frequency is the ITU designation for the range of radio frequency electromagnetic waves (radio waves) from 30 MHz to 300 MHz, with corresponding wavelengths of ten to one meters.

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J. Literature Cited

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Attachment 1: Intra-service Section 7 Biological Evaluation Form

Region 4
INTRA-SERVICE SECTION 7 BIOLOGICAL EVALUATION FORM

[Note: This form provides the outline of information needed for intra-Service consultation. If additional space is needed, attach additional sheets, or set up this form to accommodate your responses.]

Originating Person: Andrea Shipley
Telephone Number: 252.926.0266 **E-Mail:** andrea.shipley@ncwildlife.org
Date: November 8, 2016

PROJECT NAME (Grant Title/Number): NC – Division of Wildlife Management Cooperative Projects / (W-72)

I. Service Program:

_____**Ecological Services**
__X__**Federal Aid**
_____**Clean Vessel act**
_____**Coastal Wetlands**
_____**Endangered Species Section 6**
_____**Partners for Fish and Wildlife**
_____**Sport Fish Restoration**
__X__**Wildlife Restoration**
_____**Fisheries**
_____**Refuges/Wildlife**

II. State/Agency:

NORTH CAROLINA / NORTH CAROLINA WILDLIFE RESOURCES COMMISSION

III. Station Name:

FWS RALEIGH ECOLOGICAL SERVICES OFFICE

IV. Description of Proposed Action (attach additional pages as needed):

Conduct research project entitled "**Coyotes of the Albemarle: Spatial Ecology, Resource Selection, Demographics, and Interactions with a Sympatric Canid"**

The coyote (*Canis latrans*) is now abundant throughout the 100 counties in North Carolina (NC), where they are managed as nongame with no closed season or bag limit (NC Wildlife Resources Commission 2016). Previously restricted to the West and Midwest regions of the United States, by the early 1990s coyotes had expanded their range into the Albemarle Peninsula (AP), which is situated in the northeast coastal plains region of NC (Hinton et al. 2012, Murray et al. 2014).

Recently described as using "compensatory immigration," coyotes are able to opportunistically fill spatial resource gaps by periodic transiency (Hinton 2016). These periods of transiency can sometimes bring coyotes into conflict with humans and other canids, especially while taking advantage of anthropogenic resources. Though a rural area, human land uses predominate on the AP. The AP is comprised of approximately 30% agricultural fields, 50% forest and coastal marshes, and 20% "other" land cover types on federal, state and private lands (Dellinger 2011).

In 1968, individuals from a remnant population of red wolves were removed from Texas and Louisiana and a captive breeding program was initiated. The United States Fish and Wildlife Service (USFWS) released a non-essential, experimental population of red wolves (*Canis rufus*) on the Alligator River National Wildlife Refuge (ARNWR) in 1987 (Hinton et al. 2013). The red wolf population increased until 2008 and peaked at around 208 individuals (USFWS Red Wolf Recovery Program 2007), a few animals short of the recovery goal of 220 in the wild (USFWS Red Wolf Recovery Program 2013), with an estimated carrying capacity of 140-150 for the AP (Hinton et al. 2013, Kelly et al. 1999, USFWS Red Wolf Recovery Program 2007). Red wolves presently inhabit an approximately 6900 square kilometer recovery area within Beaufort, Dare, Hyde, Tyrrell, and Washington counties (Wildlife Management Institute 2014).
Accurate up-to-date estimates of the population are unavailable, but USFWS staff report a population size of 45-60 individuals with three mortalities in 2016 (https://www.fws.gov/redwolf/index.html July 2016). Hybridization with coyotes, inbreeding depression, and gunshot mortality have all been suspected issues that have affected the population growth and viability since the inception of the Red Wolf Recovery Program (RWRP) (Hinton et al. 2013). In 2013, NCWRC and USFWS established a committee to oversee the collaborative management and conservation of red wolves and other canids on the AP. A USFWS memorandum documented detailed action items for the joint management of canids on the AP, including specific research objectives which this proposal seeks to address (Attachment 1).

As coyotes on the AP increase in number, monitoring coyote movements, particularly in relation to red wolves, will provide important data to NCWRC and USFWS staff for science-based local and landscape-level decisions about coyote population management. Collection of finer temporal scale location data will help to manage interactions of both canid species with humans, as well as to support development of dynamic stochastic population models.

Coyote and red wolves will be live trapped by cooperating NCWRC and USFWS staff, and private trappers using double coil size 3 foothold traps, during the breeding season (Nov-Feb for coyote, Jan-Feb for red wolves) in the tri-county area of Dare, Hyde and Tyrrell. Morphological measurements, incidents of injury, occurrence of ectoparasites, age classification, and reproductive status will be determined; blood and tissue samples will be taken for genetic analysis. All captured individuals that meet the age classification and weight requirements will be collared with GPS collar units. All captured and collared individuals will be released at the capture site. The objectives listed below will be achieved by obtaining measurements, samples and information from the captured, collared, and tracked individuals over the course of three years using GPS location data.

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Commented [JM130]: Morse - 11 mortalities in 2016 (insert current pop. estimate

Not trapping during breeding season (February).
No tissue samples from live wolves.
Will coyotes be sterilized?

Objective 1: Use GPS collar and proximity sensor technology to test performance under various conditions and evaluate the frequency and accuracy of the scheduled fix rates.

Objective 2: Use fine scale GPS data collection for investigating annual and seasonal spatial dynamics of sympatric canids: home range and core area sizes, amount of overlap in home range and core areas, movement pathways and daily activity patterns, and cover type selection and preference.

Objective 3: Use fine scale GPS data collection for investigating the number and age structure of offspring for family groups of collared sympatric canids.

Objective 4: Use fine scale GPS data collection for investigating sources of mortality for sympatric canids.

Objective 5: Use fine scale GPS data collection for preventing and mitigating canid conflicts with landowners.

Objective 6: Determine genetic profiles of sympatric canids through DNA identification of all captured individuals, parentage, and presence of hybridization.

V. Pertinent Species and Habitat:

A. Include species/habitat: See section VI

B. Complete the following table:

SPECIES/CRITICAL HABITAT	STATUS[1]
Canis rufus	T

[1]STATUS: E = endangered, T = threatened, PE = proposed endangered, PT =proposed threatened, CH = critical habitat, PC = proposed critical habitat, C = candidate species

VI. Location:

A. Statewide

Albemarle Peninsula (see web address www.ncwildlife.org)

B. Section, township, and range (or latitude and longitude):

Dare, Hyde, Tyrrell counties

C. Distance (miles) and direction to nearest town:

As stated above

D. Species/habitat occurrence:

Canis rufus

VII. Determination of Effects:

A. Explanation of effects of the action on species and critical habitats in item V. B. (attach additional pages as needed):

SPECIES/CRITICAL HABITAT	IMPACTS TO SPECIES/CRITICAL HABITAT
Canis rufus	Trap induced injury is possible

B. Explanation of actions to be implemented to reduce adverse effects:

SPECIES/CRITICAL HABITAT	ACTIONS TO MITIGATE/MINIMIZE IMPACTS
Canis rufus	Use of appropriate trap types, daily trap checks, treatment of minor injuries, trapping season limitations and limitations on environmental conditions for trap operation

Commented [JM131]: Morse – VI B. Include Washington and Beaufort Counties

Section VII. B. Include early morning trap checks.

VIII. Effect Determination and Response Requested:

Species/ Critical Habitat	Determination[1]			Response[1] Requested
	NE	NA	AA	
Canis rufus		X		Concurrence

[1] Determination/Response Requested:

NE = No Effect. This determination is appropriate when the proposed action will not directly, indirectly, or cumulatively impact, either positively or negatively, any listed, proposed, candidate species or designated/proposed critical habitat. Response Requested is optional but a "Concurrence" is recommended for a complete Administrative Record.

NA = Not Likely To Adversely Affect. The determination is appropriate when the proposed action is not likely to adversely impact any listed, proposed, candidate species or designated/proposed critical habitat or there may be beneficial effects to these resources. Response Requested is a "Concurrence".

AA = Likely To Adversely Affect. This determination is appropriate when the proposed action is likely to adversely impact any listed, proposed, candidate species or designated/proposed critical habitat. Response Requested for listed species is "Formal Consultation". Response Requested for proposed or candidate species is "Conference".

Signature (originating station) **Date**

Title

IX. Reviewing Ecological Services Office Evaluation:

A. Concurrence _____ Non-Concurrence _____

B. Formal consultation required _____

C. Conference required _____

D. Formal conference required _____

E. Remarks (attach additional pages as needed):

_____ _____
Signature **Date**

_____ _____
Title **Office**

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Attachment 2: Joint Memorandum

MEMORANDUM

November 20, 2013

TO: All Interested Parties

FROM: "for"
Cynthia K. Dohner, Director, Southeast Region, U.S. Fish and Wildlife Service
Gordon S. Myers, Executive Director, N.C. Wildlife Resources Commission

SUBJECT: Collaborative Conservation of Red Wolves and Other Canids on North Carolina's Albemarle Peninsula

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Recovery of the federally-listed red wolf has been a priority for the U.S. Fish and Wildlife Service (FWS) for more than 20 years and is focused in North Carolina on the Albemarle Peninsula (AP; i.e., Hyde, Tyrrell, Washington, Beaufort, and Dare counties). Comprehensive stakeholder involvement and collaboration with other management agencies is critical to successful recovery of any at-risk species. The North Carolina Wildlife Resources Commission (WRC) is a key collaborator in this regard, as it has jurisdiction over all state-trust wildlife resources in N.C.

Since 2009, the FWS and WRC have worked to broaden our collaboration in the conservation and management of all canid species (including red wolves) on the AP. As these efforts have solidified, specific actions have been jointly identified by our two agencies that will improve conservation outcomes. These actions are categorized into five areas; collaboration, research, outreach, regulatory, and enforcement. Specific action items are outlined and prioritized within each of these categories in Attachment A.

This memo establishes the FWS's and WRC's commitment to initiate, or to continue, the efforts outlined in Attachment A. The common goal in this effort is to establish clear expectations and accountability for collaboration regarding the action items on Attachment A, thus resulting in enhanced and seamless canid conservation and management on the AP. This approach provides the best opportunity to achieve recovery goals for red wolves, while at the same time managing other canids to balance biological variables with social expectations. The dynamics of these canid species are complex and offer unique opportunities for innovation. Appropriate staff from each agency is hereby tasked with immediately developing a timeline to implement these actions. Through this commitment, we will continue to advance our collective conservation goals.

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Attachment A

Action Items for Collaborative Conservation of Canids on North Carolina's Albemarle Peninsula (AP)
(*Note: Action Items are prioritized within category.*)

Collaboration

1. The N.C. Wildlife Resources Commission (WRC) and U.S. Fish and Wildlife Service (FWS) will formalize in writing the collaborative management of canids on the AP. This agreement should:
    a. include a clear mission statement, goals, objectives, and implementation strategies (ask and answer the "Why?");
    b. set a goal to define success regarding canid management on the AP;
    c. espouse a philosophy of canid management operating within the context of a three-legged stool (i.e., federal and state governments and stakeholders);
    d. as available, commit funding and staffing resources for field personnel to contribute to the conservation of the red wolf and management of coyotes;
    e. as available, commit funding to conduct research pertinent to canid management on the AP;
    f. establish polices and goals for developing a collaborative genetic archive for AP canids, a data sharing portal accessible by staff in both agencies, and reciprocal sharing of all historical data (including phenotypic and genotypic data and literature) of the red wolf;
    g. establish a foundation for developing and implementing an adaptive approach to canid management on private lands on the AP;
    h. initiate development of a collaborative canid research program;
    i. describe plans to conduct the next five year Red Wolf Program review;
    j. outline options for holding annual workshops with federal and state enforcement staff;
    k. outline plans to hold semi-annual coordination meetings regarding canid management on the AP; and
    l. develop milestones for future development of a management plan for all canids in the AP.

2. The FWS will initiate a review of the current Red Wolf Recovery Plan to determine if the state-of-our-knowledge or field conditions have changed such as to warrant its revision. Review and comments from the WRC will be considered in this evaluation.

3. The WRC, with support and participation of the FWS, will establish a "Canid Forum" (similar to that established for manatees in Florida) to facilitate communication and discussion regarding canid management and citizen science opportunities on the AP.

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Attachment A

Research

1. The FWS and WRC will provide funding and logistical support for research identified by the Red Wolf Recovery Implementation Team, Red Wolf Program staff, other FWS staff, or the WRC that promote the conservation and recovery of the red wolf and other canids on the AP. Studies could include:
    a. tests of the "placeholder theory" on the AP, including behavior of sympatric canids,
    b. determining carrying capacity of canids on the AP,
    c. determining genetic profiles of canid species on the AP,
    d. evaluating predator-prey dynamics,
    e. studies of canid habitat use,
    f. epidemiology of diseases impacting canids on the AP,
    g. development of stochastic simulation models of sympatric canid population dynamics and habitat use, and
    h. canid dispersal dynamics

2. The FWS and WRC will conduct jointly-supported research to determine the attitudes and opinions of N.C. private landowners and other citizens concerning canids on the AP (i.e., human dimensions studies).

Outreach

1. The FWS and WRC will collaborate with other partners to design and implement broad-based outreach and marketing programs with clear goals, objectives, strategies, and measurable outcomes, including development of consistent agency messages and educating the public about canids on the AP.

Regulatory

1. The FWS and WRC will initiate a review and, if needed, subsequent rule-making to clarify concepts or rectify conflicts in current federal or state rules (including the current 10(J) rule).

2. The WRC will review and evaluate statutory requirements for listing red wolves as state threatened in the five AP counties.

3. As data demonstrating a relationship between coyote hunting and red wolf mortality become available, the FWS and WRC will evaluate, and if appropriate implement, adaptive approaches to regulate of take of coyotes that may result in incidental take of red wolves.

4. The WRC will evaluate the status, management, and regulation of Controlled Fox Hunting Preserves.

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5. The WRC will develop BMPs (due care provisions) for coyote hunting, trapping, and live sale.

6. The WRC will compile, compare, and contrast canid hunting and trapping regulations and programs in other states, including, but not limited to, other states with other species of wolves.

Enforcement

1. The FWS and WRC will develop coordination strategies to improve enforcement of federal regulations protecting red wolves.

Attachment 3: Landowner Agreement Form

NC Wildlife Resources Commission
Wildlife Management Division
Wildlife Diversity Program
Landowner Agreement for Scientific Collection

_____ / _____ / _____
MM DD YYYY

Property Type
Private _____ Federal _____ State _____

NC Wildlife Resources Commission
Address: 1701 Mail Service Center, Raleigh, NC 27699-1701
Phone: 919-707-0010

Cooperator's Name: _____
Last First Middle

Cooperator's Address: _____
Street City, State, Zip

Where will the work be performed? _____

give address or directions if different from above _____

Business, Farm, Property Common Name _____

Owner's or Rep Name _____ _____
If different from Cooperator Telephone Number

Owner's Address: _____
If different from Cooperator Street City, State, Zip

WRC Employee & Work Location	Species
	1)
Employee Name	2)
	3)
Duty Area	4)

I, the cooperator or cooperator's representative, have been informed of the methods and the manner in which research devices will be used, and of the possible hazards associated with their use. I understand that NCWRC, (to include its officers, employees and agents) will: exercise reasonable precautions to safeguard all persons to prevent injury to target and non-target animals; guard against the mishandling of control devices and materials; and exercise due caution and proper judgment in all scientific collection operations. I understand that NCWRC may collect Global Positioning System (GPS) coordinates at the project site as part of component or activity tracking or as wildlife disease monitoring or research data. I, the undersigned cooperator, do hereby give my consent and concurrence to NCWRC, its employees, and its agents, to use, upon lands owned, leased, or otherwise controlled by me, and identified by this document, the following methods and devices (an attachment of additional devices and/or methods may be attached):

Statement of agreement: The landowner, cooperator, or representative, as listed above hereby give permission to NCWRC to perform trap and release of the species listed for scientific collection purposes. In consideration of these understandings, I, the cooperator or cooperator's representative, agree to: assume responsibility for injury to my property under my control, when said injury is not the result of negligence on the part of NCWRC (it's officers, employees, and agents); assist in maintaining such warning signs as NCWRC may place for the purpose of notifying persons entering onto such lands of the possible hazards associated with scientific measures in use thereon; and to give adequate warning of these possible hazards to persons I authorize to enter onto such lands. Further, I, the cooperator or cooperator's representative, agree not to concurrently use or allow to be used upon lands covered by this agreement, any canid depredation efforts during the scientific collection time period.

Landowner Signature/Date _____
Signature Date

WRC Employee Signature/Date _____
Signature Date

Attachment 4: Trapper Service Contract

Contract in development.

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STATE: North Carolina

GRANT TITLE: W79-Wildlife Management

PROJECT TITLE: Pilot Study – Using Fine Scale GPS Technology to Research Sympatric Canid Population Dynamics (Job 2.0?)

A. Problem and Need

The coyote (*Canis latrans*) is now abundant throughout the 100 counties in North Carolina (NC), and is managed as nongame with no closed season or bag limit (NC Wildlife Resources Commission 2016). Previously restricted to the West and Midwest regions of the United States, by the early 1990s coyotes had expanded their range into the Albemarle Peninsula (AP), which is situated in the northeast coastal plain region of NC (Hinton et al. 2012, Murray et al. 2014). In recent years as coyotes have increased their population, some have begun to make use of the Outer Banks region.

The United States Fish and Wildlife Service (USFWS) released a non-essential, experimental population of captive-bred red wolves (*Canis rufus*) on the Alligator River National Wildlife Refuge (ARNWR) in 1987 (Hinton et al. 2013). This population increased until 2008 and peaked at around 130 individuals (Group Solutions, Inc. 2016), short of the recovery goal of 220 in the wild (USFWS Red Wolf Recovery Program 2013). The AP has an estimated carrying capacity of 140-150 wolves (Hinton et al. 2013, Kelly et al. 1999, USFWS Red Wolf Recovery Program 2007). The exact number of red wolves is not known, but USFWS staff report a population estimate of 45-60 individuals with eight mortalities to date in 2016 (https://www.fws.gov/redwolf/index.html August 2016). Hybridization with coyotes and inbreeding depression are suspected factors that have affected red wolf population growth and viability since the inception of the Red Wolf Recovery Program (RWRP), while vehicular and gunshot mortality are known factors (Hinton et al. 2013). Because of hybridization between red wolves and coyotes, the AP supports a continuum of sympatric canids, hereafter referred to as "sympatric canids."

As part of a recent program review, the USFWS halted many aspects of the RWRP in 2015 and discontinued the coyote sterilization program, potentially affecting the spatial

Commented [OSE1]: Citation! How abundant?

Commented [OSE2]: This information is obviously out of date and invalid.

Commented [OSE3]: Hybridization has not been an issue since the beginning of the program as there were no coyotes out here in the beginning.

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distribution and population dynamics of sympatric canids. Telemetry data from coyotes on the AP suggests that about 70% of coyotes are residents (i.e., those that defend set territories) while the other 30% are transients, with most being dispersing juveniles (Hinton et al. 2015). Transient coyotes do not defend set territories. Coyotes can travel long distances and become transient even as adults, especially when they lose their mate. Recently described as using "compensatory immigration," coyotes opportunistically fill spatial resource gaps by periodic transiency; when spots come open, individuals that do not yet have permanent territories and have been roaming in the area, are able to inhabit the new openings (Hinton 2016). These periods of transiency can sometimes bring coyotes into conflict with other canids and humans, especially when they are utilizing of anthropogenic resources.

Though a rural area, human land uses occupy a significant portion of space on the AP. The AP is comprised of approximately 30% agricultural fields, 50% forest and coastal marshes, and 20% "other" land cover types on federal, state and private lands (Dellinger 2011). Concerns about fear of attacks on humans and domestic pets, the effects of sympatric canids on white-tailed deer and other game populations, and homeowner property damage comprise many of the conflict calls regarding sympatric canids on the AP (Responsive Management, forthcoming data). Wildlife managers in this region frequently receive requests for information on canid management (C. Turner, personal communication, 2016).

The changes in state and federal canid management rules have resulted in confusion regarding residents' rights and options for management of property damage by sympatric canids. As a result, some citizens are unsure of the legal and most effective methods for canid conflict management. Adding to management complexity is the need to manage canids for conservation purposes, such as reducing predation on at-risk ground nesting species or reducing hybridization of sympatric canids.

In 2013, NCWRC and USFWS established a committee to oversee the collaborative management and conservation of sympatric canids on the AP. A USFWS and NCWRC joint memorandum documented detailed action items for the joint management of sympatric canids on the AP, including specific research objectives which this proposal seeks to address (Attachment 2). As sympatric canids on the AP increase in number, monitoring their

Commented [OSE4]: Does this mean that they are going to trap at Pea Island or any other state and federal land that occurs in Dare county that's not on the peninsula?

Commented [OSE5]: As stated on page one "the AP supports a continuum of sympatric canids" this means coyotes, hybrids and wolves. I guarantee that wolf numbers are declining while others on the continuum are increasing; thus making this statement false. It implies that all variations are increasing.

This sentiment is explained more clearly on page 33 paragraph 3. They refer to coyotes and wolves separately.

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movements, particularly in relation to individuals of differing ancestry, could provide important data to NCWRC and USFWS staff for science-based local and landscape-level decisions about sympatric canid populations and conflict management. Collection of finer temporal scale location data would help to manage interactions of sympatric canids with humans, as well as to support development of dynamic stochastic population models.

Commented [OSE6]: Don't see how this would work, unless they are talking about human dimensions.

B. Objectives (after December 1, 2016-November 30, 2018)

Objective 1: Use GPS collar and proximity sensor technology to test performance under various conditions and evaluate the frequency and accuracy of the scheduled fix rates.

Commented [OSE7]: Is this list a weighted list? I would hate to think that this was the objective with the highest priority.

Objective 2: Use fine scale GPS data collection for investigating annual and seasonal spatial dynamics of sympatric canids: home range and core area sizes, amount of overlap in home range and core areas, movement pathways and daily activity patterns, and cover type selection and preference.

Objective 3: Use fine scale GPS data collection for investigating the number and age structure of offspring for family groups of collared sympatric canids.

Commented [OSE8]: Why do they need location data for number of animals and age?

Objective 4: Use fine scale GPS data collection for investigating sources of mortality for sympatric canids.

Commented [OSE9]: As stated later in this proposal no target animals will be treated for disease. Not treating wolves for visible or known disease is contrary to the recovery program, whether that be for recovery in the wild or increasing numbers in captivity. By continuing treating any wolves we would be compromising the validity of any conclusions from the data. Additionally, are they talking about actual source locations, as in disease originating locus, or causes of mortality?

Objective 5: Use fine scale GPS data collection for preventing and mitigating canid conflicts with landowners.

Commented [OSE10]: How do they propose to accomplish this? Which specific conflicts? How does knowing exact location help?

Objective 6: Determine genetic profiles of sympatric canids through DNA identification of all captured individuals, parentage, and presence of hybridization.

At the end of this two-year pilot study, we will deliver an observational summary detailing the use of the GPS and sensor technology for spatial and population dynamics research on sympatric canids on the AP.

Commented [OSE11]: Their section 7 attachment state 3 years. Granted they state they will be tracking over the course of 3 years. Did they mean 2 years of trapping with an additional year of tracking so that all animals have a minimum of 2 years of tracking?

C. Expected Results and Benefits

As part of a pilot study, we will monitor the status of collared individuals by using a finer scale assessment of space and habitat use than previous studies. Earlier research focused on many of the same objectives we suggest investigating here, but during a time of intense, active

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management. Specific management techniques are no longer being carried out and dynamics between sympatric canids are expected to have changed substantially. The uncertainty regarding current dynamics presents a need for additional research in order to inform actions for the management of sympatric canids. Information gained from research may impact management rules and landowner's abilities to manage canids in some areas. Additionally, GPS technology has improved since earlier research was conducted allowing for more temporally detailed data collection and more nuanced analyses. Understanding how sympatric canids collectively use resources in areas of human-dominated landscapes will allow wildlife managers to tailor management options to local conditions. On the AP, row crop agriculture and hunting represent the primary and secondary land uses, respectively. Row crop agriculture is a significant nutrient resource on the landscape and, as opportunists, canids take advantage of such resources when they are available. Non-consumptive wildlife-driven tourism persists in all seasons and wildlife watching is a main draw for tourists in this area. For many tourists, the opportunity to see or hear large carnivores is the sole attraction for traveling to the AP. Information from this study will be provided to local constituents to establish a knowledge base regarding how sympatric canids use resources on private lands. Management and guidance could serve to prevent or minimize conflict while maximizing positive wildlife interaction opportunities for constituents. Development of a common understanding between wildlife managers and landowners based upon factual information is paramount for collaboratively achieving successful management of sympatric canids. The data collected in this pilot study is the foundation upon which this understanding and future management actions will be built.

The current level of hybridization between sympatric canids on the AP will be characterized using DNA gathered during this study. Body size exists as a continuum between coyotes and red wolves and has been documented as the most important factor for successful interspecific breeding pairs of these canids (Hinton 2014). Though both species have been found to use resources in similar manners, red wolves generally have more expansive home ranges and therefore may not use local resources as intensively as coyotes, depending on body size. Obtaining individual identification of study animals will allow managers, armed with spatial information, to infer how and why individuals in the canid species continuum exploit

Commented [OSE12]: I would like to see a citation for everything in this sentence. Additionally, how do they take advantage of the resources? Are they eating part of it? Primary hunting area?

Commented [OSE13]: Who are these local constituents? One of the main results that I can think of is that landowner requests for wolf removal will increase. Wasteful spending of federal and state money on removal efforts of coyotes, just like the failed removal effort of a coyote in 2016.

Commented [OSE14]: Is a wolf breeding with a hybrid considered hybridization?

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anthropogenic resources considering their life history traits.

In conjunction with prior research, data collected will contribute to knowledge on sympatric canid population dynamics on the AP. Estimating population size will allow managers to monitor population trends of sympatric canids and to examine the long and short-term impacts of different management strategies on their populations. While it is unknown whether sample size will allow for population estimation, obtaining population estimates for coyotes would provide wildlife managers with baseline data, when paired with annual mortality estimates, for monitoring changes in population abundance over time. Information on changes in abundance, reproductive dynamics, and habitat use could impact management strategies to influence long-term conservation outcomes. Results of this pilot study will allow managers to determine if future work will be necessary, what amount of effort will be required to achieve each objective, and whether or not population estimates will be an attainable goal.

D. Approach

The official Red Wolf Recovery Area (RWRA) covers approximately 6,900 square kilometers within Beaufort, Dare, Hyde, Tyrrell, and Washington counties (Wildlife Management Institute 2014). However, the USFWS has proposed the RWRA be constricted to the ARNWR and the Dare County Bombing Range in Dare county by the end of 2017. Due to these proposed RWRA changes, this study proposes to capture and radio-collar 25 sympatric canids within Dare, Hyde, and Tyrrell counties (hereafter referred to as "study area"); those counties being within and directly adjacent to the proposed new RWRA. The thematic subheadings below provide detailed descriptions of the approaches required for achieving the pilot study objectives.

Sampling Efforts

Trained NCWRC personnel will conduct live trapping of sympatric canids, with assistance from the USFWS RWRP biologists, and trained, experienced local trappers. NCWRC and USFWS wildlife personnel will select local trappers based on their past performance in trapping sympatric canids, but may also select trappers from the NCWRC coyote trappers list. NCWRC staff will train contracted trappers on specific trapping procedures before every trapping

Commented [OSE15]: What? They are opportunistic animals and will use any resources that they are able to, or is there something in the literature that states that coyote and wolves don't use anthropogenic resources. They even stated earlier that canids take advantage of row crops which would imply anthropogenic resources are an integral part of their life history. They are implying that the use of anthropogenic resources is abnormal behavior.

Commented [OSE16]: Are we really going to let them trap on the refuge?? Needless to say this would hand over significant control of the program over to the State. I would dare say an illegal hand over at this point.

Loss of control 1.

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season. The project lead will supervise and coordinate all trapping activities including locations for installation and the operation of trap lines and handling of captured animals. Simultaneous personal trapping activities by contracted trappers will not be permitted while performing contracted trapping services, as specified in the draft service contract (Attachment 4).

Trapping efforts will follow a spatial capture-recapture (SCR) framework with a systematic targeted sampling design, focusing on areas that contain resources previously found to be used by sympatric canids (e.g. edge, agricultural fields, secondary roads, etc.) (Harris et al. 2013, Ivan et al. 2013), while attempting to sample a diversity of habitat types. This effort will allow us to increase the probability of detection of sympatric canids on the landscape (Tom 2012). While it is important to sample a wide range of habitats, the most important requirement for SCR is the number of collared individuals; this requirement provides flexibility in the other requirements for field sampling as needed (K. Pacifici, personal communication, 2016). We will initially focus trapping in areas of known red wolf packs, as advised by RWRP.

Trapping will take place during the breeding season when the likelihood of capturing females in the later stages of gestation or whelping females will be low. Capture efforts will be conducted from soon after 1 December 2017 – February 2018 and December 2018 – February 2019. Captured sympatric canids will be surrendered to NCWRC or the USFWS at capture sites. Trapping should occur on both public and private lands to obtain sampling coverage of the study area. Ideally, all federal and state lands would be accessible for trap and release (hereafter referred to as "capture") of sympatric canids, but it is most important to be able to trap and release on Alligator River NWR and the Dare County Bombing Range as those encompass the newly proposed RWRP recovery area and comprise the majority of land area for Dare county. Unlike Dare county, there are ample private lands that surround Pocosin Lakes NWR and Lake Mattamuskeet NWR in both Tyrrell and Hyde counties that may be utilized to effectively sample individuals who may use those federal lands, should they be excluded from capture activities. Capture on federal lands may require USFWS take permits and proposed activities may be subject to a compatibility assessment (P. Benjamin, personal communication, 2016). Scientific collection activities that take place on private lands will require agreements outlining conditions mutually decided by NCWRC and landowners (Attachment 3).

Commented [OSE17]: Another level of lost control.

Loss of control 2

Commented [OSE18]: Trap shy animals will be difficult to recapture, thus biasing their results.

Commented [OSE19]: There are only two known wolf packs left in their proposed study area.

Commented [OSE20]: Breeding disruption is a possibility. Higher chance of trapping too many animals too young, as per their protocol, to collar.

In the Section 7 attachment they specifically state that coyote trapping will commence in Nov and end in Feb, while wolf trapping will start in Dec and end in Feb.

Commented [OSE21]: This sentence is a little vague. Do they mean that will have the opportunity to trap private land if the public land is excluded?

Commented [OSE22]: Compatibility assessment my ass. If this study goes through, it would effectively give the State full control of the wild population. At the bare minimum this would constitute a 10j rule change.

Where is the assessment?

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To increase probability of detection of sympatric canids, the accessible study area will be partitioned by a grid, the cell size of which will based on the average annual home range size of resident coyotes previously reported for the AP, approximately 23 km^2 (Hinton et al. 2015). As a system of sampling, trap lines will be referred here as "traps," and the number of trap sets (i.e. the actual trapping device) and number of each trap set size may vary between traps as necessary. Sampling will be standardized within each grid cell by use of equal number of traps per cell, on average 3 per cell, each at an approximate length of 10 km (Andelt and Gipson 1979, Way et al. 2004).

Target canids will be captured by using Softcatch #3 Coyote 4x4 (Oneida Victor Inc. Ltd., P.O. Box 32398, Euclid, Ohio 44132, Hinton 2014, Schemnitz 1994), the EZ Grip #7 (Livestock Protection Company, P.O. Box 725, Alpine, Texas 79831, Frame and Meier 2007), or equivalent. Various lures and baits will be used to increase trapping efficiency (Frederick et al. 1989, Shipley 2012). Traps will be laid on the Monday of each week and will be opened at the time of deployment. Traps will be checked once daily at dawn, to reduce potential stress to trapped individuals and will not be operated on days where the temperature is expected to reach or exceed 80° F (R. Nordsven, personal communication, 2016) or during times of predicted inclement weather (e.g. snow, hail, high wind, etc., Sikes et al. 2011). To standardize effort and remain logistically realistic, traps should be open for three trap nights in a row before being removed. Trap sets that have been closed due to non-target bycatch or other circumstances may be reopened and all traps should be re-baited and lured as appropriate.

Trap set locations will be marked by NCWRC or USFWS personnel using handheld GPS units (Garmin GPSMAP 64S, 1200 E. 151st St., Olathe, KS 66062-3426) and given a sequential identification number. Traps will also be given an identification number and trap set points will be documented in ArcMap 10.4. Trappers will keep detailed records on trap set operation, non-target species trapped, and other relevant details. Non-target species will be released from traps after an in-field assessment of injuries, if any, and animals with life threatening injuries will be euthanized by the trap operator. Targeted recapture of collared canids will occur annually during the same months, to replace GPS collar batteries and drop-off collar release units in field. Trapping effort will be quantified (trap nights), the effective sample area will be

Commented [OSE23]: What about freezing or below freezing temps. This concern might be covered by their inclement weather statement. The temperature range should be spelled out and private trappers would have to be explicitly told not to trap.

Commented [OSE24]: Why only 3 nights

Commented [OSE25]: Loss of control 3. Implied.

Commented [OSE26]: Good luck capturing trap shy animals. Additionally wont this interfere with subsequent trapping years of the study, or are they planning on not trapping for new animals in the same locations the following year.

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estimated, the encounter (detection) probability will be estimated using a Gaussian detection model (Amundson et al. 2014), and an estimate of density for coyotes will be calculated using a modified Huggins closed-capture estimator in program MARK, if sample size allows (Harris et al. 2013, Ivan et al. 2013).

Animal Handling

Handling of canids will follow American Society of Mammalogists (ASM) guidelines (Sikes et al. 2011) and will be performed at the capture site. Chemical immobilization agents may be used depending on the number of field staff during processing (i.e., three or more staff required during non-chemical immobilizations, Craft 2007, M. Morse, personal communication, 2016).

Chemical Immobilization

Unless adequate numbers of personnel are available to safely employ mechanical restraint techniques, target animals will be anesthetized with the chemical immobilization agent BAM (Wildlife Pharmaceuticals, Inc., Windsor, CO 80550). BAM, a combination of Butorphanol tartrate, Azaperone tartrate and Medetomidine HCl., will be delivered by intramuscular injection by syringe pole to the hip. Dosage for canids is based on field trails performed by Wildlife Pharmaceuticals (Wildlife Pharmaceuticals, Inc. 2016) and the recommended dose for coyotes is 0.2CC and red wolves is 0.3CC, with adjunct doses of 0.1-0.2CC delivered if initial dosages do not cause induction (S. Kirschner, personal communication, 2017). Induction times for coyotes and wolves ranged from 5 to 10 minutes after initial and/or adjunct dosages (Wildlife Pharmaceuticals, Inc. 2016). After field handling is concluded the anesthesia will be reversed using two reversal agents, Atipamezole and Naltrexone, at double the CC of Atipamezole to BAM that was delivered (including adjunct doses, if given) and 0.5CC of Naltrexone. Recovery time from the reversal agents ranged from 10 to 25 minutes during field trails (Wildlife Pharmaceuticals, Inc. 2016). Field personnel will observe animals for signs of adverse effects for up to 30 minutes after reversal agents are delivered.

Mechanical Immobilization

Unlike other carnivore families, the submissive behavioral response of canids to

Commented [OSE27]: Why is the sample area going to be estimated when they stated earlier that they were going to grid out accessible areas?

Commented [OSE28]: This probability is comprised of two factors. 1) Availability "which is the probability that an animal is present in the survey area and signaling its presence to the observer" and 2) Perceptibility "which is the probability that an animal available for detection (e.g., a bird sings) is detected by the observer" This is taken directly form the Amundson paper. I understand how the collars will help with determining availability, but I am curious how they will determine perceptibility. Is the perceptibility tied to the number of traps or ear tags?

Commented [OSE29]: Are they talking about immobilization while the animal is in the trap or are they talking about after the animal is out of the trap? Lots of possible implications when dealing with contract trappers if it is the former. What about total animal process time vs checking trap lines.

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perceived dominance reduces the need to use immobilization agents. Appropriate mechanical restraint techniques can reduce handling time of animals, allowing animals to reintegrate into social groups more quickly, subsequently reducing overall stress to the individual (Powell and Proulx 2003). Target canids will be mechanically restrained with a restraint pole, until two muzzles can be placed around the snout. While pinned with the restraint pole by one person, a second person will restrain the set of legs not in the trap against the ground and a third person will release the foot from the trap. This set of legs will then be restrained by the 3rd person as the restraint pole is removed. Once the restraint pole is removed the person restraining the front legs will also then restrain the head. The first person will then move forward with processing the captured animal.

Each animal will be placed on a towel or blanket to provide thermal protection from the ground, with eyes covered and lubricated with eye ointment; temperature will be monitored with a rectal thermometer. Overheating occurs at approximately 104-105°F for canids (AZA Canid TAG 2012) and the animal handling crew will monitor temperature at 5-minute intervals; if a temperature reading reaches 104°F, corrective actions will be taken and temperature will be monitored at 1-minute intervals. Should overheating occur, the individual will be removed from insulation to expedite the natural evaporative cooling process. During days that approach 80°F in temperature, measures will be taken to reduce heat stress, such as: wetting the animal with water, application of a cold pack to the groin area between the back legs, application of rubbing alcohol to foot pads, or immediate release (AZA Canid TAG 2012). If the injured individual is suspected to be a red wolf, based on morphometrics, USFWS staff will be contacted for a decision. In the event that trap caused injuries are determined to be life threatening through use of a trap injury score assessment (Frame and Meier 2007) the individual will be euthanized. In the event that NCWRC personnel cannot be present, trained USFWS personnel may collar and measure captured target animals and will provide data sheets to NCWRC staff. Target animals will not be vaccinated or otherwise treated for diseases, regardless of the presence of disease symptoms.

Non-target animals will be released on site. Captured domestic dogs will be immediately released from the trap set following an injury score assessment and only if no life-threatening

Commented [OSE30]: This is not always a guarantee that the animal is a wolf or not

Commented [OSE31]: Loss of control 4. Implied.

Commented [OSE32]: I'll be allowed to do this?! Do not do me any favors. I am not your lackey NCWRC! This statement plus several others would seem to indicate a total takeover of the red wolf program by the NCWRC.

Loss of control 5. Implied.

Commented [OSE33]: Not treating wolves for visible or known disease is contrary to the recovery program, whether that be for recovery in the wild or increasing numbers in captivity. These wolves would be integral for population increase in the wild or for the "SSP meta-population"

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injuries are present. If a domestic dog has sustained life threatening injuries and owner identification information is present on the dog, then the animal will be held in either a transportable kennel, or at a dog pen on a state game land that is equipped with such facilities, until the owner can retrieve the dog. The costs associated with injuries sustained to the dog will be the responsibility of the animals' owner. Law enforcement may be requested to help communicate with the animal's owner. If the animal does not have an identifiable owner and has incurred substantial life threatening injuries (i.e. compound fracture), the dog will be euthanized on site. Target animals showing signs of disease symptoms such as circling behavior, head tilt, muscle twitches, convulsions with jaw chewing movements and salivation ("chewing gum fits"), disorientation, incoordination, staggering caused by paralysis of the hind legs, seizures, and partial or complete paralysis will be euthanized and tested according to protocol set forth by the agency veterinarian, in order to determine if there may be a public health issue (M. Palamar, personal communication, 2016). USFWS will be contacted in cases of suspected red wolves. Staff involved in animal handling duties will have the pre-exposure rabies vaccination series completed prior to field work inception and will maintain rabies titer records through properly licensed medical services providers.

If staff is bitten and skin is broken by an animal while performing handling duties, they will be advised to immediately visit a local hospital or clinic for evaluation by healthcare professionals. The field coordinator will immediately notify supervisory staff and an injury report and workers' compensation claim will be opened for the incident. The animal will be euthanized and the head will be sent to the state lab for rabies testing; the body may be sent to the Southeastern Cooperative Wildlife Disease Study (SCWDS) laboratory for additional disease investigation.

Capture Processing and Marking

During canid handling, NCWRC personnel will record age class, sex, weight, total body length, head width, ear length, and tail length, visually assess ectoparasite load, look for and disinfect with betadine or iodine as needed any minor trap caused injuries, and affix GPS collars (Knick 1990, Sikes et al. 2011). All captured canids will be fitted with appropriately-sized GPS collars in the field based on morphometrics previously indicated as reliable thresholds for

Commented [OSE34]: Loss of control 6. Implied.

Commented [OSE35]: Do they not have facilities to hold the animal for observation? They are going to unilaterally euthanize a wolf??

Commented [OSE36]: This whole section gives state complete control of the program. Additionally are they going to remove our collars and put their own on?

Commented [OSE37]: Loss of control 7. Implied.

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species categorization: hind foot length, weight, width of head, and tail length (Hinton 2014); analysis of DNA samples collected during trapping efforts will help to assign captured canids to position along the species continuum post release. Age of individuals will be estimated based on physical characteristics, including weight and tooth replacement (Knick 1990, Hinton 2014, Gier 1968), and captured canids will be aged into one of three classes: > 2 years old as adults, < 2 but > 1 year old as juveniles, and > 6 months but < 12 months old as pups (Hinton 2014). Reproductive status will be determined based on estimated age class and presence of gonadal descent during the breeding season for males and the presence of nipple swelling or previous suckling for females (Hutson and Racey 2004, Magee 2008, Mengel 1971).

Captured individuals will be ear marked using a button tag (model 410, Ketchum Mfg. Co. [or equivalent], PO Box 10, 11 Town Shed Road, Lake Luzerne, NY 12846) placed along the middle of the ear where they are most protected from loss, with a pin-type applicator (485sa Pow-R-ceps plier, Ketchum Mfg. Co. [or equivalent]) (Silvy 2012). The puncture site will be treated with an antiseptic to deter infections. Each sympatric canid will also be marked with an individually-numbered, glass-encapsulated, passive integrated transponder (PIT model HPT12, 12.5 mm, 134.2 kHz, Biomark, Inc., 703 South Americana Blvd., Suite 150, Boise, ID; Gannon et al. 2007), using a syringe-type implanter and replaceable needle (model MK10 [implanter], model N125 [needle], Biomark, Inc.). Successful PIT placement will be verified with a mini portable reader (model GPR Plus, Biomark, Inc.). The implantation site will be prepared by swabbing with 70% alcohol (Mrozek et al. 1995) and a sterilized new needle will be used for each injection. The standard implantation site for transponders is subcutaneously on the dorsal midline of the back, cranial to the shoulder blades (Ingwersen 2000).

A skin biopsy will be taken from all captured target canids by puncturing the pinna of the ear with a biopsy punch in the same location where the ear tag will be placed (Palamar 2014). The biopsied area will be disinfected with alcohol after sampling. The skin biopsy will be placed in a labeled (ID, date, and sample type) cryogenic tube filled with 95% ethanol as buffer and then stored in a freezer until sent out to a lab for genetic analysis (Palamar 2014, Tom 2012). A selection of hairs with the root bulla attached will be pulled from the belly and placed in paper envelopes (Janecka et al. 2007). Hair samples will serve as back up to tissue samples

Commented [OSE38]: What is the point of this if they are going to have a collar on them. Would this be used for mark/recapture purposes for any animal in excess of the 25 collars? Or is this for continued identification after the collars fall off. Collars falling off of wolves does us no good for continued tracking after the study.

I have conflicting thoughts on this. Makes it easier to identify while in a trap prior to release but makes it easier for someone to see and shoot the animal. Alternatively it could stop someone from shooting and thus biasing mortality results.

Commented [OSE39]: Are we going to give them our tags or will they use their own. Either way is a loss of control of the program.

Commented [OSE40]: What is the point of this and how does it help them achieve any of their stated goals? Are they proposing to make a hole in the ear first using this method and then place the tag in the hole?

Commented [OSE41]: Not opposed to this but again, why? Can they get more info from this than from blood samples? They are proposing 3 separate DNA samples.

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for genetic testing. All samples will be sent to the Laboratory for Ecological, Evolutionary and Conservation Genetics, at University of Idaho (875 Perimeter Drive, MS 1136, Moscow, ID 83844) for genotyping to determine species as well as individual identification, hybridization presence, and parentage analysis following previously developed protocols (Adams et al. 2007, Hinton 2014, Miller et al. 2003). The appropriate genetic analyses that examine the coyote-hybrid-wolf species continuum will be performed.

Blood will be collected from all juvenile and adult target canids by venipuncture of the brachial or jugular veins using a 22-28-gauge needle (M. Palamar, NCWRC veterinarian, personal communication, 2016). As per NCWRC veterinarian recommendations, approximately 12 ml of blood will be collected for each animal for possible future testing for diseases of importance to sympatric canid species as well as the humans and domestic animals that they may come into contact with. A minimum of two 6 ml lavender top tube (for whole blood with EDTA) will be filled. Samples should be refrigerated at all times; a cooler with ice will suffice while in the field. Samples should be sent to the NCWRC within 48 hours or frozen for later shipping. Skin scrapes will be collected from animals presenting signs compatible with sarcoptic mange (lesions) for possible future diagnostic purposes. Lesions will be scraped until blood is drawn; the scrapings will be placed onto a slide and covered with a piece of clear tape for later visual confirmation.

Should overheating occur, processing will be performed in the following prioritization order and the first five items will need to be completed before releasing any individuals: 1) trap injury evaluation, 2) collaring, 3) DNA (skin biopsy) sample collection, 4) morphometrics, 5) aging, 6) PIT tagging, 7) weight, 8) ear tagging, 9) reproductive status, 10) ectoparasite evaluation, 11) blood collection, and 12) skin scrape collection.

Commented [OSE42]: Given our concerns over many aspects of tissue collection, I feel that this list should be revisited.

Collaring

Vertex Plus GPS Collars will be attached to 25 sympatric canids captured on the study area, 10 of which will be equipped with proximity sensors (Vectronic Aerospace GmbH, Carl-Scheele-Str. 12, 12489 Berlin, Germany). Project staff will pilot test proximity sensor technology for utility in analysis of spatial and temporal community dynamics. Proximity sensors trigger increased GPS location acquisition during those time intervals when two collared individuals

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come within a set distance from each other (http://www.vectronic-aerospace.com/wildlife-monitoring/sensors/uhf-id-tags, accessed August 2016).

To avoid instances of collar induced strangulation, only adult (>2 years old) male and female individuals will receive collars (Hinton 2014). ASM guidelines recommends a collar weight of <5-10% of a canids bodyweight, we will observe these guidelines (Sikes et al. 2011). Sympatric canids not releasable at a capture site will not be collared and will not become study animals.

GPS radio-collars will have both VHF and GPS Iridium locational systems as well as store-on-board capabilities. Radio-collar units will be programmed to record GPS coordinates once every 1.75 hours producing approximately 13 locations per day while cycling through the 24-hour time cycle. These settings will allow for a GPS battery life of 300 to 552 days, averaging 431 days. The VHF beacon will be in operation from 0800 – 1600 hours daily. GPS locations will be sent via satellite once per day and each transmission with contain 12 locations. The use of an integrated drop off firing mechanism should allow the collars to drop off within a maximum of approximately 548 days after deployment. The drop off schedule once set cannot be changed. The drop off firing mechanism is wired to a battery unit independent of the collar battery, therefore should the collar battery become depleted, the drop off mechanism will not be affected (C. Akakpo, Vectronic Aerospace GmbH, personal communication, 2016). Unless a collared individual is recaptured before the collar battery dies, the drop off mechanism will fire at the scheduled time frame post collar deployment.

Observation of sympatric canid habitat use and movements will occur through GPS data obtained with combination GPS/VHF radio-collars. VHF relies on triangulation, the process of estimating the location of a transmitter by using two or more compass bearings obtained by using directional antennas at known locations remote from the transmitter's position (White and Garrott 1990), whereas GPS uses a satellite based system to obtain location coordinates. There have been many published studies where one or both of these methods were used, with mixed success for determining various aspects of carnivore ecology throughout the United States (Hinton et al. 2012, Schrecengost et al. 2009, Sparkman et al. 2012). While GPS technology has developed rapidly in recent history, the real time functional advantage of VHF

Commented [OSE43]: I have a feeling that there is going to be many animals that fall into this category especially considering the prevalent landowner attitude towards carnivores in general and coyotes specifically. Additionally this constitutes a double standard in regards to releasing animals. We have landowner authorization in many cases but the State still will not allow us to use those lands for release, but it's okay for the State to do as they please? Also I feel that they should have all landowner agreements in place and the study/trapping areas well defined prior to any trapping effort. I have serious doubts that they can get this in place prior to Dec 1st.

Commented [OSE44]: What frequency range?

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cannot be disregarded. When GPS technology falters or malfunctions, VHF can serve as replacement for data collection in addition to its use in real time monitoring of study animals. Canids will be minimally monitored for mortality approximately every 30 days by using VHF aerial telemetry techniques (Whitehouse and Steven 1977) as there may be a delay in satellite transmission of GPS location data due to weather, season, and animal behavior. Transient canids and individuals from breeding pairs that have lost a mate, have been found to use much larger areas versus paired residents, potentially increasing the opportunity for losing track of these individuals when GPS technology reaches its functional capacity or experiences malfunction. VHF data may also provide locations of canids in cover too dense for GPS units to function. Use of VHF telemetry techniques for data collection may be expanded as necessary for project needs.

Commented [OSE45]: Can the GPS collars transmit through water? If not and you have an animal that tumbles into water right after mortality you've lost data.

Spatial Data Analyses

Both minimum convex polygon (MCP) and adaptive kernel (AK) home ranges (95%) and core use areas (50% and 25%) (Seaman and Powell 1996, Seaman et al. 1999) will be calculated from GPS data by using BIOTAS (Ecological Software Solutions LLC, 2016) and Geospatial Modelling Environment (Spatial Ecology, LLC, 2016) for ArcGIS 10.2.2 (Environmental Systems Research Institute, 2016) (Benson et al. 2006, Riley 2006, Tucker et al. 2008, Hinton 2014) for comparison to older studies. These estimations can also be calculated using VHF data, provided data minimum requirements are met. Spatial distribution in relation to habitat will also be estimated by dynamic Brownian bridge movement models as described by Hinton (2014) with R statistical software (R Core Team 2016) using the moveud package with habitat covariates important to each species (Bryne et al. 2014, Collier 2013, Kranstauber and Smolla 2013, C. Proctor, personal communication, 2016). Additionally, recent research into how canids shift their ranges will also be investigated for populations on the AP (Morin and Kelly, in review). Spatial overlap and co-occurrence will be assessed using methods described by Shipley (2012). Habitat and cover types will be estimated from digitized maps created by the SEGAP (Hinton 2014) or ortho files, as available (Shipley 2012). Percent composition of habitat and cover types within home ranges and core areas as well as edge density will be quantified (Shipley 2012). Habitat selection and cover type use effects on spatial distribution will be estimated at both the population (2nd order) and individual (3rd order) spatial scales using resource selection functions

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(Johnson et al. 2006, Manly et al. 2002, Shipley 2012). Effects of seasonality and time of day activity will also be explored. The spatial and temporal patterns of space use by sympatric canids will be studied using data generated from the interaction GPS collar sensors, particularly distance between individuals and duration of proximity.

Den Monitoring

Project staff will attempt to locate den sites for sympatric canids to get pup counts, morphometric measurements, age estimates, and skin biopsies. Project staff will also attempt to monitor pup survival during the pup rearing season by using remote cameras placed around the den site (Harrison and Gilbert 1985, Parks 1979, Way et al. 2001). Pups will be weighed, measured, and PIT tagged during May and June of each year when they become active but are still den-obligated (Gier 1968). We will investigate the use of remote camera traps for monitoring den behavior with a two-camera array around the den (H. Garbe, personal communication, 2016, Kays and Slauson 2008). This method has been successfully used to monitor kit fox pup survival (Kluever et al. 2013). Because coyotes have been found to be sensitive to den site disturbance, there is a general lack of data in the literature regarding this approach for monitoring pup survival. Approaching an experimental methodology systematically will be important for determining which methods are effective and which are not. As a starting point for testing this methodology, remote cameras will be placed two to five meters from main den entrances and set to take photos using a passive infrared sensor trigger (a beam that when broken by movement through it, triggers the camera to take a series of photos) with a time restriction between photo intervals to limit the number of photos taken and maximize the space on the memory card for the time period between camera checks (Kluever et al. 2013). Cameras will be checked six days after deployment and will be redeployed (i.e. new batteries and memory card, if required); cameras will remain at each den site until radio-collar data indicates the den site has been moved (Kluever et al. 2013). Cameras will be not be redeployed to a new coyote den site during a season if that breeding pair has already moved the den once due to the disturbance of camera presence/deployment.

Commented [OSE46]: No mention USFWS personnel in conjunction with this phrase.

Loss of control 8. Implied in conjunction with Project Personnel section.

Commented [OSE47]: No need for biopsies. Again, why do they need this? We already draw blood.

Commented [OSE48]: Getting this close to dens in order to set up the cameras will cause high enough disturbance that the mother will move the pups or will abandon the pups all together. Even if by some miracle they were not moved or abandoned after first deployment, good luck with that not occurring after your first 6 day revisit. Looking at the Kluever paper I noticed 2 major differences between the Kluever study and this one.

The first is terrain. The Kluever study was conducted in the Great Basin in NE Utah. The area as described in the paper is very open and lacks dense vegetation. Lines of site were not an issue. Often times canid dens in SE will be located in dense vegetation. Not to say that this issue cannot be overcome, but it may be impractical to deploy cameras effectively, or site modification, i.e. clearing out veg, could be enough to cause den abandonment or den relocation.

The second issue is animal behavior is quite different. Kluever et al. were observing kit foxes. Camera deployment was done in the afternoons when the foxes were underground in their dens. The foxes most likely had no clue that the researchers were ever there. In fact the authors attributed the lack of den abandonment to this probable factor. There would never be a time where a pack would not be aware of, or disturbed by camera deployment here in NC.

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Mortalities

If a collared animal dies during the project, the carcass will be sent to SCWDS for necropsy. Red wolves will be sent to the SCWDS laboratory for necropsy, unless it is determined to be a law enforcement case. In potential law enforcement cases, the NCWRC Division of Wildlife Management Chief and USFWS Ecological Services Raleigh Field Office Field Supervisor will be contacted and requested to contact the appropriate law enforcement personnel, immediately after determining the need for law enforcement involvement. The carcass and all relevant information will then be turned over to law enforcement; the GPS-collar will be removed and genetic samples will be taken from the individual prior to release to law enforcement.

Commented [OSE49]: We have our own facility for this. This would be another point of lost control.

Loss of control 9.

Commented [OSE50]: Why? Just contact LE and then inform the Chief and Field Supervisor

E. Project Personnel

Andrea Shipley has worked for the North Carolina Wildlife Resources Commission as a Canid Biologist since February 2016. Prior to that, she worked as a Wildlife Biologist for a non-profit located in northeastern Nevada as well as in several different field biologist oriented positions. Andrea has a background in carnivore and spatial ecology, having earned her MS in Biological Sciences from Eastern Kentucky University and BS in Biological Sciences from Rutgers University; Andrea will act as project lead and coordinator.

Brandon Sherrill has worked for the North Carolina Wildlife Resources Commission as a Mammalogist since December 2013. Prior to that, he worked as an educator at the North Carolina Museum of Natural Sciences and as a regional wildlife biologist for the South Carolina Department of Natural Resources. Brandon earned a BS and MS in Fisheries, Wildlife, and Conservation Biology from North Carolina State University; Brandon will act as project supervisor.

Krishna Pacifici, Research Assistant Professor at NCSU, will be the quantitative analysis collaborator on the project. Krishna's background and experience in quantitative ecology makes him well suited to consult and assist with advanced statistical analyses of spatial data.

Lisette Waits, Department Head and Distinguished Professor at the University of Idaho, will be the DNA analysis collaborator for the project, responsible for all DNA related sample processing and subsequent analyses.

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F. Schedule and Estimated Costs

The project will run from soon after December 1, 2017 through June 30, 2020. The estimated timeline for major tasks is as follows:

Year 1: Initiate field work soon after December 1, 2017 with assistance from 1-2 field technicians; 1 technician will be required for trapping and den monitoring efforts. Data collection will begin immediately after collar deployment and data will be managed by Andrea Shipley throughout the life of the project. Data analysis will be initiated after den monitoring season concludes, with guidance and assistance from Krishna Pacifici at North Carolina State University (NCSU). Report, manuscript and presentation production will be initiated concurrently with data analysis.

Year 2: Continue field work and data collection with assistance from 1-2 field technicians. Continue data analysis with guidance and assistance from Krishna Pacifici at NCSU. Continue and finalize report and manuscript production, and presentation at professional working groups and/or meetings.

GPS technology allows researchers to collect locational data at fine spatial and temporal scales through the deployment of collar units on wildlife study subjects. In this project, we propose to study a sample of sympatric canid populations with GPS radio-collars, in order to investigate the population parameters outlined in previous sections as well as species interactions. The purchase and use of this technology is critical to meeting the research objectives set forth in this document as well as in the document included in Attachment 1.

While GPS technology has evolved over the past 20 years, the cost of technology has plateaued. Upfront cost per unit remains relatively high, however project savings occurs at the back end when compared to older telemetry technology such as very high frequency (VHF)

Commented [OSE51]: Where are these techs coming from? Are we going to be paying for them?

Commented [OSE52]: Will we have any access to these data or only receive what the State is willing to give us? How will these data be used? Will the state cherry pick data and use it as a claim that the wolf is not a species?

Loss of control 10.

Commented [OSE53]: Where is year 3; as stated in their section 7 attachment?

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which require intensive labor to collect data at similar spatial and temporal scales. Pilot testing the proximity sensor enabled GPS-collars will allow investigation of the utility of this relatively new tool for community dynamics analysis by providing an increased locational data acquisition when individuals come within a set distance, or closer, from each other. Additionally, these sensors record the identities of the interacting individuals and the duration of their interactions. Using a trigger to temporarily switch GPS fix schedules will enable us to collect very fine scale data while conserving battery life, achieving project objectives in an efficient manner. Exploring the efficaciousness of this technology has the potential to positively impact future research projects requiring use of GPS-collars for data collection.

Aerial tracking will provide regular study animal surveillance useful to investigate cases of mortality, collar malfunction, or satellite data transmission delays, which can vary seasonally. In some situations, ground tracking could prove less expensive than aerial tracking. However, ground telemetry techniques require more than one biologist working in tandem to acquire accurate location estimates. This often translates to increased labor to collect data, particularly in large study areas. Aerial tracking will provide a more efficient and cost-effective method for surveilling study subjects in this large study area, requiring only one biologist and a contracted pilot. NCWRC personnel will perform aerial tracking along with the NCWRC pilot at a minimum frequency of every 30 days.

Use of local trappers to assist with sampling efforts provides several benefits. Local trappers have established, long-term relationships with private land owners, thereby providing access to private lands that might be otherwise difficult to secure. This will enable project biologists to obtain a representative sample of sympatric canids in the study area, as well as to operate more trap lines concurrently. This is particularly important when using a SCR sample design, as it will have direct implications on the resulting analyses and inferences.

Commented [OSE54]: Access does not necessarily denote cooperation. A land owner may say it's okay to trap but nay not agree to releasing the animal back on to the property.

As part of collaboration efforts, the project will contract the services of Krishna Pacifici, Research Assistant Professor in the Applied Ecology department at NCSU. Krishna's expertise is in quantitative ecology; consultation and assistance services provided will allow project biologists to make appropriate statistically relevant inferences from collected data.

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DNA analysis will be contracted to Lisette Wait's lab at the University of Idaho. Lisette's team at The Laboratory for Ecological, Evolutionary and Conservation Genetics has previous experience in analyzing red wolf and coyote hybrid molecular samples and has the most comprehensive DNA methodology for this sympatric canid species continuum in the nation. This expertise will facilitate expedient species identification on collared study animals besides landscape level population dynamics analysis.

	Commission	In-kind	Total
a. Personnel	$ 7,200.00	$ -	$ 7,200.00
b. Fringe Benefits	$ -	$ -	$ -
c. Travel	$ 30,000.00	$ -	$ 30,000.00
d. Equipment	$ 54,000.00	$ -	$ 54,000.00
e. Supplies	$ 61,500.00	$ -	$ 61,500.00
f. Contractual	$315,590.00	$ -	$315,590.00
g. Construction	$ -	$ -	$ -
h. Other	$ 6,000.00	$ -	$ 6,000.00
i. Total Direct Charges (sum of a – h)	$474,290.00	$ -	$474,290.00
j. Indirect Charges	$ 4,800.00	$ -	$ 4,800.00
k. Totals (sum of i and j)	$479,090.00	$ -	$479,090.00
Federal (75%)			$359,317.50
State (25%)			$119,772.50

Commented [OSE55]: Do they even work with hair or biopsy samples?

Commented [OSE56]: 30k for travel? Where are they going? Vegas?
300k for contracts? How many trappers are they going to use? All of them?

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G. Geographic Location

Three counties of the Albemarle Peninsula of North Carolina (Dare, Hyde, and Tyrrell counties).

H. Related Federal Projects

NC-W-F15AF00726 (W-72) NC-Division of Wildlife Management Cooperative Projects

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I. Glossary

Abundance: Species abundance is the number of individuals per species, and relative abundance refers to the evenness of distribution of individuals among species in a community.

Adaptive kernel (AK): A probabilistic home range estimator based on the distribution and density of locations that has been collected over a period of time.

Adverse reactions: In pharmacology, any unexpected or dangerous reaction to a drug.

Aerial: Existing, happening, or operating in the air.

Annually: Once a year; every year.

Anthropogenic: Caused or influenced by humans.

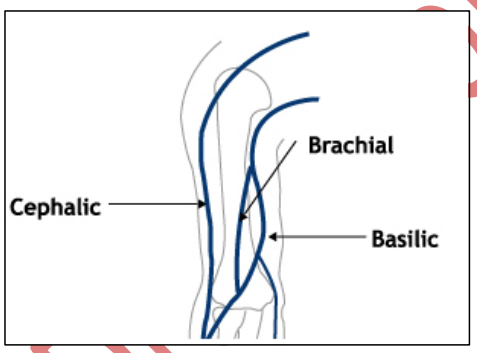
Apex: Having no natural predators in its ecosystem.

Ataxia: The loss of full control of bodily movements.

Beacon: A radio beacon whose purpose is the investigation of the propagation of radio signals.

Biopsy: The removal for diagnostic study of a piece of tissue from a living body.

Brachial vein: One of a pair of veins accompanying the brachial artery and uniting with each other and with the basilic vein to form the axillary vein.



Breeding pair: A pair of animals which cooperate over time to produce offspring with some form of a bond between the individuals.

Carrying capacity: The maximum population size of the species that the environment can sustain indefinitely, given the food, habitat, water, and other necessities available in the environment.

Compensatory immigration: Individuals emigrating from areas with lower mortality to those with higher mortality; filling a deficiency of individuals in a population experiencing higher mortality. The increase in size or activity of one part of an organism or organ that makes up for the loss or dysfunction of another.

Composition: The combining of distinct parts or elements to form a whole.

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Co-occurrence: Refers to observation of the spatial overlap between two (or more) different individuals over a period of time.

Coordinates: Any of the scales or magnitudes that serve to define the position of a point.

Core use areas: An area within a home range exhibited by a dense concentration of location points; commonly estimated at 50% of the location data points.

Covariates: A variable that is possibly predictive of the outcome under study.

Cranial: Pertaining to the cranium or to the anterior (in animals) or superior (in humans) end of the body.

Cryogenic: Very low temperatures, e.g. -80°C.

Den-obligated: Restricted to a particular condition of life, in this case restricted to a den site.

Density: A measure of the number of organisms that make up a population in a defined area.

Deployment: To organize and send out (people or things) to be used for a particular purpose.

Depredation: The act of preying upon.

Depressed respiration: A decrease in the ability to exhale and inhale; respiration that has a rate below 12 breaths per minute or that fails to provide full ventilation and perfusion of the lungs.

Diagnostic: The process of determining by examination the nature and circumstances of a diseased condition.

Disorientation: Loss of one's sense of direction, position, or relationship with one's surroundings.

Distribution: The manner in which a biological taxon is spatially arranged.

DNA: (deoxyribonucleic acid) is a type of macromolecule known as a nucleic acid. It is shaped like a twisted double helix and is composed of long strands of alternating sugars and phosphate groups, along with nitrogenous bases (adenine, thymine, guanine and cytosine).

Dorsal: Situated on or toward the upper side of the body, equivalent to the back, or posterior, in humans; situated on or toward the posterior plane in humans or toward the upper plane in quadrupeds.

Duration: A continuous period of time.

Dynamic Brownian bridge movement models: Incorporates temporal and behavioral characteristics of movement paths into estimation of home range.

Ectoparasite: a parasite that lives on the outside of its host rather than within the hosts body; e.g. fleas and lice.

Effective trap area: Calculated by buffering each trap site by half the mean maximum distance traveled, each of these boundaries are dissolved, creating a measurable area.

Efficacious: Producing or capable of producing a desired effect.

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Efficient: Accomplishment of or ability to accomplish a job with a minimum expenditure of time and effort.

Euthanize: The act of putting to death painlessly or allowing to die, as by withholding extreme medical measures, a person or animal suffering from an incurable, especially a painful, disease or condition.

Expedient: Suitable for achieving a particular end in a given circumstance.

Evaporative cooling: reduction in temperature resulting from the evaporation of a liquid, which removes latent heat from the surface from which evaporation takes place.

Facilitate: Make an action or process easy or easier.

Genotyping: Investigate the genetic constitution of (an individual organism).

Gonadal descent: The act or process of descending from a higher to a lower location; testicular descent occurs during the breeding season annually.

GPS: Global Positioning System, is a radio navigation system that allows land, sea, and airborne users to determine their exact location, velocity, and time 24 hours a day, in all weather conditions, anywhere in the world.

Home range: an area over which an animal or group of animals regularly travels in search of food or mates, and that may overlap with those of neighboring animals or groups of the same species.

Hybridization: The result of mixing, through sexual reproduction, two animals or plants of different breeds, varieties, species or genera.

Immobilization agent: An active force or substance capable of producing an effect.

Implantation: To put or fix firmly.

Inbreeding depression: The reduced biological fitness in a given population as a result of inbreeding, or breeding of related individuals.

Inception: The establishment or starting point of an institution or activity.

Interspecific: Existing or occurring between different species.

Iridium: A satellite constellation providing voice and data coverage to satellite phones, pagers and integrated transceivers over the Earth's entire surface.

Jugular vein: Any of several large veins in the neck, carrying blood from the head and face.

Lacerations: A deep cut or tear in skin or flesh.

Locational: A position or site occupied or available for occupancy or marked by some distinguishing feature.

Malfunction: Fail to operate in the normal or usual manner

Methodology: A system of methods used in a particular area of study or activity.

Midline: A median line or plane of bilateral symmetry, especially that of the body.

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Minimum convex polygon (MCP): Completely enclose all data points by connecting the outer locations in such a way as to create a convex polygon.

Molecular samples: Genetic samples that may be used for investigation of genetic constitution of an individual.

Morphometrics: The process of measuring the external shape and dimensions of landforms, living organisms, or other objects.

Mortality: The state of being subject to death.

Non-target bycatch: Animals caught by accident that are not the target species being sought.

Parameters: A numerical or other measurable factor forming one of a set that defines a system or sets the conditions of its operation.

Parentage: The origin of something; the state or relation of a parent.

Passive integrated transponder: A microchip implant is an identifying integrated circuit placed under the skin of an animal.

Pinna: The external part of the ear in humans and other mammals; the auricle.

Plateaued: A period or state of little or no growth or decline.

Population dynamics: The branch of life sciences that studies the size and age composition of populations as dynamic systems, and the biological and environmental processes driving them (such as birth and death rates, and by immigration and emigration).

Population growth: The increase in the number of individuals in a population.

Population size: A group of organisms of the same species that live in the same area.

Population status:

Population trend: Changes over time and can include changes in ranging behavior and distribution, biogeography and life-history.

Population viability: The process that determines the probability that a population will go extinct within a given number of years.

Proximity: Nearness in space, time, or relationship.

Quantified: Express or measure the quantity of.

Quantitative: Relating to, measuring, or measured by the quantity of something rather than its quality.

Radio-telemetry: The use of radio waves for transmitting information from a distant instrument to a device that indicates or records the measurements.

Recumbency: The state of leaning, resting, or reclining.

Reintegrate: Restore (elements regarded as disparate) to unity.

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Remnant: A small remaining quantity of something.

Reproductive status: Relating to or effecting reproduction.

Spatial: Relating to, occupying, or having the character of space.

Spatial capture-recapture: A method commonly used in ecology to estimate an animal population's size. A portion of the population is captured, marked, and released. Marked animals are either recaptured or are tracked, each tracking location being considered a recapture.

Species Continuum: An aggregate of species capable of interbreeding, resulting in fertile hybrid offspring whose genetic composition may represent a varying array of phenotypes and genotypes from the parental species, at which the extreme ends of the spectrum are distinct.

Standardize: Cause (something) to conform to a standard.

Statistically relevant inferences: the process of deducing properties of an underlying distribution by analysis of data. Inferential statistical analysis infers properties about a population: this includes testing hypotheses and deriving estimates.

Stochastic population models: Ecological population modeling is concerned with the changes in population size and age distribution within a population as a consequence of interactions of organisms with the physical environment, with individuals of their own species, and with organisms of other species; stochasticity possesses some inherent randomness. In stochastic population models, the same set of parameter values and initial conditions will lead to an ensemble of different out puts.

Strangulation: The condition in which circulation of blood to a part of the body is cut off by constriction.

Stratifying: Form or arrange into strata, one of a number of portions or divisions likened to layers or levels.

Surveillance: Continuous observation of a place, person, group, or ongoing activity in order to gather information.

Survival: A living or continuing longer than, or beyond the existence of, another person, thing, or event.

Sympatric: Occurring within the same geographical area; overlapping in distribution.

Tachycardia: A heart rate that exceeds the normal resting rate. In general, a resting heart rate over 100 beats per minute is accepted as tachycardia in human adults.

Telemetry: See radio-telemetry.

Temporal: Of or relating to time.

Tooth replacement: The process of development of two successive sets of teeth, initially the deciduous set and consecutively the permanent set.

Transmitter: A set of equipment used to generate and transmit electromagnetic waves carrying messages or signals, especially those of radio or television.

Transponder: A device for receiving a radio signal and automatically transmitting a different signal.

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Vaccinate: Treat with a vaccine to produce immunity against a disease; inoculate.

Venipuncture: The puncture of a vein as part of a medical procedure, typically to withdraw a blood sample or for an intravenous injection.

VHF: Very high frequency is the ITU designation for the range of radio frequency electromagnetic waves (radio waves) from 30 MHz to 300 MHz, with corresponding wavelengths of ten to one meters.

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Attachment 1: Intra-service Section 7 Biological Evaluation Form

Region 4

INTRA-SERVICE SECTION 7 BIOLOGICAL EVALUATION FORM

[Note: This form provides the outline of information needed for intra-Service consultation. If additional space is needed, attach additional sheets, or set up this form to accommodate your responses.]

Originating Person: Andrea Shipley

Telephone Number: 252.926.0266 **E-Mail:** andrea.shipley@ncwildlife.org

Date: November 8, 2016

PROJECT NAME (Grant Title/Number): NC – Division of Wildlife Management Cooperative Projects / (W-72)

I. Service Program:

_____**Ecological Services**
__X__**Federal Aid**
  _____**Clean Vessel act**
  _____**Coastal Wetlands**
  _____**Endangered Species Section 6**
  _____**Partners for Fish and Wildlife**
  _____**Sport Fish Restoration**
  __X__**Wildlife Restoration**
_____**Fisheries**
_____**Refuges/Wildlife**

II. State/Agency:

NORTH CAROLINA / NORTH CAROLINA WILDLIFE RESOURCES COMMISSION

III. Station Name:

FWS RALEIGH ECOLOGICAL SERVICES OFFICE

IV. Description of Proposed Action (attach additional pages as needed):

Conduct research project entitled "**Coyotes of the Albemarle: Spatial Ecology, Resource Selection, Demographics, and Interactions with a Sympatric Canid"**

The coyote (*Canis latrans*) is now abundant throughout the 100 counties in North Carolina (NC), where they are managed as nongame with no closed season or bag limit (NC Wildlife Resources Commission 2016). Previously restricted to the West and Midwest regions of the United States, by the early 1990s coyotes had expanded their range into the Albemarle Peninsula (AP), which is situated in the northeast coastal plains region of NC (Hinton et al. 2012, Murray et al. 2014).

Recently described as using "compensatory immigration," coyotes are able to opportunistically fill spatial resource gaps by periodic transiency (Hinton 2016). These periods of transiency can sometimes bring coyotes into conflict with humans and other canids, especially while taking advantage of anthropogenic resources. Though a rural area, human land uses predominate on the AP. The AP is comprised of approximately 30% agricultural fields, 50% forest and coastal marshes, and 20% "other" land cover types on federal, state and private lands (Dellinger 2011).

In 1968, individuals from a remnant population of red wolves were removed from Texas and Louisiana and a captive breeding program was initiated. The United States Fish and Wildlife Service (USFWS) released a non-essential, experimental population of red wolves (*Canis rufus*) on the Alligator River National Wildlife Refuge (ARNWR) in 1987 (Hinton et al. 2013). The red wolf population increased until 2008 and peaked at around 208 individuals (USFWS Red Wolf Recovery Program 2007), a few animals short of the recovery goal of 220 in the wild (USFWS Red Wolf Recovery Program 2013), with an estimated carrying capacity of 140-150 for the AP (Hinton et al. 2013, Kelly et al. 1999, USFWS Red Wolf Recovery Program 2007). Red wolves presently inhabit an approximately 6900 square kilometer recovery area within Beaufort, Dare, Hyde, Tyrrell, and Washington counties (Wildlife Management Institute 2014).
Accurate up-to-date estimates of the population are unavailable, but USFWS staff report a population size of 45-60 individuals with three mortalities in 2016 (https://www.fws.gov/redwolf/index.html July 2016). Hybridization with coyotes, inbreeding depression, and gunshot mortality have all been suspected issues that have affected the population growth and viability since the inception of the Red Wolf Recovery Program (RWRP) (Hinton et al. 2013). In 2013, NCWRC and USFWS established a committee to oversee the collaborative management and conservation of red wolves and other canids on the AP. A USFWS memorandum documented detailed action items for the joint management of canids on the AP, including specific research objectives which this proposal seeks to address (Attachment 1).

As coyotes on the AP increase in number, monitoring coyote movements, particularly in relation to red wolves, will provide important data to NCWRC and USFWS staff for science-based local and landscape-level decisions about coyote population management. Collection of finer temporal scale location data will help to manage interactions of both canid species with humans, as well as to support development of dynamic stochastic population models.

Coyote and red wolves will be live trapped by cooperating NCWRC and USFWS staff, and private trappers using double coil size 3 foothold traps, during the breeding season (Nov-Feb for coyote, Jan-Feb for red wolves) in the tri-county area of Dare, Hyde and Tyrrell. Morphological measurements, incidents of injury, occurrence of ectoparasites, age classification, and reproductive status will be determined; blood and tissue samples will be taken for genetic analysis. All captured individuals that meet the age classification and weight requirements will be collared with GPS collar units. All captured and collared individuals will be released at the capture site. The objectives listed below will be achieved by obtaining measurements, samples and information from the captured, collared, and tracked individuals over the course of three years using GPS location data.

Objective 1: Use GPS collar and proximity sensor technology to test performance under various conditions and evaluate the frequency and accuracy of the scheduled fix rates.

Objective 2: Use fine scale GPS data collection for investigating annual and seasonal spatial dynamics of sympatric canids: home range and core area sizes, amount of overlap in home range and core areas, movement pathways and daily activity patterns, and cover type selection and preference.

Objective 3: Use fine scale GPS data collection for investigating the number and age structure of offspring for family groups of collared sympatric canids.

Objective 4: Use fine scale GPS data collection for investigating sources of mortality for sympatric canids.

Objective 5: Use fine scale GPS data collection for preventing and mitigating canid conflicts with landowners.

Objective 6: Determine genetic profiles of sympatric canids through DNA identification of all captured individuals, parentage, and presence of hybridization.

V. Pertinent Species and Habitat:

A. Include species/habitat: See section VI

B. Complete the following table:

SPECIES/CRITICAL HABITAT	STATUS[1]
Canis rufus	T

[1]STATUS: E = endangered, T = threatened, PE = proposed endangered, PT =proposed threatened, CH = critical habitat, PC = proposed critical habitat, C = candidate species

VI. Location:

A. Statewide

Albemarle Peninsula (see web address www.ncwildlife.org)

B. Section, township, and range (or latitude and longitude):

Dare, Hyde, Tyrrell counties

C. Distance (miles) and direction to nearest town:

As stated above

D. Species/habitat occurrence:

Canis rufus

VII. Determination of Effects:

A. Explanation of effects of the action on species and critical habitats in item V. B. (attach additional pages as needed):

SPECIES/CRITICAL HABITAT	IMPACTS TO SPECIES/CRITICAL HABITAT
Canis rufus	Trap induced injury is possible

B. Explanation of actions to be implemented to reduce adverse effects:

SPECIES/CRITICAL HABITAT	ACTIONS TO MITIGATE/MINIMIZE IMPACTS
Canis rufus	Use of appropriate trap types, daily trap checks, treatment of minor injuries, trapping season limitations and limitations on environmental conditions for trap operation

VIII. Effect Determination and Response Requested:

Species/ Critical Habitat	Determination[1]			Response[1] Requested
	NE	NA	AA	
Canis rufus		X		Concurrence

[1] Determination/Response Requested:

NE = No Effect. This determination is appropriate when the proposed action will not directly, indirectly, or cumulatively impact, either positively or negatively, any listed, proposed, candidate species or designated/proposed critical habitat. Response Requested is optional but a "Concurrence" is recommended for a complete Administrative Record.

NA = Not Likely To Adversely Affect. The determination is appropriate when the proposed action is not likely to adversely impact any listed, proposed, candidate species or designated/proposed critical habitat or there may be beneficial effects to these resources. Response Requested is a "Concurrence".

AA = Likely To Adversely Affect. This determination is appropriate when the proposed action is likely to adversely impact any listed, proposed, candidate species or designated/proposed critical habitat. Response Requested for listed species is "Formal Consultation". Response Requested for proposed or candidate species is "Conference".

Signature (originating station) **Date**

Title

IX. Reviewing Ecological Services Office Evaluation:

A. Concurrence _____ Non-Concurrence _____

B. Formal consultation required _____

C. Conference required _____

D. Formal conference required _____

E. Remarks (attach additional pages as needed):

_____ _____
Signature **Date**

_____ _____
Title **Office**

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Attachment 2: Joint Memorandum

MEMORANDUM

November 20, 2013

TO: All Interested Parties

FROM: "for"
Cynthia K. Dohner, Director, Southeast Region, U.S. Fish and Wildlife Service
Gordon S. Myers, Executive Director, N.C. Wildlife Resources Commission

SUBJECT: Collaborative Conservation of Red Wolves and Other Canids on North Carolina's Albemarle Peninsula

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Recovery of the federally-listed red wolf has been a priority for the U.S. Fish and Wildlife Service (FWS) for more than 20 years and is focused in North Carolina on the Albemarle Peninsula (AP; i.e., Hyde, Tyrrell, Washington, Beaufort, and Dare counties). Comprehensive stakeholder involvement and collaboration with other management agencies is critical to successful recovery of any at-risk species. The North Carolina Wildlife Resources Commission (WRC) is a key collaborator in this regard, as it has jurisdiction over all state-trust wildlife resources in N.C.

Since 2009, the FWS and WRC have worked to broaden our collaboration in the conservation and management of all canid species (including red wolves) on the AP. As these efforts have solidified, specific actions have been jointly identified by our two agencies that will improve conservation outcomes. These actions are categorized into five areas; collaboration, research, outreach, regulatory, and enforcement. Specific action items are outlined and prioritized within each of these categories in Attachment A.

This memo establishes the FWS's and WRC's commitment to initiate, or to continue, the efforts outlined in Attachment A. The common goal in this effort is to establish clear expectations and accountability for collaboration regarding the action items on Attachment A, thus resulting in enhanced and seamless canid conservation and management on the AP. This approach provides the best opportunity to achieve recovery goals for red wolves, while at the same time managing other canids to balance biological variables with social expectations. The dynamics of these canid species are complex and offer unique opportunities for innovation. Appropriate staff from each agency is hereby tasked with immediately developing a timeline to implement these actions. Through this commitment, we will continue to advance our collective conservation goals.

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Attachment A

Action Items for Collaborative Conservation of Canids on North Carolina's Albemarle Peninsula (AP)
(*Note: Action Items are prioritized within category.*)

Collaboration

1. The N.C. Wildlife Resources Commission (WRC) and U.S. Fish and Wildlife Service (FWS) will formalize in writing the collaborative management of canids on the AP. This agreement should:
    a. include a clear mission statement, goals, objectives, and implementation strategies (ask and answer the "Why?");
    b. set a goal to define success regarding canid management on the AP;
    c. espouse a philosophy of canid management operating within the context of a three-legged stool (i.e., federal and state governments and stakeholders);
    d. as available, commit funding and staffing resources for field personnel to contribute to the conservation of the red wolf and management of coyotes;
    e. as available, commit funding to conduct research pertinent to canid management on the AP;
    f. establish polices and goals for developing a collaborative genetic archive for AP canids, a data sharing portal accessible by staff in both agencies, and reciprocal sharing of all historical data (including phenotypic and genotypic data and literature) of the red wolf;
    g. establish a foundation for developing and implementing an adaptive approach to canid management on private lands on the AP;
    h. initiate development of a collaborative canid research program;
    i. describe plans to conduct the next five year Red Wolf Program review;
    j. outline options for holding annual workshops with federal and state enforcement staff;
    k. outline plans to hold semi-annual coordination meetings regarding canid management on the AP; and
    l. develop milestones for future development of a management plan for all canids in the AP.

2. The FWS will initiate a review of the current Red Wolf Recovery Plan to determine if the state-of-our-knowledge or field conditions have changed such as to warrant its revision. Review and comments from the WRC will be considered in this evaluation.

3. The WRC, with support and participation of the FWS, will establish a "Canid Forum" (similar to that established for manatees in Florida) to facilitate communication and discussion regarding canid management and citizen science opportunities on the AP.

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Attachment A

Research

1. The FWS and WRC will provide funding and logistical support for research identified by the Red Wolf Recovery Implementation Team, Red Wolf Program staff, other FWS staff, or the WRC that promote the conservation and recovery of the red wolf and other canids on the AP. Studies could include:
    a. tests of the "placeholder theory" on the AP, including behavior of sympatric canids,
    b. determining carrying capacity of canids on the AP,
    c. determining genetic profiles of canid species on the AP,
    d. evaluating predator-prey dynamics,
    e. studies of canid habitat use,
    f. epidemiology of diseases impacting canids on the AP,
    g. development of stochastic simulation models of sympatric canid population dynamics and habitat use, and
    h. canid dispersal dynamics

2. The FWS and WRC will conduct jointly-supported research to determine the attitudes and opinions of N.C. private landowners and other citizens concerning canids on the AP (i.e., human dimensions studies).

Outreach

1. The FWS and WRC will collaborate with other partners to design and implement broad-based outreach and marketing programs with clear goals, objectives, strategies, and measurable outcomes, including development of consistent agency messages and educating the public about canids on the AP.

Regulatory

1. The FWS and WRC will initiate a review and, if needed, subsequent rule-making to clarify concepts or rectify conflicts in current federal or state rules (including the current 10(J) rule).

2. The WRC will review and evaluate statutory requirements for listing red wolves as state threatened in the five AP counties.

3. As data demonstrating a relationship between coyote hunting and red wolf mortality become available, the FWS and WRC will evaluate, and if appropriate implement, adaptive approaches to regulate of take of coyotes that may result in incidental take of red wolves.

4. The WRC will evaluate the status, management, and regulation of Controlled Fox Hunting Preserves.

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5. The WRC will develop BMPs (due care provisions) for coyote hunting, trapping, and live sale.

6. The WRC will compile, compare, and contrast canid hunting and trapping regulations and programs in other states, including, but not limited to, other states with other species of wolves.

Enforcement

1. The FWS and WRC will develop coordination strategies to improve enforcement of federal regulations protecting red wolves.

Attachment 3: Landowner Agreement Form

NC Wildlife Resources Commission
Wildlife Management Division
Wildlife Diversity Program
Landowner Agreement for Scientific Collection

_____ / _____ / _____
MM DD YYYY

Property Type
Private _____ Federal _____ State _____

NC Wildlife Resources Commission
Address: 1701 Mail Service Center, Raleigh, NC 27699-1701
Phone: 919-707-0010

Cooperator's Name: _____
Last First Middle

Cooperator's Address: _____
Street City, State, Zip

Where will the work be performed? _____

give address or directions if different from above _____

Business, Farm, Property Common Name _____

Owner's or Rep Name _____ _____
If different from Cooperator Telephone Number

Owner's Address: _____
If different from Cooperator Street City, State, Zip

WRC Employee & Work Location	Species
	1)
Employee Name	2)
	3)
Duty Area	4)

I, the cooperator or cooperator's representative, have been informed of the methods and the manner in which research devices will be used, and of the possible hazards associated with their use. I understand that NCWRC, (to include its officers, employees and agents) will: exercise reasonable precautions to safeguard all persons to prevent injury to target and non-target animals; guard against the mishandling of control devices and materials; and exercise due caution and proper judgment in all scientific collection operations. I understand that NCWRC may collect Global Positioning System (GPS) coordinates at the project site as part of component or activity tracking or as wildlife disease monitoring or research data. I, the undersigned cooperator, do hereby give my consent and concurrence to NCWRC, its employees, and its agents, to use, upon lands owned, leased, or otherwise controlled by me, and identified by this document, the following methods and devices (an attachment of additional devices and/or methods may be attached):

Statement of agreement: The landowner, cooperator, or representative, as listed above hereby give permission to NCWRC to perform trap and release of the species listed for scientific collection purposes. In consideration of these understandings, I, the cooperator or cooperator's representative, agree to: assume responsibility for injury to my property under my control, when said injury is not the result of negligence on the part of NCWRC (it's officers, employees, and agents); assist in maintaining such warning signs as NCWRC may place for the purpose of notifying persons entering onto such lands of the possible hazards associated with scientific measures in use thereon; and to give adequate warning of these possible hazards to persons I authorize to enter onto such lands. Further, I, the cooperator or cooperator's representative, agree not to concurrently use or allow to be used upon lands covered by this agreement, any canid depredation efforts during the scientific collection time period.

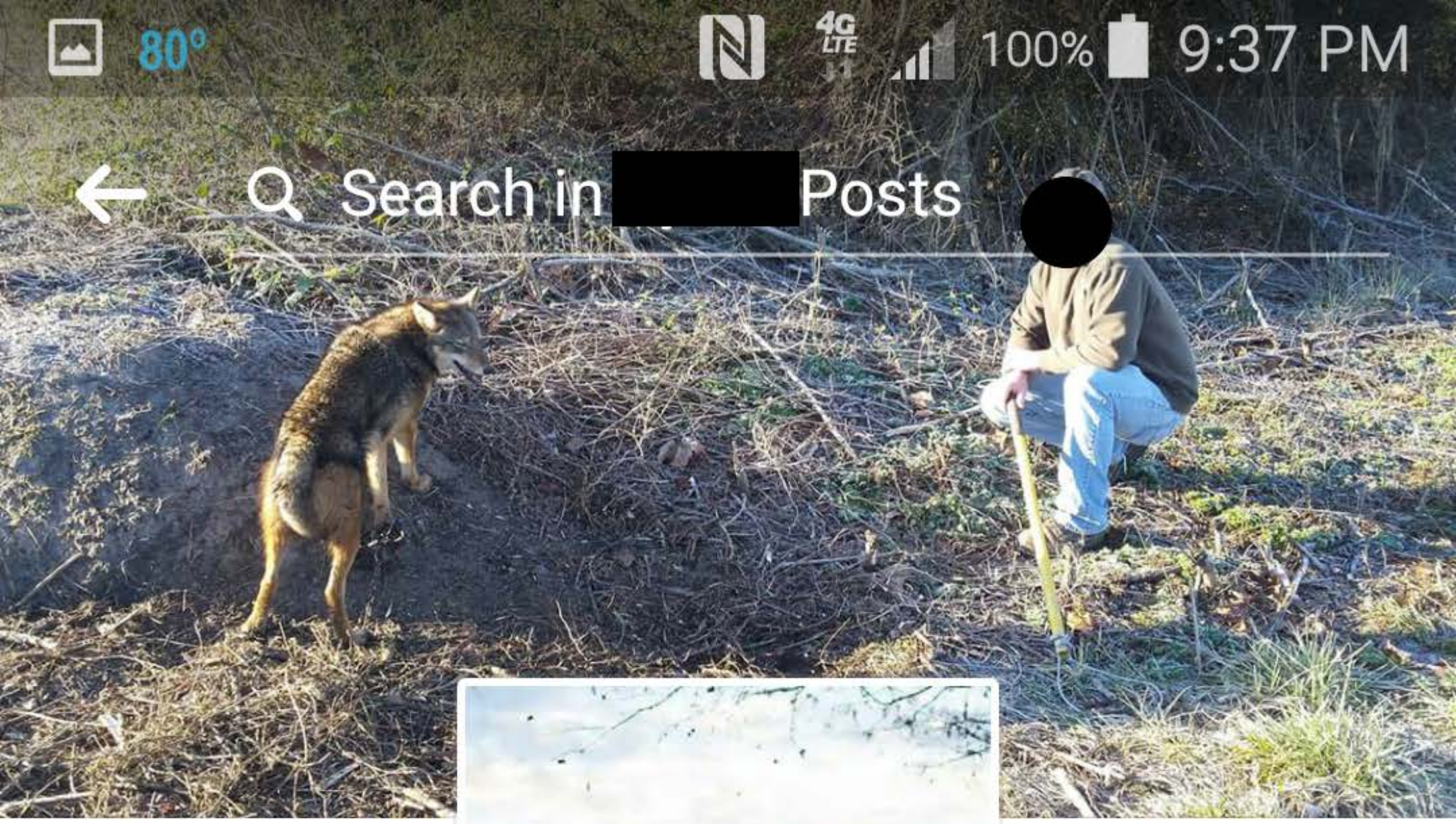
Landowner Signature/Date _____
Signature Date

WRC Employee Signature/Date _____
Signature Date

Attachment 4: Trapper Service Contract

Contract in development.

Draft - Confidential





[redacted]

1 mutual friend: [redacted]

Add Friend

Message

Self-Employed

Lives in **Creswell, North Carolina**

Married

From **Creswell, North Carolina**

ABOUT **PHOTOS** **FRIENDS**


Approximate capture location
Pungo Lake
Google Earth
© 2018 Google
N
2 mi

From the Field: Implementing recovery of the red wolf—integrating research scientists and managers



Michael K. Stoskopf, Karen Beck, Bud B. Fazio, Todd K. Fuller, Eric M. Gese, Brian T. Kelly, Frederick F. Knowlton, Dennis L. Murray, William Waddell, and Lisette Waits

Abstract The United States Fish and Wildlife Service (USFWS) developed guidelines for the composition and role of endangered species recovery implementation teams, but few teams have been established and their success has not been evaluated. Using the recovery program of the red wolf (*Canis rufus*) as a model, we describe the genesis, function, and success of the Red Wolf Recovery Implementation Team (RWRIT) in helping guide the establishment of a viable red wolf population in eastern North Carolina. In operation since 1999, the RWRIT meets bi-annually to review USFWS progress and provide recommendations aimed at maximizing success of species recovery. The team is comprised of 8 research scientists from disciplines including population genetics, canid ecology, population ecology, veterinary medicine, and captive management. Representation from each of these disciplines is deemed necessary for proper evaluation of recovery progress and assessment of future needs. Meeting attendance by the USFWS field management team ensures both proper reporting of past progress and future implementation of management recommendations. Over time, RWRIT members have assumed specific assignments for data analyses, further contributing to the recovery effort. Through the combined efforts of the USFWS field team and the RWRIT, the threat of introgression of coyote (*Canis latrans*) genes into the red wolf population has been substantially curtailed within the recovery area, and red wolf numbers and range have increased. The RWRIT serves as an example of a recovery implementation team that is successfully incorporating the principles of adaptive management and whose template could be adapted to other endangered species.

Key words adaptive management, *Canis rufus*, endangered species, implementation, recovery, red wolf

Recovery of any endangered species is influenced by a range of political, economic, social, as well as biological issues (Tear et al. 1993, Scott et al. 1995, Lundquist et al. 2002). Reconciling disparate concerns and perspectives into a cohesive program requires planning and decision-making processes that consider conflicting interests of various stakeholders. However, for a recovery program to succeed, it is equally critical that professionals tasked with the responsibility for managing endangered species be able to move forward with timely decisions based on practical management needs and scientific knowledge (Westrum 1994). The United States Fish and Wildlife Service (USFWS) red wolf (*Canis rufus*) recovery program is an example of a program faced with complex issues, where man-

agement successes have been strengthened and accelerated by integrating active adaptive management with careful and timely scientific inquiry. This paper describes how this integration is being achieved via a designated "recovery implementation team."

The red wolf is an endangered species that once roamed an extensive range including the southeastern United States, and possibly the entire woodlands of eastern North America (Wilson et al. 2000, Nowak 2002, Grewal et al. 2004). Although listed as endangered in 1967 (USFWS, 1967), population decline and apparent hybridization with coyotes (*Canis latrans*) were recognized in the early 1960s (McCarley 1962, McCarley and Carley 1979). The remaining red wolves were removed from the wild in the mid- to late 1970s with the goals of establishing a captive breeding program and eventually restoring captive-bred animals to portions of their historical range (U.S. Fish and Wildlife Service [USFWS] 1989). In 1987 the first red wolves were released in easternmost North Carolina (Figure 1) with the plan to establish a viable population (Parker 1987). The reintroduction efforts faced a myriad of social, political, and biological issues as the Red Wolf Recovery Plan (USFWS 1989) was implemented (Henry and Lucash 2000, Phillips et al. 2003).

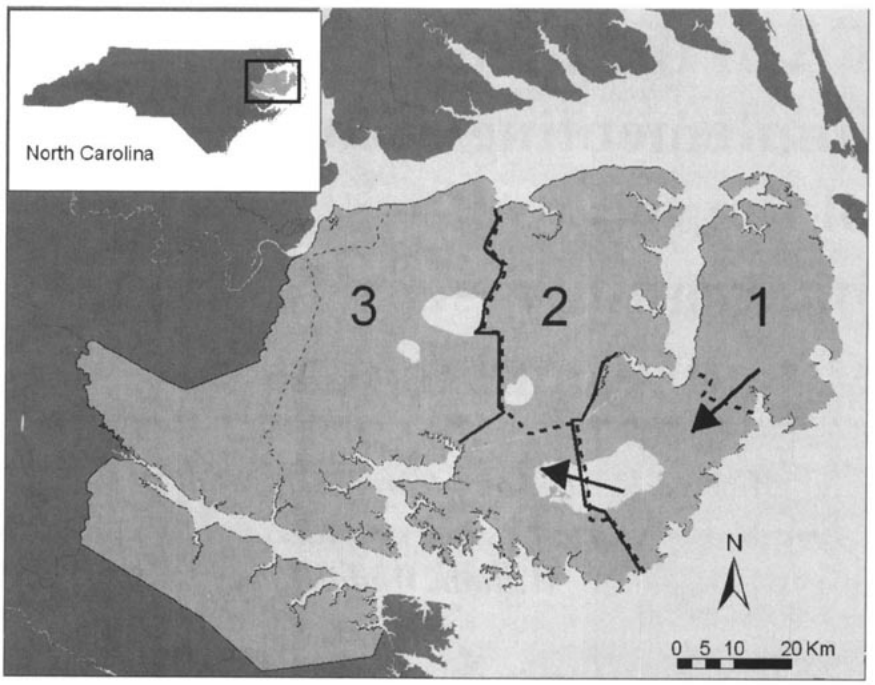


Figure 1. Changes in management zone boundaries within the Red Wolf Recovery Area of eastern North Carolina, as made in accordance with Red Wolf Adaptive Management Plans. The boundaries of the original management Zones 1, 2, and 3 (dashed lines) were first established in April 2000. In March 2002, as red wolf recovery proceeded, boundaries in the southern parts of the zones were moved west (solid lines); part of Zone 2 became Zone 1, while part of Zone 3 became Zone 2 (arrows). In August 2003 some management aspects of canids (i.e., sterilization vs. euthanasia) captured in the eastern half of Zone 3 (thin dotted line) began to follow guidelines applied to Zone 2.

Although the reintroduction area was initially considered uninhabited by coyotes, by the mid-1990s it was apparent coyotes had infiltrated the area and hybridization with red wolves was recurring (Phillips et al. 2003). Due primarily to the renewed hybrid threat and termination of the reintroduction of red wolves into Great Smoky Mountains National Park (Henry 1998), the USFWS decided it needed to re-evaluate its red wolf recovery effort in light of what had been learned over the previous decade. A key step in this review process involved a Population and Habitat Viability Assessment (PHVA) organized by the USFWS in 1999 and facilitated by the Conservation Breeding Specialists Group of the World Conservation Union, Species Survival Commission (IUCN SSC) (Kelly et al. 1999). The diverse assemblage of attendees, representing a variety of expertise and interests, agreed that introgression of coyote genes into the red wolf population was the principal threat to recovery success (Kelly et al. 1999). The group also recognized this issue required urgent attention before hybridization became so pervasive as to virtually ensure the genetic swamping of the only extant free-ranging population of red wolves. However, 2 views of how to address the hybrid threat emerged from the PHVA; one believed research was integral to addressing the problem, and the other expressed concern that research efforts would distract from the primary goal of maintaining the only free-ranging population of red wolves in the world. A consensus agreement was reached on this debate and resulted in an overarch-

ing workshop statement, including:

> "...our primary recovery focus must be protecting and promoting the growth of a self-sustaining, non-hybridizing population of red wolves in the wild and sustaining an active captive component. Actions to be taken will use an adaptive management approach that will not compromise the ability to achieve this goal." (USFWS 1999:52)

This level of agreement among the diverse participants of the PHVA set the stage for designing an adaptive management plan (*cf.* Lancia et al. 1996) that would reduce the threat of wolf-coyote hybridization. This plan (Kelly 2000) diverged from conventional endangered species management because it involved an incremental process tailored to modify field protocols according to past success in eliminating the threat of hybridization. Specifically, it required the release area to be segregated into several defined management zones, each managed to provide an integrated optimization of risk reduction within the resource limitations available to the project (Figure 1). As nonwolf canids were removed from given zones and replaced with red wolves, management options could be adapted by modifying zone boundaries or adjusting specific management protocols.

Adoption of this plan, requiring frequent re-evaluation of data and attendant management adjustments, spawned close interactions between USFWS field biologists and scientists with backgrounds relevant to the work being undertaken. A Red Wolf Recovery Implementation Team (RWRIT) was formed to advise USFWS as they implemented the adaptive management plan; this team was created pursuant to Section 4(f)(2) of the amended Endangered Species Act (ESA), which authorizes the Secretary of the Interior to procure the services of appropriate public and private agencies, institutions, and other qualified persons to help implement endangered species recovery plans. Other USFWS-designated species-specific implementation teams, as opposed to planning teams, have been formed (e.g., black-footed ferret [*Mustela nigripes*], northern right whale [*Eubalaena glacialis*], Okaloosa darter [*Etheostoma okaloosae*], and southern sea otter [*Enhydra lutris*]; USFWS files), but they are rare and no formal description of one's workings or success has yet been documented.

Recovery implementation team composition

Selection of the RWRIT scientists and their leadership was important to the success of implementing and evaluating the adaptive management plan. The PHVA helped the USFWS identify individuals with the combined expertise and personality considered important in a functional RWRIT. The PHVA also provided insight to the breadth of expertise needed over the long term. This expertise included such diverse fields as systematics, genetics, population modeling, health management, and canid biology, behavior, ecology, and management. Social scientists were not required in this case because those issues were, and continue to be, successfully dealt with by the USFWS field management team in conjunction with non-governmental organizations (Henry and Lucash 2000). Direct experience with the red wolf was not a requisite criterion for RWRIT membership. In fact, due to the long and controversial scientific history of the red wolf, some team members were sought for their naiveté of red wolves to minimize preconceived notions regarding the problems the adaptive management plan addressed. Thus, a mixture of experienced and young research scientists with strong records of scientific productivity and interpersonal skills was selected. Each member of the RWRIT had to be willing to use a data-driven approach to decision-making while remaining open to challenges of interpretation. Each member also had to be willing to accept group decisions as well as devote considerable personal time toward solving issues associated with the red wolf program.

The RWRIT needed to be large enough to provide the scientific diversity needed to assess the broad range of critical issues, but small enough to support close working relationships among members and result in productive meetings (Clark and Westrum 1989). A basic philosophy was that if the RWRIT needed expertise from individuals or disciplines outside the RWRIT to address specific issues, guest scientists would be invited to participate in the appropriate meetings. Initially, a goal of 8 members and 4 alternates was considered. Interactions of the group and reliability of participation in early meetings were used to identify the core members of the RWRIT. Since then, the size and composition of the RWRIT (8 members, no alternates) has worked well, sustaining effective decision-making with absences at meetings being rare. The leader of

the RWRIT needed to moderate meetings efficiently while allowing for creative interactions among RWRIT members. To ensure this, a senior scientist at a local university was selected due to his demonstrated scientific and leadership skills.

Experienced and stable field team

The USFWS field team involved in the day-to-day operation and management of the red wolf recovery program was key to the success of the RWRIT. The field team attended all RWRIT meetings as nonvoting members and provided the necessary data and expertise for the meetings to progress effectively. This distinction between the teams initially caused some anxiety, but this subsided once roles had been fully elucidated. The field team is remarkably stable and has worked cohesively on the red wolf project for many years (Phillips et al. 2003). Scientists of the RWRIT recognize the field team as the most experienced red wolf biologists and essential for successful functioning of the RWRIT itself. In turn, the field team's willingness to listen to and implement recommendations made by the RWRIT has been a critical factor in the success of the program. Open communications between the 2 teams keeps RWRIT scientists aware of the implementation of recommendations and fosters respect for the dedication of the field team.

Getting started

The first meeting of the RWRIT was important in establishing the tenor of group interactions and future functioning. Subsequent meetings would focus on examining data related to specific questions within an established agenda, but the first meeting focused on developing operating procedures for decisions as well as the types of data and data formats the team preferred for review and evaluation. This was a step that helped acquaint members of the team and recognize proper working protocols. It also ensured that all members of the team had a common understanding of the Red Wolf Adaptive Management Plan (RWAMP).

The charge of the RWRIT was established a priori by the Team Leader of the Red Wolf Recovery Program (i.e., "Red Wolf Program Leader"). This task was defined specifically as reviewing progress on the RWAMP and recommending changes to the plan based on data provided by the USFWS. As the team gained experience, this charge evolved to include recommendations for data relevant to answering specific questions important to the field team in the day-to-day management of the wild red wolf population. The 2 charges were closely related, frequently blended, seldom distinct, fundamental to the Adaptive Management Paradigm (Walters 1986), and are the responsibilities that drive efforts of RWRIT members. From the beginning, per the ESA, RWRIT recommendations were strictly advisory, with decisions for implementation being at the discretion of the USFWS.

Ground rules established in the first meeting have rarely been adjusted. Some established the mechanics of operations. For example, it was decided a minimum of 6 RWRIT members would be required as a quorum for a functional meeting. Failure to achieve quorum would trigger an evaluation by the RWRIT Leader and the Red Wolf Program Leader to assess whether the RWRIT remained an appropriate mechanism. To date this has not been necessary due to continued strong and enthusiastic attendance.

Other rules provided guidance for RWRIT interactions. To reduce stifling potentially meritorious but perhaps unconventional ideas, the team adopted a basic rule indicating that speakers must present alternative solutions when challenging or negating a proposed idea or approach. Ideas would be withdrawn from consideration only after careful efforts to refine them failed to produce workable solutions. To the fullest extent possible, data would be used to support all positions.

Other procedural mechanisms established in the first meeting have had a beneficial effect on RWRIT operations. For example, tentative dates, times, and location of future meetings are established jointly early in the agenda of each meeting. In addition, the agenda of the next meeting is established near the completion of the current session, which probably produces a more dynamic agenda than a call just before the meeting. Opportunities to add agenda items at any time remain, but the draft of the agenda appears in the final minutes; serving as a reminder for participants as they prepare for the coming meeting.

An important activity reserved for the end of each meeting is an exercise in prioritizing "action items", which are further classified as either "tasks" (expected to be accomplished within the time frame of the meeting or between meetings); "projects" (longer duration activities); or "manuscripts" (the drafting of information for publication).

Individual RWRIT members are recognized as responsible for addressing each item. With many issues to consider and an active agenda, many more action items are identified than can typically be accomplished with the resources available. The action items established throughout the meeting and recognized as "projects" are assembled in a descriptive list and as a final exercise, each member of the RWRIT assigns a priority level to each item and the mean rating is computed. This rating is offered to the Red Wolf Program Leader as a recommendation for activities to pursue or fund. At the first meeting, a pattern was established where RWRIT members worked to identify key management questions and to focus scientific inquiry in areas of need with constant reference to the adaptive management plan. Assets are identified and resource limitations discussed so recommendations have a reasonable likelihood of implementation. Short proposals outlining the objective of projects and the team member(s) involved in the work are distributed to the RWRIT via the team's webpage. The webpage also includes team member contact information, minutes of meetings (see below), data sets, reports, press releases, publications, project descriptions, manuscripts in progress, and upcoming meeting agendas and related materials such as reports and summaries.

Since 2000 the RWRIT has met bi-annually, which is sufficient to respond in a timely manner to questions from the field and to strengthen collegial bonds among members. This schedule also allows sufficient time for the field team to implement recommendations and to document their progress and for RWRIT members to work independently on action items. Other factors affecting meeting schedules include a need to make recommendations ahead of budget deadlines and to accommodate schedules of the individual RWRIT members and the field team. The current pattern of meetings includes 1 meeting in March prior to the denning season and a second in October prior to intensive trapping efforts.

Staying flexible

Any group with dynamic tasks needs a mechanism for adjusting the nature of the group as it matures and as tasks change (Clark and Reading 1994). The concept of alternate members soon was abandoned because of the strong attendance by RWRIT members and because it reduced inefficiencies associated with updating new attendees. The ability to invite experts in areas not represented on the RWRIT provides a mechanism to maintain flexibility and adaptability. Periodic review of expertise needed for specific tasks and projects of the RWRIT keeps the issue of change before the team. In addition, there exists ample opportunity to discuss candidly both the pros and cons of the teams' efforts, either formally at the end of each meeting or informally during meals or after hours. The RWRIT Leader needs to recognize dissenting views and address contentious issues promptly and effectively. The fact that for most meetings the entire RWRIT was communally housed in rented accommodations further ensured the establishment of favorable personal relationships benefiting RWRIT interactions and discussion.

Complete minutes of RWRIT deliberations provide documentation of the team's discussions and recommendations. An iterative process of editing minutes is used by the RWRIT, ensuring important information developed at each meeting is recorded accurately and in language deemed appropriate by the participants. Notes are converted into a draft each evening and individualized, and printed copies are distributed to attendees the following morning for editing. All drafts are synthesized into the penultimate draft for further comment, which is followed by a final draft distributed electronically shortly after completion of the meeting. The RWRIT members have a week to return any corrections, after which the final minutes are completed and distributed electronically. The deliberations of the RWRIT are considered privileged communication, and all meeting participants are asked to limit discussions of information received at the meetings to individuals within their respective research groups. This policy allows RWRIT members access to sensitive and preliminary data and provides more freedom of discussion without concerns about inappropriate disclosure. Distribution of the minutes beyond the RWRIT is at the discretion of the Red Wolf Program Leader.

How well does it work?

The test of any system is how well it functions to meet the goals and objectives of the program it serves. In the 4 years since the first formal meeting of the RWRIT, key challenges to implementing the plan developed at the PHVA have been identified and strategies have been devised to provide practi-

cal solutions and evaluate success of recovery efforts. Perhaps more importantly, all RWRIT members and the entire red wolf field team have become close colleagues who look forward to each meeting. We enjoy the frank and open exchange of ideas, the ability to quickly address both practical and theoretical problems and make changes in management practices, and the successes in the field that result from the collaboration. The details of these changes and successes are the basis of several scientific papers, some already published or in press and others currently in preparation, but a brief summary is warranted.

Prior to 1998 all canids captured in the red wolf recovery area were assumed to be wolves unless they were so small as to be considered coyotes, if they were black, or if they looked part dog. If there was some indication that a single female wolf was consorting with a coyote or dog, pups she produced were removed (A. Beyer, USFWS, personal communication). Thus, the basic challenge of rapidly and confidently identifying animals as red wolves versus hybrids or coyotes, especially young animals, was identified early as a key concern of the PHVA and the field team. The RWRIT served as catalyst for developing an enhanced and improved genomic testing protocol by expanding the ability to assess alleles at 19 loci (Miller et al. 2003). A priority placed on obtaining genomic assessments of the entire group of founders in the captive breeding program, as well for coyotes in the vicinity of the wolf release zones, greatly improved the confidence in the genomic data now available. Genetic analyses were integrated with pedigree and morphometric data to develop decision trees for all captured animals (Table 1). Extension of the DNA analysis capabilities to fecal samples increased the potential for assessing presence of red wolves, as well as undesired non-red wolves, in the field samples without the need of capturing and handling animals (Adams et al. 2003). Additional research efforts were directed at using this technology for assessing red wolf population size (J. R. Adams and L. P. Waits, University of Idaho, unpublished data).

To evaluate progress of the adaptive management plan, RWRIT scientists wanted detailed and current descriptions of animal locations, their genotypes, and canid inventory efforts in relation to geographic areas. A coordinated Geographic Information System (GIS) database system is now used at all RWRIT meetings to examine recovery progress. This is steadily approaching the goal of a real-time data view as data entry and validation challenges are addressed and data summaries are refined. These tools help identify areas where data are insufficient to define the status of canids and help develop strategies to eliminate so-called "areas of ignorance" by concentrating efforts in areas needing more attention. In addition, they have lead to improved ground telemetry efforts and more efficient use of resources and personnel.

Modeling effects of coyote genomic intrusion, using more refined data sets and newer models than available at the PHVA, provided RWRIT scien-

Table 1. Decision path for genetic results of red wolves (RW) captured in the experimental population area in northeastern North Carolina, applied in fall of 2003 (explanation of genetic result classifications given in Miller et al. 2003). Decision parameters listed in the following priority: Genetic testing; Pedigree; Morphology; Mate.

	Capture location[a]	
Decision parameter	Zone 1	Zone 2
1. Genetic test: 100% RW (pedigree 100% RW)	Release	Release
1. Genetic test: 100% RW but cannot exclude 75% RW hypothesis	Consider pedigree (go to 2)	
2. Pedigree is 100% to 87.5% RW	Release	Release
2. Pedigree is 87% to 75% RW or unknown	Consider morphology (go to 3)	
3. Morphologically "hybrid-like"	Euthanize	Sterilize
3. Morphologically "RW-like"	Consider mate (go to 4)	
4. Mate is ≥75% RW	Release	Release
4. Mate is <75% RW or uncertain	Euthanize	Sterilize 1 mate
1. Genetic Test: 75% RW or 75% RW but cannot exclude 50% RW hypothesis	Consider pedigree (go to 5)	
5. Pedigree is <75% RW	Euthanize	Sterilize
5. Pedigree is ≥75% RW or unknown	Consider morphology (go to 3)	

[a] See Figure 1.

tists new insights into impacts of genomic intrusion (e.g., Miller et al. 2003). This allowed for key insights to establishing acceptable risks defined in the decision trees. This also assisted in the making of informed recommendations for modifying approaches to the various management zones for red wolf recovery. Recently, the RWRIT initiated an effort to conduct detailed analyses of home range, spatial interactions, habitat use, and demographic attributes of all radiomonitored red wolves since 1986, with the objective of developing a population viability model to help guide future management and recovery actions. Den management techniques via implementation of early genomic sampling and use of cross-fostering of wild-caught and captive bred pups into wild litters have been developed (cf. Kitchen and Knowlton, *in press).* Methodology also has been enhanced to conduct surgical procedures to support the use of hormonally intact but sterile hybrids and coyotes to serve as sterile buffers (i.e., temporary territory placeholders that discourage establishment of new, intact nonwolves) in peripheral management zones (Figure 1).

The net result of such activities has led to an increase in the area occupied by red wolves, total number of red wolves, and number of red wolf social units, as well as a major decrease in the total area where the status of canids, in general, is unknown (B. B. Fazio, USFWS, unpublished data). Such changes in these metrics were identified in the RWAMP as key indicators of the successful management of wolf-coyote hybridization. Importantly, coyotes or hybrids have essentially been eliminated from fully half of the red wolf recovery area. To date, genetic intrusion into the red wolf population has been largely controlled, albeit through aggressive intervention.

The effective functioning of the RWRIT has ensured that issues identified at the PHVA as described in the RWAMP have been, or are being, successfully addressed by USFWS. And as should be expected, the original red wolf adaptive management plan is now revised to include 5 years of evolving adaptive management (Fazio et al. 2004). The approach taken by the RWRIT represents a good example of successful application of the Adaptive Resource Management paradigm and is likewise consistent with, and respectful of, concerns raised by the participants at the PHVA that the primary goal of conserving the only free-ranging population of red wolves not be overshadowed by the desire to conduct research. Indeed, the USFWS recently highlighted the efforts of the Red Wolf Recovery Program in a videotape on how the use of sound science is key to meeting its mission.

We believe the recent tangible success in red wolf recovery is a direct result of conducting the PHVA, crafting a RWAMP, establishing the RWRIT, and the cooperation and close interaction between the RWRIT and the USFWS field team directly tasked with red wolf recovery. Endangered species recovery should involve a strong linkage between scientific investigation under the rubric of adaptive management and the appropriate blend of social, political, and economic issues (Clark et al. 1994). In light of the mixed past success in recovering endangered species in the United States (Crouse et al. 2002, Gerber and Hatch 2002), we believe, based on the success of the RWRIT, that recovery implementation teams can serve as an effective vehicle for helping guide recovery programs and actions.

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The collaborators on this paper have a variety of academic degrees, work experiences, and publications in a wide selection of fields and disciplines and have studied species from A to Z. They include (seated, from left to right) ***Karen Beck*** (ecological epidemiologist), ***Buddy Fazio*** (fiscal conservationist), ***Todd Fuller*** (quasi-experimental theoriologist), ***Eric Gese*** (investigative carnivologist), and ***Brian Kelly*** (politico-ecologist), and (standing, left to right) ***Fred Knowlton*** (historical canidilist), ***Dennis Murray*** (taxon-free numero-ecologist), ***Michael Stoskopf*** (conservation metabonomist), ***Will Waddell*** (ex-situ zoologist), and ***Lisette Waits*** (pan-molecular faecologist).

CHARTER

For the

Albemarle Peninsula Collaborative Canid Conservation Team

I. Mission

The mission of the Albemarle Peninsula Collaborative Canid Conservation Team (APCCC) is to *promote science based conservation and management of all wild canids, including the red wolf, on the Albemarle Peninsula while considering ecological variables and striving to meet social expectations.*

II. Executive Committee

The work of the APCCC will be overseen by an Executive Committee comprised of the North Carolina Wildlife Resources Commission (NCWRC) Executive Director and the U.S. Fish and Wildlife Service (USFWS) Assistant Southeast Regional Director for Ecological Services. The Executive Committee's responsibility is to ensure that the APCCC is meeting the expectations identified in the November 20, 2013, memorandum establishing the APCCC (Exhibit A). The Executive Committee appoints members to the Steering Committee and approves Steering Committee work products.

III. Steering Committee

Activities of the APCCC will be guided by the Steering Committee. The primary responsibility of the Steering Committee will be to provide the necessary resources and guidance to accomplish the APCCC Mission. The Steering Committee will establish, as needed, sub-committees of the Steering Committee and/or Working Groups comprised of members of the Steering Committee and other stakeholders, charged with developing various products that will comprise a comprehensive conservation strategy for Albemarle Peninsula canids. Members of the Steering Committee will serve as a managing body for the Working Groups, resolve impasses in consensus within the Working Groups, and approve all final Working Group and sub-committee plans and products.

IV. Membership

Members of the Steering Committee include:

- Dr. David Cobb, Wildlife Chief, NCWRC;
- Dr. Maria Palamar, Wildlife Veterinarian, NCWRC;
- Brandon Sherrill, Mammalogist, NCWRC;
- Dr. David Rabon, Red Wolf Program Coordinator, USFWS;
- Art Beyer, Red Wolf Field Coordinator, USFWS;
- Pete Benjamin, Raleigh Ecological Services Field Office Supervisor, USFWS.

V. Responsibilities of Members

A. Attendance. Members of the Steering Committee agree to attend all meetings.

B. Preparation for Meetings. Members of the Steering Committee agree to read appropriate material and arrive prepared to work.

C. Representation. Members represent their individual organization's positions to the Steering Committee. Members also represent the Steering Committee's position to their associated organizations.

D. Members agree to support the mission of the APCCC.

VI. Decision Process and Internal Organization

Use of Consensus: The Steering Committee will operate by consensus. Steering Committee decisions will be made only with concurrence of all members represented at the meeting. No member can be outvoted.

Failure to Reach Consensus: If the Steering Committee fails to reach consensus on an issue, the issue will be presented to the Executive Committee for resolution. This will occur only after the Steering Committee members have agreed that consensus cannot be reached (i.e., there is consensus on the lack of consensus).

Officers: A Chair shall be selected annually from the members of the Steering Committee at the first meeting of each calendar year. Members will serve as Chair for a one-year term. A Vice Chair shall also be selected annually to function in the absence of the Chair. When the Chair's term ends, the Vice Chair will become the new Chair and a new Vice-Chair will be selected.

Subcommittees: The Steering Committee may establish subcommittees to address specific issues as needed. Subcommittees may consult individuals with technical skills and information pertinent to the issue at hand. Subcommittees are not authorized to make decisions for the Steering Committee unless the Steering Committee explicitly grants such authorization. Subcommittee findings will be forwarded to the Steering Committee Chair.

Working Groups: The Steering Committee may establish Working Groups comprised of APCCC members and non-member stakeholders to address specific issues, as needed. Working Groups are not authorized to make decisions for the Steering Committee. Working Group findings will be forwarded to the Steering Committee Chair.

Agendas: Prior to each scheduled meeting, a draft meeting agenda will be developed by the Steering Committee Chair for distribution to committee members for review and approval.

Meeting Summaries: The Steering Committee Chair will distribute a draft meeting summary to all Steering Committee members for review prior to the next regular meeting. The summary will include attendance record, a summary of actions taken at the meeting, and other information pertaining to the deliberations.

Schedule: The Steering Committee will meet as needed or at least quarterly each year.

VII. Rules of Order:

A. Ground rules: Members of the Steering Committee (and all Subcommittees) agree to participate constructively in all meetings. Ground rules for constructive interaction include:

1. Treat all members with courtesy and respect.
2. Speak one at a time.
3. Listen carefully.
4. Be clear and concise in your comments.
5. Stick to the agenda; avoid off-target discussions.
6. Be prepared to take part; be an active participant.
7. Be candid; it's ok to disagree.
8. Ask relevant questions.
9. Focus on the problem, not finding fault.
10. Separate interests from positions.
11. Don't bring hidden agendas.
12. Meetings adjourn on schedule or can be extended in duration by consensus.

These ground rules may be amended at any meeting. These ground rules will be provided to all subcommittees.

B. Enforcement of Ground Rules: Ground rules will be monitored and enforced by Steering Committee members and/or the Chair.

VII: Responsibilities of the Chair

The primary task of the Chair is to guide the meetings of the Steering Committee, Sub-committees, and Working Groups within the framework of the charter. These responsibilities may include managing the meeting agenda, encouraging participation, helping the Steering Committee stay on task, and helping the Steering Committee reach consensus.

VIII. Changes to the Organizational Protocol

Changes to this charter can be made at any scheduled meeting of the Steering Committee through a consensus procedure.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
1875 Century Boulevard
Atlanta, Georgia 30345

JUN 19 2014

In Reply Refer To:
FWS/R4/ES

Mr. Gordon Myers
Executive Director
Wildlife Resources Commission
1701 Mail Service Center
Raleigh, North Carolina 27699-1701

Dear Mr. Myers:

Thank you for your June 2, 2014, letter responding to the U.S. Fish and Wildlife Service's (Service) request for renewal of a permit from the North Carolina Wildlife Resources Commission (Commission) to trap, sterilize, and release coyotes in the five-county red wolf recovery area on North Carolina's Albemarle Peninsula. At the same time, you expressed concerns about our current management strategies and requested a program evaluation to determine whether the red wolf non-essential, experimental population (NEP) should be continued in eastern North Carolina.

The red wolf became one of the earliest federally protected species with its listing as endangered under the Endangered Species Act (ESA) on March 11, 1967. The initial phase of recovery for the red wolf involved capturing all remaining wild red wolves in Southeastern Texas and the establishment of a captive population. This action became a landmark effort in conservation and has saved this wolf from the brink of extinction. The red wolf breeding program evolved into one of the most successful captive-breeding efforts in the United States and now includes close to 200 red wolves located at 43 facilities, of which greater than 90% are independently funded conservation programs.

In 1986, the Service moved ahead with the establishment of the NEP on federal lands at Alligator River National Wildlife Refuge and Dare County Bombing Range. Efforts to establish a red wolf NEP succeeded to the point where in 1995 the Service expanded the NEP to include Pocosin Lakes National Wildlife Refuge. At this stage of the Red Wolf Recovery Program, the Service had over 310,000 acres of federal lands able to support a maximum population of approximately 45 to 55 animals of all age classes. The established recovery goal calls for a total of 220 red wolves in three separate self-sustaining populations. The NEP in eastern North Carolina is just one. A second attempt to establish a red wolf NEP was started in western North Carolina in 1991. This project ended in 1998. The locations for the other two populations have not been identified.

The Service met its population goal for the Albemarle Peninsula in the late 1990s. This significant accomplishment was a first-of-its-kind for a canid species protected under the ESA. The Service continued to manage the red wolf population to a point where it expanded on federally managed and private lands and currently is estimated to be between 90 and 110 red wolves in the NEP's five-county area. Even with this accomplishment, the red wolf in the NEP continues to face challenges, including hybridization and gunshot mortality.

Hybridization with coyotes was identified as a significant threat to the species when the Service decided to remove it from the wild in the 1970s. Now, with the expansion of coyotes across North Carolina and into formerly unoccupied habitats in the Albemarle Peninsula, hybridization must be addressed. Since 1999, the Service has trapped, sterilized and released coyotes as a tool to manage hybridization. Under our November 2013 joint memorandum, our two agencies agreed to evaluate the placeholder theory as the underlying principle for canid management in the Albemarle Peninsula. However, we acknowledge that our renewed permit to trap coyotes in the five-county area will no longer allow for sterilization and release of trapped coyotes but rather require that they be humanely euthanized. We will fully comply with your permit requirements regarding coyote trapping.

The Service fully supports appropriate management tools for canids, including hunting. We have concerns about night hunting as stated in our April 16, 2012 letter and also have concerns about the increase in red wolf gunshot mortality since 2004 in the five-county recovery area. We welcome continued conversations on the November 2013 joint memorandum which is designed, in part, to balance coyote control and red wolf recovery, as well as manage non-natural mortality (e.g., vehicular strikes).

We support protecting private landowners, who through mistaken identity and without intent to take a red wolf, from prosecution under Section 9 of the ESA. The Service clarified this position in the Federal Register in April 1995, specifically finding that it is appropriate to modify the language of the special red wolf rule by limiting the Section 9 prohibition on private lands only to intentional and willful taking of red wolves.

Lastly, the Service agrees it is time to conduct a program evaluation of the red wolf recovery efforts in the Albemarle Peninsula of eastern North Carolina. We are committed to perform this evaluation together with the state as was outlined in our November 2013 agreement. In fact, we have already begun that process. This evaluation will consider the program's history and its results as well as the perspectives of all stakeholder groups including private landowners, local, state and federal agencies, and conservation partners. We also want to ensure that the evaluation addresses your concerns regarding habitat management on federal lands and the Service's implementation of legislated provisions to protect the interests of private landowners. The Service will conduct this evaluation in close coordination with the Commission. We expect to develop a scope of work for this evaluation by the end of June. To that end, I have asked Leopoldo Miranda, Assistant Regional Director of Ecological Services, to coordinate with you on the scope and logistics of this program evaluation.

The Service remains committed to continuing the collaborative approach to canid management on the Albemarle Peninsula espoused in the memorandum we jointly signed in November 2013. That agreement builds on a strong collaboration over the past five years by setting commitments to re-evaluate science, identify research needs, and establish a broad partnership. While these issues are complex, we believe our collective commitment to this strong partnership will serve us well as we identify solutions that meet our mutual conservation objectives moving forward.

Again, thank you for your work on these issues. We will be following up with you in the days ahead. In the meantime, please let me know if you have any questions or need additional information.

Sincerely yours,

Cynthia K. Dohner
Regional Director

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Factors influencing red wolf–coyote hybridization in eastern North Carolina, USA

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ABSTRACT

Understanding the mechanisms that govern interspecific hybridization is vital to mitigating its impacts on endangered species. Research suggests that behavioral mechanisms such as mate choice and social disruption can regulate the rate at which hybridizing species interbreed. We investigated hybridization events between endangered red wolves (*Canis rufus*) and coyotes (*Canis latrans*) in eastern North Carolina to evaluate potential factors that may promote hybridization between these species. Specifically, we examined spatial location, breeding experience, breeder origin (captive vs wild), breeder ancestry (pure vs hybrid), and past history of the animal. There were over four times (126 vs 30) as many red wolf litters as hybrid litters over a 13 year time period. Over half of the hybridization events followed the disruption of a stable breeding pair of red wolves due to mortality of one or both breeders. Of these 69% were due to anthropogenic causes, primarily gunshot mortality prior to the red wolf breeding season. Both male and female red wolves interbred with coyotes, although a majority (90%) of the events we observed involved females. Wolves that produced hybrid litters tended to be young, first-time breeders with slightly higher levels of coyote ancestry. Only 16% of the hybrid litters were produced in the inner core of the red wolf recovery area. Our results suggest that disruption of stable breeding pairs of red wolves facilitates hybridization, jeopardizing future recovery of the red wolf. They also indicate the importance of behavioral forces, especially social stability, in regulating hybridization.

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1. Introduction

Human activity has the potential to disrupt dynamics between hybridizing species, which can cause hybridization and introgression to emerge as conservation threats (Rhymer and Simberloff, 1996; Allendorf et al., 2001). As with any conservation problem, developing solutions requires recognizing the mechanisms that influence the process. For hybridization, that requires understanding the mechanisms that cause previously reproductively isolated species to interbreed. Species introductions (Rhymer and Simberloff, 1996; Stigall, 2010), habitat destruction and ecological homogenization (Seehausen et al., 2008; Crispo et al., 2011), and the spread of domesticated species (Likre et al., 2010; Champagnon et al., 2012) have been implicated as processes that may facilitate these shifts.

Still, these forces primarily influence whether hybridizing species come into contact, not necessarily whether individuals will interbreed. There is increasing recognition that behavioral processes such as mate choice (Pfennig, 2007; Reyer, 2008; Svedin et al., 2008; Gilman and Behm, 2011; Robbins et al., 2014), interspecific competition (Wolf et al., 2001; Krosby and Rohwer, 2010; Sacks et al., 2011), and Allee effects (Lode et al., 2005) can influence the rate of hybridization. The potential for behavioral forces to moderate hybridization and introgression may be a critical factor that would influence conservation schemes.

Understanding the mechanisms that govern interspecific mating is vital to recovery of species threatened by hybridization, especially the critically endangered red wolf (*Canis rufus*) in eastern North Carolina. Historically red wolves were distributed across eastern North America, but overharvest, habitat destruction, and hybridization with coyotes (*Canis latrans*) led to extinction in the wild by 1980 (Paradiso and Nowak, 1972; Nowak, 2002; USFWS, 1990). Beginning in 1987, captive red wolves were reintroduced into eastern North Carolina and today a population of about 80–100 individuals occupies the 600 000 hectare Albemarle Peninsula (Phillips and Parker, 1988; Phillips et al., 2003; Bartel and Rabon, 2013).

At the same time, coyotes expanded their range into North Carolina (Hill et al., 1987) and in 1993 the first hybridization event between a reintroduced red wolf and a coyote was detected (Phillips et al., 2003). A subsequent population viability analysis

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suggested that hybridization was the greatest threat to red wolf recovery (Kelly et al., 1999). This led to the development of an aggressive adaptive management plan by the US Fish and Wildlife Service (USFWS) and the Red Wolf Recovery Implementation Team (RWRIT, Stoskopf et al., 2005) to limit hybridization and introgression. The genetic composition of the population is managed by an active monitoring program combined with genetic testing to remove hybrid individuals from the landscape (Stoskopf et al., 2005; USFWS, 2007; Bartel and Rabon, 2013).

Such aggressive practices have been implemented based on the hypothesis that a small red wolf population would be genetically swamped by coyotes without human intervention (Kelly et al., 1999). This is predicated on the assumption that when sympatric, red wolves and coyotes will breed indiscriminately. However, this assumption has not been tested empirically. Fredrickson and Hedrick (2006) modeled red wolf viability and found that positive assortative mating and aggressive interactions between the species were the most important factors in maintaining population viability. They developed hypothetical values for those parameters because empirical estimates did not exist. USFWS field biologists have observed red wolves displacing and occasionally killing coyotes and hybrids (USFWS, 2007). Otherwise, there is little understanding of how mate choice and social structure influence interactions between these species. Given the importance of social dynamics on the ecology of mammalian carnivores, there is potential for behavioral processes such as mate choice, social structure, and competition to limit hybridization (Rutledge et al., 2010; Sacks et al., 2011; Shurtliff, 2011). Conversely, disrupting these social systems may in turn influence reproductive patterns (Brainerd et al., 2008; Borg et al., in press) and hybridization rates (Rutledge et al., 2010).

We examined breeding records and individual histories of red wolves involved in hybridization events from 2001 to 2013 to elucidate factors that facilitate interbreeding between these species. Specifically, we asked the following questions: (1) Do age, prior breeding experience, and origin of the wolf influence the likelihood of hybridization, (2) are individuals with mixed red wolf/coyote ancestry more likely to hybridize, (3) are hybridization events evenly distributed across the recovery area, and (4) are hybrid litters produced under particular scenarios or breeder histories? If breeding between these species is indiscriminate, we would expect young dispersing red wolves to be the most likely individuals to encounter and breed with a coyote. Breeding opportunities within wolf packs are often restricted to a dominant breeding pair, which forces individuals in search of mates to disperse outside the pack (Mech and Boitani, 2003; Sparkman et al., 2012). In this system dispersing would increase the likelihood of an individual encountering a coyote considering that wolf packs are known to exclude coyotes within their range (USFWS, 2007). This is similar to observations of eastern wolf (*Canis lycaon*) packs in southern Canada (Benson and Patterson, 2013). We predicted that hybridization would increase from east to west, since the western portion of the study area has the fewest wolves, least stringent management, and closest proximity to the mainland coyote population. Also, we hypothesized that individuals with mixed red wolf/coyote ancestry would be involved in more hybridization events. By examining the characteristics and history of red wolves responsible for hybridization events with coyotes, we can better understand the mechanisms that govern hybridization, aiding recovery of this species.

2. Materials and methods

2.1. Genetic monitoring

Every spring USFWS biologists track female red wolves to locate active dens that contain pups. Blood samples are collected from pups and genetic testing is conducted to assess their ancestry and place them within the red wolf pedigree (Adams, 2006; Bohling et al., 2013). Since the implementation of the adaptive management plan in 2000 monitoring of red wolf dens and genetic testing of captured canids, including pups, became standard, which improved detectability of hybridization events (Stoskopf et al., 2005; USFWS, 2007). As a result, we only considered hybridization events that have occurred since 2000 for this study. USFWS biologists possessed permits for capturing and handling red wolves that have been jointly issued by the USFWS, Association of Zoos and Aquariums Reintroduction Scientific Advisory Group, and IUCN Species Survival Commission Reintroduction Specialist Group.

Parentage for red wolf and hybrid litters was determined following the methods of Adams (2006) and Bohling et al. (2013). To summarize, each pup was genotyped at 17 microsatellite loci and assigned to red wolf parents using genetic and field data, allowing for $\leqslant 1$ mismatch for a parent pair. Based on this pedigree we were able to estimate an individual's ancestry by averaging the amount of red wolf ancestry possessed by the parents as traced through the pedigree. In the case of hybrid litters, typically only the red wolf parent was identified, although in several situations the non-red wolf parent was later captured and determined to be a parent using genetic analysis. Several hybrid litters were detected when hybrid offspring were captured as juveniles and later assigned to a red wolf parent. Three hybrid litters fit this scenario; thus, the exact size of those litters could not be determined.

2.2. Location

The adaptive management plan divided the peninsula into three zones with different management goals (Stoskopf et al., 2005) (Fig. 1). Zone 1, the easternmost portion of the peninsula, serves as the core red wolf population and coyotes and hybrids captured in this area are euthanized. In Zone 2, directly west of Zone 1, hybrid individuals are euthanized but coyotes are sterilized under the hypothesis that sterile individuals would serve as territorial placeholders that discourage undetected coyotes from dispersing into the peninsula (Bartel and Rabon, 2013). Zone 3 is the furthest west section and falls at the junction of the peninsula and the mainland. Management practices in Zone 3 vary, but many sections of this area are managed similarly to Zone 2. This entire region has been designated as the Red Wolf Experimental Population Area (RWEPA).

We classified each hybrid and red wolf litter to a Zone based upon where it was detected (Zone 1, 2, or 3) and used a χ^2-squared test of independence to evaluate the distribution of each type of litter across all three zones. As noted, some hybrids were discovered as adults. In these situations, once the red wolf parent was identified via genetic testing we assigned the location of these litters according to the home range of that red wolf during the prior breeding season.

2.3. Breeder experience

To examine the impact of breeder experience on hybridization we compared both the age and prior breeding experience of red wolves that produced hybrid and red wolf litters. For breeding experience we classified each litter according to whether it was produced by a first-time breeder or an experienced breeder. This was only performed for females since the sample size of male red wolves was low (see Section 3.1). We defined first-time breeder as any individual producing its first known litter of pups, regardless of whether it was a hybrid or red wolf litter. An individual was considered an experienced breeder once it had produced a second litter. We compared the proportion of total red wolf and hybrid litters that were born to experienced breeders using a χ^2

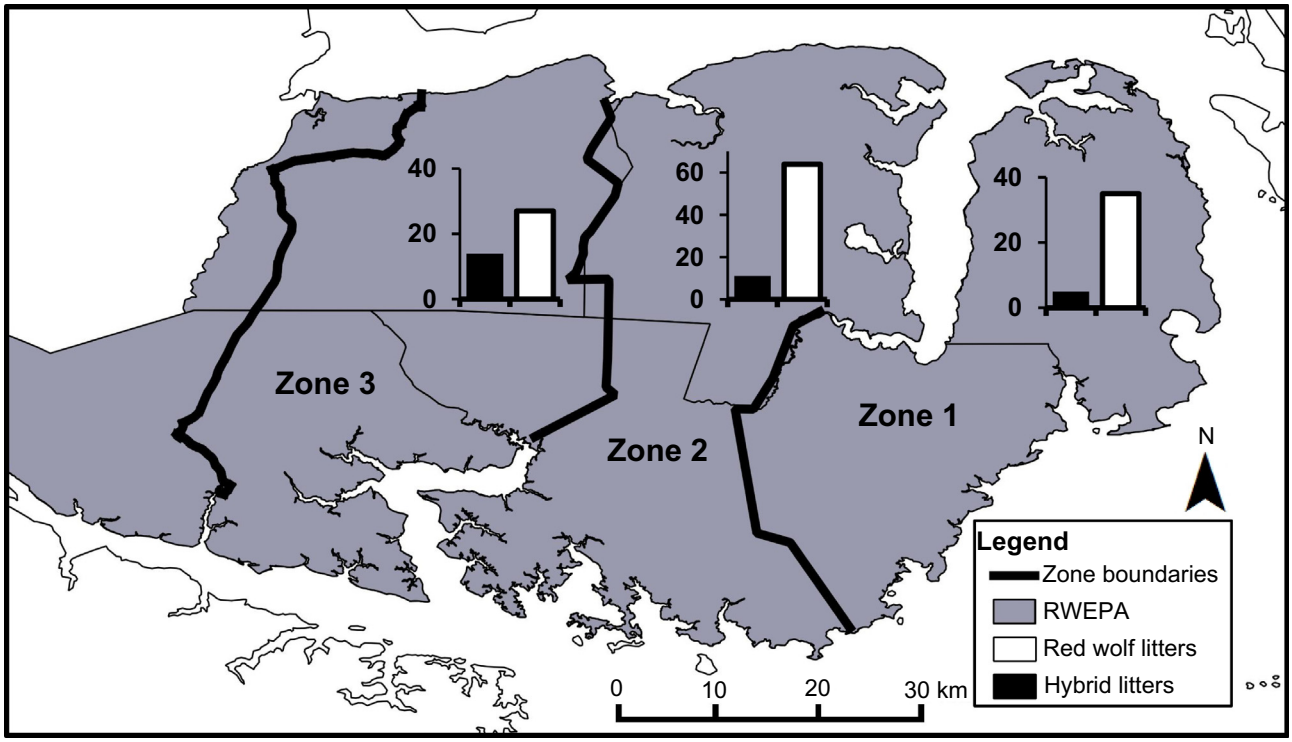


Fig. 1. Map of the Red Wolf Experimental Population Area (RWEPA) and the spatial distribution of hybrid and red wolf litters from 2001 to 2013. The thick black lines indicate the boundaries of the management zones 1, 2, and 3. The number of hybrid and red wolf litters per zone indicated by the graphs within each zone boundary. White columns represent red wolf litters, black hybrid litters.

test of independence. The effect of breeder age was measured by comparing the overall age of individuals responsible for hybridization events to the age of individuals producing red wolf litters. For three females the year of birth was unknown (Table 1).

2.4. Breeder origin

Over the past two decades the USFWS has released captive individuals and individuals raised in island-propagation programs to augment the wolf population. The island-propagation program consists of releasing captive red wolves to isolated, unoccupied barrier islands in the southeastern US so they can acclimate to the wild (Phillips et al., 2003). We hypothesized that the unfamiliarity of captive and island-raised individuals with the RWEPA would inhibit their ability to locate red wolf mates, increasing the likelihood that they would encounter and breed with a coyote. Using the pedigree we were able to determine the origin of each red wolf (wild, captive, and island-born) and whether it produced any litters. We also noted wolves produced through cross-fostering, which involves integrating recently born captive pups into wild litters to provide an input of genetic diversity (Bartel and Rabon, 2013).

2.5. Breeder ancestry

The hybridization event that occurred in 1993 between a female red wolf and male coyote resulted in introgression of coyote genetic material into the red wolf population. Two F1 hybrid males from this event bred with female red wolves and their offspring backcrossed with the red wolf population. The USFWS and RWRIT decided that any individual possessing >87.5% red wolf ancestry based on pedigree assignment would remain in the population (Stoskopf et al., 2005). A large segment of population now consists of these backcrossed individuals that have a slight amount of known coyote ancestry (87.5–98% red wolf) (Adams, 2006; Bohling et al., 2013). Our goal was to determine whether these admixed individuals had a higher propensity to hybridize than 'pure' wolves. We calculated the average ancestry of individuals involved in hybridization events using the pedigree and compared that to the ancestry of individuals producing red wolf litters using a two-tailed *t*-test. We applied an arcsin transformation to ancestry values prior to analysis.

Even though red wolves and coyotes hybridize, there are noticeable differences in morphology, behavior, and ecology between the species (Phillips and Henry, 1992; Nowak, 2002; Phillips et al., 2003; Hinton and Chamberlain, 2014). Hybrids are intermediate between the two species; thus, we predicted that a red wolf would be more likely to select a hybrid as a mate than a coyote. However, since aggressive management practices remove hybrids from the landscape, we hypothesized that the production of hybrid litters would be primarily driven by interbreeding with coyotes. Since the non-red wolf parent was identified for several hybrid litters, we evaluated the ancestry of these animals using two methods to determine if they were coyotes or individuals of mixed ancestry. First, ancestry of non-red wolf individuals was assessed using the Bayesian clustering program STRUCTURE 2.3 (Pritchard et al., 2000; Falush et al., 2003). We used four known genetic groups as training sets: coyotes ($N = 94$) from North Carolina, Virginia, and Texas; gray wolves ($N = 38$) (*Canis lupus*) from Idaho and Alaska; domestic dogs ($N = 28$); and founders of the captive red wolf population ($N = 17$). Our previous work (Bohling and Waits, 2011; Bohling et al., 2013) showed that these four groups form distinct clusters when applied to STRUCTURE in a free-clustering framework. In the STRUCTURE analysis, individuals from our four known genetic groups were assigned a POPFLAG designation of 1 and the 'Use Population Information' option was used as the ancestry model with the default parameter settings and the correlated allele frequency model. Unknown individuals were given the

Table 1
Characteristics of the individual wolves involved in hybridization events.

Year	Wolf[a]	Sex[b]	% Red wolf ancestry[c]	Origin[d]	Year born	First breeding event	Litter size	Zone[h]	Coyote ID[i]	History[j]
2001	11100	F	100	Wild[e]	NA[f]	Yes	6	2		Wolf dispersed
2001	11055	F	75	Wild	NA	No	3	3	30145	No previous history[k]
2001	10884	F	100	Wild	1995	Yes	9	3		No previous history
2001	11049	F	87.5	Wild	1999	Yes	6	3	20271	No previous history
2002	10947	M	75	Wild	NA	No	5	1	30214	Mistaken identity[l]
2002	11168	M	87.5	Wild	NA	Yes	NA[g]	1	30218	Breeder killed-poison
2002	11231	F	87.5	Wild	NA	No	NA	3	30272	Breeder killed-gunshot
2002	11030	F	100	Wild	1999	Yes	6	3	30205	Mistaken identity
2003	11030	F	100	Wild	1999	Yes	5	3	30205	Mistaken identity
2005	11037	F	87.5	Wild	1999	No	9	1		Breeder killed-gunshot
2005	11049	F	87.5	Wild	1999	No	6	3	20290	Breeder killed-gunshot
2006	11132	F	87.5	Wild	2001	No	9	2	20377	Breeder killed-natural
2006	11163	F	93.75	Wild	2001	Yes	6	2	20375	Breeder killed-trap injury
2006	11049	F	87.5	Wild	1999	No	1	3		Breeder killed-gunshot
2006	11248	F	100	Wild	2003	Yes	5	3		Breeder killed-gunshot
2006	11148	F	87.5	Wild	2001	Yes	6	3		Wolf displaced
2007	11323	F	96.9	Wild	2004	Yes	2	3		Coyote displaced
2008	11541	F	100	Wild	2006	Yes	4	1		Breeder killed-mange
2008	11517	F	100	Wild	2006	Yes	7	2		Breeder killed-gunshot
2008	11301	M	93.75	Wild	2004	No	NA	3	20493	Coyote displaced
2009	11440	F	93.75	Wild	2005	Yes	6	2		No previous history
2009	11429	F	96.9	Wild	2005	Yes	6	3		Breeder killed-gunshot
2010	11298	F	87.5	Wild	2003	No	8	2		Breeder killed-intraspecific mortality
2011	11779	F	90	Wild	2009	Yes	5	2		Previous breeder disappeared
2011	11630	F	96.9	Wild	2007	No	6	2		No previous history
2011	11725	F	100	Island	2007	Yes	5	2		No previous history
2012	11725	F	100	Island	2007	No	4	2		No previous history
2013	11837	F	100	Wild	2010	Yes	4	2		Breeder killed-gunshot
2013	11693	F	96.9	Wild	2008	No	6	3		Previous breeder disappeared
2013	11819	F	93.8	Wild	2010	Yes	4	1		Breeder killed-gunshot

[a] Identification number of the individual wolf involved in the hybridization event.
[b] F – female; M – male.
[c] Based on the red wolf pedigree.
[d] Birth location of individual.
[e] Wild-born individual from the reintroduced population in North Carolina.
[f] For these individuals the age of birth could not determined.
[g] These litters were detected after USFWS biologists captured the hybrids as juveniles and genetic testing assigned parents.
[h] Refers to the management zone that the litter was discovered.
[i] The individual that bred with the red wolf was unable to be determined for all litters.
[j] History of the location and/or red wolf prior to the production of the hybrid litters.
[k] No significant history was recorded for these individuals.
[l] The individual the red wolf had paired with had been erroneously identified as a red wolf.

POPFLAG = 0 designation, which means their genotypes were not used to estimate allele frequencies. The number of populations was set to four with a burn-in period of 100 000 reps followed by 1 000 000 MCMC repetitions.

For each genetic cluster STRUCTURE produces a probability value that an individual's genotype originated from that group. We considered an individual 'admixed' using two different criteria following Bohling and Waits (2011). If an individual had a probability of assignment $\geqslant 0.1$ for two or more species, we considered that evidence of admixture under our 'Relaxed' criterion. STRUCTURE estimates credibility intervals around each probability value. If the 90% credibility intervals for the values of two or more genetic groups did not overlap zero, we considered this strong evidence of admixture under our 'Conservative' criterion. Our reasoning was to provide two perspectives for interpreting individual ancestry (Bohling and Waits, 2011; Latch et al., 2011). A concern with comparing these results with the red wolf pedigree is that the pedigree is based on theoretical expectations of inheritance while the STRUCTURE results are based on model-estimates using genetic data. To examine if there was any bias in using ancestry estimates based on the pedigree, we compared ancestry estimates produced by both methods for all red wolves involved in hybrid and wolf reproductive events using a paired *t*-test.

Miller et al. (2003) developed a maximum-likelihood assignment test specifically for this red wolf–coyote system. This Canid Assignment Test (CAT) uses genotypes of founders of the captive red wolf population and coyotes from Texas, Virginia, and North Carolina to simulate genotypes of red wolves, coyotes, F1 and F2 hybrids, and F1 × backcrosses with each parental species. Maximum-likelihood tests are then used to estimate the probability of an individual's genotype originating from those six classes. This test is used by the USFWS in conjunction with the pedigree assignment in management decisions and we included those results for another perspective on ancestry.

2.6. Breeder history

We assessed breeder history for each red wolf involved in known hybridization events. The information we collected focused on qualitative descriptions of specific events experienced by the wolves and/or the pack they were associated with. These events were documented by USFWS biologists as they monitored individual wolves over the course of the main period of dispersal and breeding (October–March). Examples of significant events included but were not limited to dispersal, displacement, formation of a new pack, disruption of breeding pairs, and mortality of an associated breeder. In the case of mortalities, a necropsy was conducted to determine whether the cause of mortality was natural or anthropogenic.

3. Results

3.1. Location

From 2001 to 2013, 30 hybrid litters and 126 red wolf litters were documented by USFWS biologists and confirmed via genetic testing (Fig. 2). The mean number of hybrid litters per year was 2.2 ($\pm 1.4\sigma$) whereas the mean number of red wolf litters was 9.7 ($\pm 1.7\sigma$). The average number of pups were higher in hybrid litters (5.5) than red wolf litters (4.2) ($p = 0.001$). In a majority of the cases (27 of 30) a female was confirmed as the red wolf parent of a hybrid litter. A total of 23 female red wolves were involved in hybridization events; most only produced one hybrid litter. Two females were responsible for two hybrid litters each and another was responsible for three. The three male red wolves that produced hybrid litters were responsible for one each.

A majority of the hybrid litters were found in Zones 3 ($n = 14$) and 2 ($n = 11$), with the lowest number in Zone 1 ($n = 5$) (Fig. 1). Conversely, red wolf litters were more evenly distributed (Zone 1 = 35, Zone 2 = 64, Zone 3 = 27). The distribution of red wolf and hybrid litters across the zones was significantly different ($\chi^2 = 8.05$, $p = 0.02$). All red wolves that produced hybrid litters were originally born in the wild except for one female wolf that was born in the island propagation program. Most of the females responsible for red wolf litters were also wild-born ($n = 43$), but four cross-fostered and three island-born females also produced litters. Among males that produced red wolf litters, 47 were wild-born, six island-born, one captive-born, and one cross-fostered.

3.2. Breeder experience

Since a majority of the hybrid litters were produced by females, we only examined breeding age and experience for female red wolves. Among hybrid litters, 16 of 27 involved a female breeding for the first time. This was a significantly higher ($\chi^2 = 8.8$, $p = 0.003$) than the proportion of red wolves litters that involved a first-time breeding female (35 out of 120). Across all litters, the average age of female red wolves responsible for hybrid litters (4.2 years ± 1.6σ) was less than the average age of those responsible for red wolf litters (5.2 years ± 2σ; $p = 0.007$).

3.3. Breeder ancestry

There was no significance difference between the values of ancestry produced by the pedigree and STRUCTURE for individual red wolves ($p = 0.89$). Thus, we report results from the pedigree. Due to the low number of males involved in hybrid litters, we restricted comparisons to female wolves to ensure adequate sample sizes. The average red wolf ancestry of females involved in hybrid events was 0.939 while those involved in red wolf litters had an average of 0.963. Following data transformation, these values were not significantly different ($t = 2.02$, $p = 0.128$). For males, the average amount of red wolf ancestry was 0.947 for those that produced red wolf litters and 0.854 for those producing hybrid litters, but we did not test statistical significance due to low sample size.

The suspected non-red wolf parent was identified by USFWS biologists using field observations for 16 hybrid litters. Two litters involved the same non-red wolf parent: a male that had been mistakenly identified as a red wolf based on morphological examination in the field. Genotypes were obtained for 10 of these non-red wolf parents. Based on the STRUCTURE results, only three individuals appeared to be pure coyotes using the 0.9 q-value threshold (Fig. 3). Two additional individuals also appeared to be coyotes, for they had q-values of 0.81 and 0.77, respectively, for the coyote cluster and no other q-value >0.1. For these five individuals the credibility interval surrounding the q-value for only the coyote cluster did not overlap zero. Four of these individuals we classified as coyotes by the CAT; one, 30272, was classified as a coyote × F1 backcross (Table 2).

Two individuals had q-values indicative of F1 coyote–red wolf hybrids (Fig. 3). Using the red wolf pedigree, we were able to identify the red wolf and coyote parent for both of these individuals, confirming that they were F1 hybrids. Individual 30205 was the only individual for which the credibility intervals for the coyote and red wolf cluster did not overlap zero. Both individuals were classified as F1 hybrids by the CAT (Table 2). Two other individuals appeared to be F1 × red wolf backcrosses (75%), which were confirmed using the pedigree, and one (30145) produced credibility intervals for two clusters that did not overlap zero. The CAT also classified these individuals as F1 × red wolf backcrosses. One individual appeared to be a F1 coyote–dog hybrid × coyote backcross (~75% coyote, ~25% dog) using the 'Relaxed' criterion. To the CAT, which does not incorporate dog ancestry, this individual was a coyote.

3.4. Breeder history

Seven of the 30 hybrid litters had no notable previous history associated with the red wolf responsible for the litter (Table 1). Only two instances resulting in hybrid litters involved red wolves that were considered 'dispersers'. One was a female red wolf that had been displaced by a neighboring female wolf and settled with a non-red wolf mate. The other was a female that exhibited wide movement patterns during the breeding season and never paired

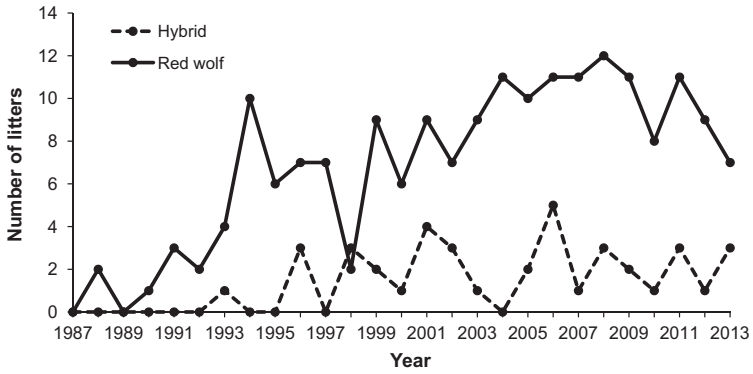


Fig. 2. Number of red wolf and hybrid litters produced each year since the reintroduction of red wolves into North Carolina. Beginning in 2000 the FWS implemented an adaptive management program to genetically monitor the population and reduce hybridization. As a result, for this study we focused solely on litters produced after 2001.

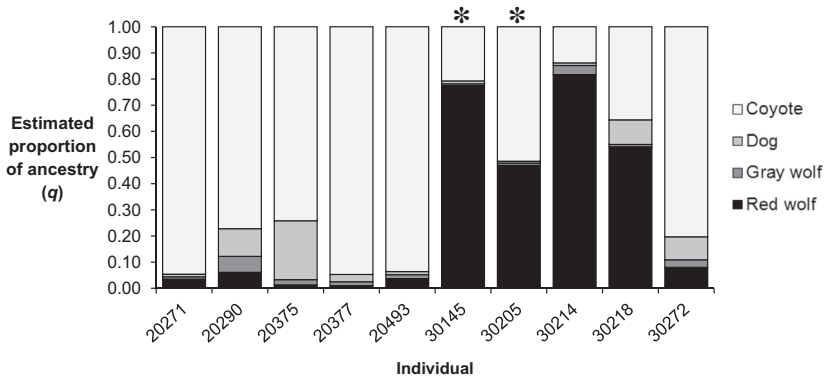


Fig. 3. STRUCTURE ancestry coefficients for the non-red wolf individuals responsible for hybridization events. Each bar represents an individual ancestry composition and each color reflects the ancestry value assigned to each species. This analysis was conducted with a dataset containing 17 polymorphic microsatellite loci. For individuals with a * above their bar plot, the STRUCTURE 90% credibility intervals did not overlap zero for two genetic groups. Individuals 30205 and 30218 were determined to be F1 coyote–red wolf hybrid using the pedigree. Individuals 30145 and 30214 were determined to be F1 × red wolf backcrosses using the pedigree.

Table 2
Results from the Canid Assignment Test (CAT) for non-red wolf individuals responsible for hybridization events. This test uses maximum-likelihood statistics to evaluate the probability of an individual belonging to six separate ancestry classes. The six classes are the two parental species (red wolf, coyote), F1 and F2 hybrid, and F1 backcrosses with each parental species. Values indicated the probability (p) that an individual's genotype can be excluded from that ancestry class. The most likely class is indicated by the term 'LMI'. Coyotes Specific Alleles (CSA) refers to number of alleles possessed by an individual that are found only in coyotes and not the founders of the red wolf population.

Individual	Most likely classification	Maximum-likelihood probability of assignment						CSA
		Red wolf	Coyote	F1	RWBC[a]	CoyBC[b]	F2	
20271	Coyote	0.004	LMI	0.004	0.004	0.072	0.004	11
20290	Coyote	0.004	LMI	0.004	0.004	0.0112	0.008	10
20375	Coyote	0.004	LMI	0.004	0.004	0.028	0.004	16
20377	Coyote	0.004	LMI	0.004	0.004	0.012	0.004	13
20493	Coyote	0.004	LMI	0.004	0.004	0.124	0.004	10
30145	RWBC	0.004	0.004	0.004	LMI	0.004	0.052	3
30205	F1	0.004	0.004	LMI	0.004	0.024	0.04	5
30214	RWBC	0.004	0.004	0.004	LMI	0.004	0.02	2
30218	F1	0.004	0.004	LMI	0.004	0.036	0.048	5
30272	CoyBC	0.004	0.044	0.004	0.004	LMI	0.036	10

[a] Red wolf × F1 hybrid backcross.
[b] Coyote × F1 hybrid backcross.

with a male red wolf. Three hybridization events were the result of a red wolf pairing with an individual that was previously believed to be a red wolf until genetic testing revealed otherwise. The previous history of these females was unknown. All three of these cases occurred in 2002 and 2003, soon after the implementation of the new management plan and strict genetic testing. Two of these cases involved the same female red wolf and male non-red wolf.

Half of the hybrid litters (16 of 30) followed the disruption of a stable breeding pair of red wolves prior to or during the breeding season. Most of these litters ($n = 9$) followed the death of one or both members of a breeding pair of red wolves by gunshot. Another two followed the death of a red wolf breeder by either poison or a trap injury. Two hybrid litters followed the "disappearance" of a breeder, meaning the FWS has lost radio contact with a breeding member of a red wolf pack. Five hybrid litters followed the disruption of a breeding pair by natural causes. One involved a female wolf whose male partner died naturally after a foreign object punctured a lung, causing a systemic lung infection. Another occurred when a female wolf mated with a non-red wolf after both the breeders in her pack died of mange. The third case involved a female whose mate was killed by another wolf. In two other situations a female red wolf had been paired with a sterilized coyote that was subsequently displaced or killed by a red wolf from another pack; these female red wolves then mated with non-red wolves.

To summarize, excluding the seven cases with no known history, 78% (18/23) of the hybrid events followed disruption of social groups. Of these, 61% (11/18) followed anthropogenic mortality, which could be an underestimate if the two individuals that "disappeared" had a similar fate. In situations of breeder disruption either the remaining breeder ($n = 7$) or a previously unmated member of the pack ($n = 9$) interbred with a non-red wolf.

4. Discussion

Exploring individual records of hybridization events in this red wolf–coyote system provides insights into mechanisms that may regulate interactions between these two species. There are several observations we can draw from the wolves involved in these events. First, a large number (90%) of hybridization events involved female red wolves. Based on genetic data, researchers have hypothesized that introgression between wolves and coyotes predominantly occurred when male wolves bred with female coyotes (Lehman et al., 1991; Mozón et al., 2014); our findings refute that hypothesis and support the genetic results of Hailer and Leonard (2008). It also matches the predictions of Wirtz (1999) that hybridization is driven by females from the rarer species selecting heterospecific mates from the more common species.

Ultimately, it appears that hybridization events tend to follow the disruption of stable breeding pairs of wolves, frequently due to anthropogenic actions such as gunshot mortality. In this system canids begin establishing pair bonds during a period that corresponds with the onset of hunting seasons for large mammals. The elimination of red wolf breeders during the breeding season forces reproductively active red wolves to quickly locate another

mate. A higher percentage of hybrid than red wolf litters were produced by first-time female breeders, which is likely due to the low natural turnover in red wolf breeders from year to year (Sparkman et al., 2011). We hypothesize that as stable red wolf pairs dissolve a social 'release' occurs for young wolves providing them with the opportunity to breed, which echoes findings from other wolf populations (Brainerd et al., 2008). The inexperience of these animals coupled with the timing of pair dissolution during the breeding season may facilitate selection of a heterospecific mate.

Such findings correspond with those from other mammalian carnivore social systems that have demonstrated sensitivity to disruption due to human activity (Tuyttens and Macdonald, 2000; Loveridge et al., 2007; Packer et al., 2009; Wallach et al., 2009; Rutledge et al., 2010; Davidson et al., 2011; Borg et al., in press). By pooling data from multiple wolf populations across Europe and North America, Brainerd et al. (2008) found breeder loss facilitated pack dissolution and abandonment of territory. Disrupting stable social systems in canids has cascading effects on intraspecific and, as shown by this red wolf system and wolves in southeastern Canada (Rutledge et al., 2010, 2011), interspecific interactions. Management of wolves must take into account the consequences of breeding pair dissolution for these events can facilitate genetic introgression into small populations.

The disparity between the number of red wolf and hybrid litters suggests that red wolf pairings are more common than those between red wolves and coyotes, which is encouraging considering coyotes outnumber wolves in portions of the RWEPA (USFWS, 2007; Bohling, 2011; Bartel and Rabon, 2013). Such patterns are heavily influenced by human management, which impacts our interpretation of these results. Regardless, the low number of hybridization events that could be attributed to naturally dispersing individuals suggests that even when sympatric these species do not breed randomly and red wolves seek conspecific mates. This is despite the fact that the red wolf population is increasingly inbred (Brzeski et al., 2014) and genetic diversity has declined over time (Bohling et al., 2013). Inbreeding avoidance can facilitate selection of a heterospecific mate (Palmer and Edmunds, 2000; Gee, 2003). In pack-forming canids inbreeding avoidance is linked with dispersal from natal packs (Sillero-Zubiri et al., 1996; vonHoldt et al., 2008; Sparkman et al., 2012), which could facilitate hybridization if dispersing increases the probability of interacting with heterospecifics. Despite the abundance of coyotes and limited gene pool, hybridization does not appear to be fueled by dispersing red wolves, which indicates some form of assortative mating may be operating in this system.

Many of the non-red wolf parents involved in these hybridization events had mixed ancestry. With the removal of hybrids from the landscape, we expected most hybridization events to involve coyotes; these results, however, suggest that red wolves may be selecting for admixed mates over pure coyotes if available. Both traditional trapping (USFWS, 2007; Bartel and Rabon, 2013) and non-invasive genetic sampling (Adams et al., 2007; Bohling, 2011; Bohling and Waits, 2011) reveal that coyotes vastly outnumber hybrids in this landscape, yet admixed individuals were responsible for 40% of the hybridization events when the non-wolf parent was identified. In hybrid systems in which there is a morphological, behavioral, ecological, or size disparity between the parental groups suggest, hybrids can serve as a bridge between the two parental groups and facilitate introgression (Dowling and Secor, 1997; Goodman et al., 1999; Seehausen et al., 2008; Duvernell and Schaefer, 2014). If red wolves are preferentially selecting admixed mates in this landscape, then efforts to remove hybrids must remain a management priority.

Characterizing the wolves involved in hybridization events is difficult due to the circumstances that surround these events. Any observed patterns could simply be a result of a random artificial selection due to the stochastic nature of anthropogenic mortality. For example, wolves involved in hybridization events tended to have slightly higher levels of coyote ancestry. However, this was not a strong pattern and could be a random artifact. Low sample size of hybridization events relative to red wolf litters, although good for red wolf conservation, limits our ability to draw inferences. Ascertainment bias may also influence the results since the breeding habits of red wolves that are not monitored are difficult to determine. This may explain the overwhelming bias toward female red wolves producing hybrid litters: USFWS biologists monitor female wolves as they begin to localize around a den site so they can locate the pups but do not do the same for males. Questions regarding the impact of genetic ancestry, breeding experience, and sex on hybridization could be best answered with mate choice experiments.

The realization that hybridization tends to follow the disruption of stable breeding pairs is important for management of the red wolf population. There has been a dramatic increase in the amount of gunshot and overall human-caused mortality over the past decade (Bartel and Rabon, 2013). For the adaptive management plan to be successful, more effort must be placed in reducing the number of red wolves killed by gunshot to facilitate efforts to restrict hybridization. A recent agreement between the North Carolina Wildlife Resources Commission and several environmental groups to limit coyote hunting in the RWEPA is a positive step toward achieving this goal (SELC, 2014).

Interpreting the spatial distribution of hybridization events and their significance for red wolf conservation is more complex. Trapping surveys indicate that wolves and coyotes are not evenly distributed across the RWEPA (USFWS, 2007; Bartel and Rabon, 2013). Non-invasive genetic surveys suggest that over 80% of the canids in Zone 1 are red wolves, whereas coyotes composed 70% of the population in Zone 3 (Bohling, 2011). Zone 2 is close to a 50–50 split between the two species. Thus, the abundance of hybridization events in Zone 3 could be simply a result of an abundance of coyotes and the inability of wolves to locate conspecifics, which matched our initial expectations and the classic 'desperation hypothesis' (Hubbs, 1955).

The distribution of hybrid events may also be linked to human social factors and land use practices. Zone 1 is predominantly composed of protected areas under public ownership and the first reintroductions occurred in this area, meaning the USFWS has longstanding relationships with many of the landowners. Expansion of the red wolf population westward has mainly occurred on private lands. Many of these landowners did not anticipate wolf colonization of their property, which has created friction between local communities and the USFWS as was highlighted in an independent review of the red wolf program (WMI, 2014). This conflict, combined with lack of protected refuges for wolves, lack of awareness among the hunting community, and proximity to the mainland coyote population, likely facilitates breeding pair disruption and the spatial pattern of hybridization events.

The management approach taken by the USFWS places value on protecting the genetic 'purity' of the population by limiting hybridization. Such efforts hinge on the commitment to protect a species that today is populated by descendants from just a few founders. The taxonomy and ancestry of these founders has been the source of controversy and some genetic studies suggest the red wolf is a relatively recent product of hybridization between coyotes and gray wolves (Lehman et al., 1991; Roy et al., 1996; vonHoldt et al., 2011). An alternative perspective is that red wolves align closely with eastern wolves in southeastern Canada, which represent a North American-derived wolf sharing a close evolutionary relationship with coyotes (Wilson et al., 2000; Hedrick et al., 2002; Kyle et al., 2006; Rutledge et al., 2012). The debate concerning these alternative hypotheses is ongoing (vonHoldt et al., 2011;

Rutledge et al., 2012). This uncertainty has fueled debate regarding the efficacy of investing resources in the protection of a population potentially derived from hybridization (Gittleman and Pimm, 1991; O'Brien and Mayr, 1991; Jenks and Wayne, 1992; vonHoldt et al., 2011). Further complicating matters is the perception that red wolves have a high propensity to hybridize, leading some to suggest management should be lessened allowing the population to assimilate with the surrounding coyote population (Kyle et al., 2006).

Our results provide a new perspective in this debate by revealing the extent to which human factors, both positive and negative, govern hybridization dynamics in this system. The opposing forces of management designed to maintain the red wolf gene pool and human disruption eroding reproductive boundaries impact our perception of potential red wolf recovery. The current introduced population has remained morphologically (Hinton and Chamberlain, 2014) and genetically (Adams et al., 2007; Bohling et al., 2013) distinct from the resident coyote population. We must recognize that human management as a principle factor in maintaining this pattern. At this point, though, management may operate as a zero-sum game, with facilitation of red wolf reproduction counteracting the impacts of pack disruption. In this case, the infrequency and stochasticity of hybridization events and low number of hybrids across this landscape (Adams et al., 2007; Bohling, 2011; Bohling and Waits, 2011) suggest behavioral processes play a role in maintaining the distinctiveness of the red wolf population.

Research has demonstrated the importance of behavioral forces in regulating interspecific hybridization and species boundaries (Wolf et al., 2001; Pfennig, 2007; Reyer, 2008; Svedin et al., 2008; Krosby and Rohwer, 2010; Sacks et al., 2011; Robbins et al., 2014). Even in the face of introgression, boundaries between parental groups can be maintained through behavioral mechanisms. Our findings mirror those of eastern wolves around Algonquin Park in which hunting disrupted pack dynamics and facilitated coyote introgression (Rutledge et al., 2010, 2011). Following restrictions on hunting in areas surrounding the park, the social dynamics of the population were restored and introgression became less frequent. Reducing manipulation, especially pack disruption, would reveal whether red wolves are capable of maintaining their genetic profile as eastern wolves have. Decisions regarding the future of red wolf management must account for the fact that human activity can facilitate hybridization and in turn impacts our interpretation of the relationship of this species to other canids.

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Mattamuskeet Ventures coyote removal records

Oct, 2018

01) Date 10/02/2018

Sex: Female

Hock measurement – 8 ¾ inches

Tail measurement – 12 ¼ inches

GPS location: N

Hair Sample: Yes

Tooth: yes

Reporting number – CKR - 00053

02) Date 10/04/2018

Sex – Male

Hock Measurement: 7 ¾

Tail measurement: 15 ½

GPS Location: N35. 34’ 42.6” – W 076. 03’ 54.3”

Hair sample - yes

Tooth: yes

Reporting number – CKR - 00054

03) 10/06/2018

Sex – Female

Hock Measurement: 8 ¼”

Tail Measurement: 14”

GPS Location: N 35.35.19.1 – W 76.07.12.1

Hair Sample – yes

Tooth: Yes

Reporting number – CKR - 00055

Fecal collection protocol for microbiome analysis

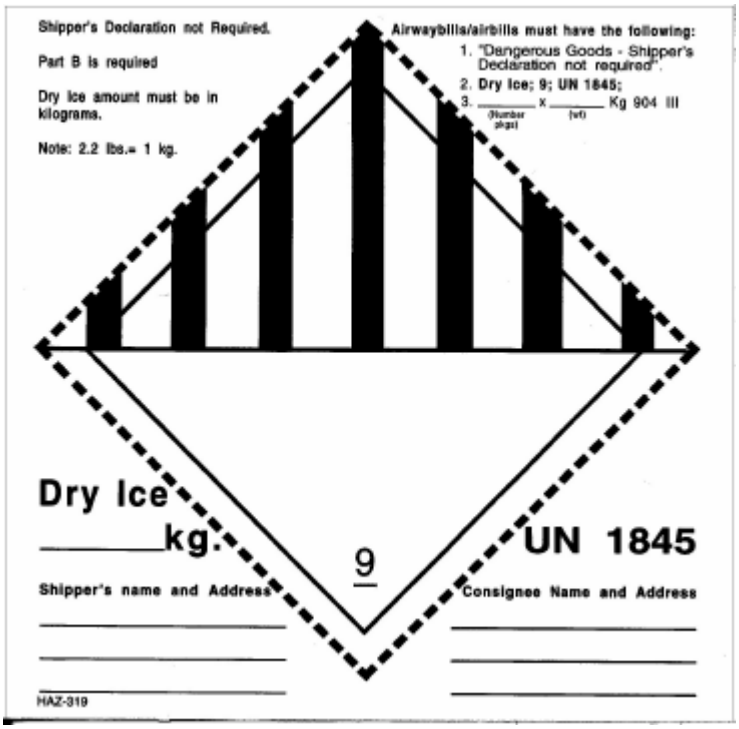
Frequency: 1 time in either October, November or December

Protocol

1. Collect fresh fecal sample (~50g); golf ball size) in a sterile manner within one hour of defecation
2. Place in clean ziplock bag or falcon tube.
3. Record the studbook number, sex, collection date, institution on the bag or tube. Also please write “MICROBE” on the bag or tube as well.
4. Keep samples in -20C until shipped to SCBI. Avoid using any freezers that have a freeze-thaw cycle.
5. To ship samples please put the samples in a Styrofoam-lined box with dry ice (see label below) . Samples should be sent early in the week (Mon. – Wed.) to avoid weekend delivery. Please put “red wolf” as the reference on shipping label.

   Dr. Nucharin Songsasen
   Smithsonian Conservation Biology Institute
   1500 Remount Road
   Front Royal, VA 22630
   Tel: 540-635-0030

6. Contact Morgan, mbragg2@masonlive.gmu.edu, when samples are ready to be sent out so I can give the FedEx account number.



Joe's General Comments (others in the email to Pete and in the document)

- What is their plan if they catch a red wolf that already has a collar?

- What is the actual authority of NCWRC currently to capture, process and "harass" red wolves? Are they already legally permitted to do that?

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Page 12; 336-340: In the event of overheating, priority must be cooling/ensuring survival of the animal. After that assess any injuries, radio-collar, draw blood. Then weights, measurements, etc.

Page 13; 354-355: In regards to the VHF signal, we really need to continue using the 164-165 mHz frequency range already being used for canids on the A.P. While regular GPS locations may be sufficient for research purposes, there is often a need for RWRP personnel to be able to track canids in real time (depredations and other complaints, reports of injuries, den locations, telemetry flights, etc.) It is not practical to carry two separate sets of telemetry gear at all times (especially when thick vegetation or when walking long distances), or to gear aircraft with two sets of antennas, or to constantly have to switch between two sets of gear when time is a factor. There are many field-based scenarios where utilizing two sets of gear would be problematic at best. Previous researchers (including the ones cited in this proposal) utilizing VHF or GPS collars on canids for data collection within the red wolf recovery area have always used frequencies consistent with ours to help alleviate these problems.

Page 13; 358: I would set the VHF beacon to operate beyond 1600 hours daily. You occasionally run into situations (depredations or complaints for example) that require the need to track animals in real time beyond 1600 hours. Ours are set on 12 hour rotations – 0700 to 1900 (0800 to 2000 during daylight savings).

Page 14; 378: A flight every 30 days is not going to be enough to determine cause of mortality should the GPS function fail. We already fly between 50 and 100 times a year to monitor red wolves, I'm not sure an additional 12 is going to benefit anything.

Page 15; 411-412: We already do den work on red wolves. The dens should not be disturbed more than once so any data collected must be in conjunction with USFWS. With fewer than 25 red wolves currently known to exist in the wild, the survival of each and every pup is vital, so no unnecessary risks will be taken. Time spent at the den must be minimal to minimize the disturbance. Skin biopsies are not necessary. We collect a blood sample for genetics and that should suffice. I'm not sure if morphometric measurements are necessary but if done it must be completed quickly. PIT tags are implanted for future identification. We use Trovan and would prefer to keep this consistent with the canids already on the A.P.

Page 15; 413-432: Cameras at a red wolf den site are a bad idea. We have attempted the use of them a couple of times in the past. One time it caused a visible disturbance when the adults returned, and the other time it resulted in puppy deaths when the female would not re-enter the den. Again, each and every red wolf pup is vital. If attempts want to be made to experiment with cameras at den sites, use them at coyote dens but not wolf dens, at least until more is known about potential disturbance (2 to 5 meters is likely too close). Another issue with these cameras is that wolves, and likely coyotes as well, will typically move the pups to a new den site very soon after a disturbance. In the type of habitat found

on the A.P., den sites are usually located in vegetation so thick cameras may be ineffective, and any human visit to the site is going to cause an unavoidable disturbance.

Page 16; 435: Red wolf carcasses go to the lab in Madison, WI as they always have. LE cases go to Asheland, OR. Coyotes can go to SCWDS.

Page 16; 436-442: We notify LE after every red wolf mortality. They decide if it will become an LE case and if they need to take possession of the animal. LE also probably won't allow genetic samples to be taken from animals they need to take possession of for evidence.

Aside from the specific concerns addressed above, I am also concerned by the overall scope of this proposal. I would prefer to see a research proposal more limited in scope with a clearer objective (for example, an analysis or quantification of predator/prey relationships on the A.P. would be beneficial), and to use equipment and protocols consistent with equipment and protocols already in place on the A.P. Sympatric canids should be targeted in current zones of ignorance (which is now the majority of the A.P.) instead of targeting known wolf packs.

If this proposal were carried out as written, it would effectively hand control and management of the red wolf program at the field level to the WRC. WRC plans to collar 25 "sympatric canids", and initially target known red wolf packs with their trapping efforts. There are only 23 known red wolves currently on the A.P. If they were to successfully radio-collar the majority of those wolves with collars emitting their own frequency range, it would severely limit our ability to monitor and manage this population. They also propose doing their own den work, using their own labs for necropsies, using separate protocols for data collection, etc. All this is concerning on two fronts. First, it is our (USFWS) legal mandate to manage and recover this federally listed species on the landscape. We do not turn over management to a state agency until the species is recovered to the point where federal protections are no longer needed. Second, the WRC has made it clear that their objective is to eradicate this species from the state of North Carolina. Turning monitoring and field management over to the WRC likely would not bode well for the recovery of this species.

While I think it is preferable in theory for the two agencies to collaboratively conserve and manage red wolves and other canids on the A.P., it is problematic when their respective objectives are polar opposites of one another. It is quite clear now, after exhaustive and repetitive reviews on the taxonomy and historical range of the red wolf, that the best available science indicates that this is indeed a valid listable species native to northeast NC. If the two agencies are to realistically work towards the conservation and management of canids on the A.P., the WRC needs to, at minimum, rescind their resolution requesting that red wolves be removed from the state of NC and declared extinct in the wild, and move towards listing the red wolf as a state listed threatened species. Then, in addition to collaborative research, we can explore joint regulatory efforts to reduce anthropogenic causes of red wolf mortality, take steps to minimize hybridization and control the coyote population as necessary, and collaboratively manage and recover red wolves on the A.P. Until then I am not comfortable handing over this level of monitoring and management of red wolves on the A.P. to WRC.

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Page 12; 332-335: Animals showing signs of mange should be held and treated for mange before release to avoid spreading it to surrounding canid population, particularly red wolves. Again, conservation of the species needs to be priority number one.

Page 12; 336-340: In the event of overheating, priority must be cooling/ensuring survival of the animal. After that assess any injuries, radio-collar, draw blood. Then weights, measurements, etc.

Page 13; 354-355: In regards to the VHF signal, we really need to continue using the 164-165 mHz frequency range already being used for canids on the A.P. While regular GPS locations may be sufficient for research purposes, there is often a need for RWRP personnel to be able to track canids in real time (depredations and other complaints, reports of injuries, den locations, telemetry flights, etc.) It is not practical to carry two separate sets of telemetry gear at all times (especially when thick vegetation or when walking long distances), or to gear aircraft with two sets of antennas, or to constantly have to switch between two sets of gear when time is a factor. There are many field-based scenarios where utilizing two sets of gear would be problematic at best. Previous researchers (including the ones cited in this proposal) utilizing VHF or GPS collars on canids for data collection within the red wolf recovery area have always used frequencies consistent with ours to help alleviate these problems.

Page 13; 358: I would set the VHF beacon to operate beyond 1600 hours daily. You occasionally run into situations (depredations or complaints for example) that require the need to track animals in real time beyond 1600 hours. Ours are set on 12 hour rotations – 0700 to 1900 (0800 to 2000 during daylight savings).

Page 14; 378: A flight every 30 days is not going to be enough to determine cause of mortality should the GPS function fail. We already fly between 50 and 100 times a year to monitor red wolves, I'm not sure an additional 12 is going to benefit anything.

Page 15; 411-412: We already do den work on red wolves. The dens should not be disturbed more than once so any data collected must be in conjunction with USFWS. With fewer than 25 red wolves currently known to exist in the wild, the survival of each and every pup is vital, so no unnecessary risks will be taken. Time spent at the den must be minimal to minimize the disturbance. Skin biopsies are not necessary. We collect a blood sample for genetics and that should suffice. I'm not sure if morphometric measurements are necessary but if done it must be completed quickly. PIT tags are implanted for future identification. We use Trovan and would prefer to keep this consistent with the canids already on the A.P.

Page 15; 413-432: Cameras at a red wolf den site are a bad idea. We have attempted the use of them a couple of times in the past. One time it caused a visible disturbance when the adults returned, and the other time it resulted in puppy deaths when the female would not re-enter the den. Again, each and every red wolf pup is vital. If attempts want to be made to experiment with cameras at den sites, use them at coyote dens but not wolf dens, at least until more is known about potential disturbance (2 to 5 meters is likely too close). Another issue with these cameras is that wolves, and likely coyotes as well, will typically move the pups to a new den site very soon after a disturbance. In the type of habitat found

on the A.P., den sites are usually located in vegetation so thick cameras may be ineffective, and any human visit to the site is going to cause an unavoidable disturbance.

Page 16; 435: Red wolf carcasses go to the lab in Madison, WI as they always have. LE cases go to Asheland, OR. Coyotes can go to SCWDS.

Page 16; 436-442: We notify LE after every red wolf mortality. They decide if it will become an LE case and if they need to take possession of the animal. LE also probably won't allow genetic samples to be taken from animals they need to take possession of for evidence.

Aside from the specific concerns addressed above, I am also concerned by the overall scope of this proposal. I would prefer to see a research proposal more limited in scope with a clearer objective (for example, an analysis or quantification of predator/prey relationships on the A.P. would be beneficial), and to use equipment and protocols consistent with equipment and protocols already in place on the A.P. Sympatric canids should be targeted in current zones of ignorance (which is now the majority of the A.P.) instead of targeting known wolf packs.

If this proposal were carried out as written, it would effectively hand control and management of the red wolf program at the field level to the WRC. WRC plans to collar 25 "sympatric canids", and initially target known red wolf packs with their trapping efforts. There are only 23 known red wolves currently on the A.P. If they were to successfully radio-collar the majority of those wolves with collars emitting their own frequency range, it would severely limit our ability to monitor and manage this population. They also propose doing their own den work, using their own labs for necropsies, using separate protocols for data collection, etc. All this is concerning on two fronts. First, it is our (USFWS) legal mandate to manage and recover this federally listed species on the landscape. We do not turn over management to a state agency until the species is recovered to the point where federal protections are no longer needed. Second, the WRC has made it clear that their objective is to eradicate this species from the state of North Carolina. Turning monitoring and field management over to the WRC likely would not bode well for the recovery of this species.

While I think it is preferable in theory for the two agencies to collaboratively conserve and manage red wolves and other canids on the A.P., it is problematic when their respective objectives are polar opposites of one another. It is quite clear now, after exhaustive and repetitive reviews on the taxonomy and historical range of the red wolf, that the best available science indicates that this is indeed a valid listable species native to northeast NC. If the two agencies are to realistically work towards the conservation and management of canids on the A.P., the WRC needs to, at minimum, rescind their resolution requesting that red wolves be removed from the state of NC and declared extinct in the wild, and move towards listing the red wolf as a state listed threatened species. Then, in addition to collaborative research, we can explore joint regulatory efforts to reduce anthropogenic causes of red wolf mortality, take steps to minimize hybridization and control the coyote population as necessary, and collaboratively manage and recover red wolves on the A.P. Until then I am not comfortable handing over this level of monitoring and management of red wolves on the A.P. to WRC.

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Evaluating potential effects of widening US 64 on red wolves in Washington, Tyrrell, and Dare Counties, North Carolina



Final Report

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16. Abstract

We used data from 16 red wolves fitted with GPS-collars between January 2009 and April 2011 to evaluate home range size and habitat selection, road permeability, and identify significant red wolf highway crossing locations. Home range size for red wolves averaged 13.7 mi^2 with no significant difference between males and females. Although we found no significant difference in home range size among age classes, dispersers tended to have larger home ranges than adults and juveniles. Red wolf home ranges were larger during winter than during other seasons. Red wolves avoided wetter habitats such as pocosins, wetlands, and lowland forests, leaving agriculture the best predictor of red wolf presence. Red wolves also selected for the presence of agriculture/forest road systems for travel. Road permeability, calculated using GPS-collar data, was 100%, thus the current 2-lane highway does not impose a barrier effect on the red wolf population. This increases the risk of road mortality events. Using a 3281 ft. (1 km) buffer, construction north of the current US 64 in Tyrrell County has the potential to remove up to 0.16 mi^2 of red wolf habitat and 6% of the home range area used by a current red wolf pack while construction to the south will impact only 0.09 mi^2 of red wolf habitat and will not displace any current red wolf packs. East of Alligator River in Dare County, a widening of the current highway to the south has the potential to remove up to of 0.07 mi^2 of red wolf habitat and 20% of the home range used by the only existing red wolf pack in Alligator River National Wildlife Refuge if construction disturbs out to 3281 ft. (1 km) from the current road. Construction to the north of US 64 in Dare County has the potential to remove up to 0.04 mi^2 of red wolf habitat and will not overlap with any current packs, based on 95% home ranges. Through the use of GPS-collars and remote camera traps, we identified 5 important red wolf crossing locations, 4 in Tyrrell County west of Alligator River and 1 in Dare County east of Alligator River. The presence of agricultural fields, successional fields, and/or upland forests 328 to 492 ft. from the road provided the most parsimonious explanation for the location of crossing sites identified using GPS-collar locations; trail/road width provided the best explanation for the location of crossing sites identified by remote camera traps. The presence of agricultural fields, successional fields, and upland forests as well as proximity to maintained agricultural/forest roads at crossing sites corresponds to habitat selection results. Four of the 5 red wolf crossing locations we identified are suitable for crossing structures. The most western crossing site is located within the town of Colombia, NC where retro-fitting a wildlife underpass is not practical. Well maintained trails at least 26.24 ft. (8 m) in width leading to and from underpasses, which connect habitats selected for by red wolves (e.g. agriculture, successional fields, and upland forests), is suggested to optimize efficacy.

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Executive Summary

Information reported here is the result of a 2-year study evaluating red wolf (*Canis rufus*) habitat use and crossing patterns along US 64 from Columbia, NC east to the 64/264 intersection in Manns Harbor, NC. This report includes a problem statement and background information, evaluation of red wolf home range size and habitat selection, an analysis of probable effects to red wolf home range and habitat availability in the event of a highway widening, identification of current red wolf crossing locations, and suggestions for the location and type of crossing structures to mitigate potential adverse effects of a highway widening of US 64.

We used data from 16 red wolves fitted with GPS-collars between January 2009 and April 2011 to evaluate home range size and habitat selection. Home range size for red wolves averaged 13.7 mi^2 with no significant difference between males and females. Although we found no significant difference in home range size among age classes, dispersers tended to have larger home ranges than adults and juveniles. Red wolf home ranges were larger during winter than during other seasons. Red wolves avoided wetter habitats such as pocosins, wetlands, and lowland forests, leaving agriculture the best predictor of red wolf presence. Red wolves also selected for the presence of agriculture/forest road systems for travel.

Road permeability, calculated using GPS-collar data, was 100%, thus the current 2-lane highway does not impose a barrier effect on the red wolf population. This increases the risk of road mortality events. A decrease in the red wolf population to the west of Columbia, NC, prevented collaring of red wolves where widening to a 4-lane highway was completed. Therefore, we were not able to compare highway permeability between 2- and 4-lane highways. Using a 3281 ft. (1 km) buffer, construction north of the current US 64 in Tyrrell County has the potential to remove up to 0.16 mi^2 of red wolf habitat and 6% of the home range area used by a current red wolf pack while construction to the south will impact only 0.09 mi^2 of red wolf habitat and will not displace any current red wolf packs. East of Alligator River in Dare County, a widening of the current highway to the south has the potential to remove up to of 0.07 mi^2 of red wolf habitat and 20% of the home range used by the only existing red wolf pack in Alligator River National Wildlife Refuge if construction disturbs out to 3281 ft. (1 km) from the current road. Construction to the north of US 64 in Dare County has the potential to remove up to 0.04 mi^2 of red wolf habitat and will not overlap with any current packs, based on 95% home ranges.

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Four of the 5 red wolf crossing locations we identified are suitable for crossing structures. The most western crossing site is located within the town of Colombia, NC where retro-fitting a wildlife underpass is not practical. Well maintained trails at least 26.24 ft. (8 m) in width leading to and from underpasses, which connect habitats selected for by red wolves (e.g. agriculture, successional fields, and upland forests), is suggested to optimize efficacy.
Detailed results and discussion are provided in the report below.

Evaluating potential effects of widening US 64 on red wolves in Washington, Tyrrell, and Dare Counties, North Carolina

Final Report

Principal Investigators:
Michael R Vaughan, PhD and Marcella J Kelly, PhD

Introduction

Roads have profound effects, both direct and indirect, on natural ecosystems (see reviews by Forman et al. 2003 and Coffin, 2007). Forman and Alexander (1998) estimated that the approximately 10.9 million hectares of public roads in the US and their related habitat loss and degradation has affected >20% of land area in the United States. In a 43-year period (1960 – 2003), the number of registered cars increased from 74 to 231 million nation-wide and the annual distance traveled by car in the US grew from approximately 720,000 to 2.8 million miles (Ouren and Watts, 2005). As transportation needs increase, a rise in the amount of habitat lost and degraded due to road construction can be expected. Indeed, the link between economic development and transportation expansion was well documented by the mid 1960's (Kansky, 1963; Taaffe et al., 1963; Haggett 1965). Such large-scale and multifaceted changes to ecosystems have many detrimental impacts on wildlife (Jackson, 1999), including direct mortality (Lalo, 1987; Harris and Scheck, 1991; Schwabe and Schuhmann, 2002), habitat destruction (Theobald et al., 1997; Angelsen and Kaimowitz, 1999), barrier effects (Forman et al, 2003), and increased human land use activities (Bjurlin and Cypher, 2003; Coffin, 2007).

There is perhaps no other human impact as transportation infrastructure whose far-reaching, cumulative effects on wildlife are so devastating and demanding of attention, yet so commonly underestimated. Direct wildlife mortality results from construction injury and vehicular collisions (Trombulak and Frissell, 2000) and has now surpassed hunting as the leading direct human cause of vetebrate mortality on land (Forman and Alexander, 1998), with an estimated 720,000 to 1.5-million deer-vehicle crashes reported annually (Conover et al., 1995; Forman et al., 2003). While the number of common species killed along roads is staggering, in most cases road mortality of wildlife does not translate into population level effect. However, road related impacts to threatened and endangered species are of particular concern. Road kill is the primary cause of mortality in Florida for Florida panthers, black bears, key deer, and crocodiles (Harris and Scheck, 1991) and accounts for a high percentage of deaths in Iberian lynx (Ferreras et al., 1992). In addition, road impacts have been found in gray wolves (Thiel, 1985; Paquet and Callaghan, 1996), desert tortoises (Boarman, 1996), and some populations of San Joaquin kit foxes (Bjurlin and Cypher, 2003). For the declining copperbelly water snake in Indiana, road mortality accounts for approximately 17% of all deaths (Roe et. al, 2006). Road mortality was the second highest cause of death for red wolves in North Carolina within the 5 county recovery zone between 1999 and 2006, accounting for 14% of mortality overall (USFWS, 2007). When broken down by age class, vehicle strikes were the leading cause of death in dispersing red

wolves, accounting for 19% of mortality (USFWS, 2007). The increasing incidence of wildlife-vehicle collisions also presents a real issue for humans, as they claim hundreds of lives, cause tens of thousands of injuries, and inflict an enormous monetary cost for medical treatment and vehicle repair each year nationwide (Forman et al., 2003). For example, in 1993 1.5 million deer-vehicle crashes were reported in the US leading to $1.1 billion in vehicle damages (Durbin, 2004). Deer-vehicle collisions have been reported to cause 29,000 human injuries and claim 211 lives (Conover et al., 1995).

Beyond direct mortality, roads can negatively affect wildlife populations by degrading habitat quality (Theobald et al., 1997; Carr et al., 2002), fragmenting habitat and populations (Oxley et al., 1974; Trombulak and Frissell, 2000; Nellermann et al., 2001), hindering gene flow (Gerlach and Musolf, 2000; Epps et al., 2005; Riley et al., 2006), skewing sex ratios (Gibbs and Steen, 2005), and limiting dispersal (Beier, 1995). Most roads exhibit a distinct trade-off between permeability and road kill (Forman and Alexander, 1998). A highly permeable road might result in a high level of wildlife/vehicular collisions, whereas an impermeable road might have few road kill events. Yet this decrease in road kill comes at the expense of habitat connectivity. As individuals lose their mobility and gene flow is reduced, portions of the population become isolated. In the event of local extinction due to some stochastic event, fragmentation can make recolonization of previously-occupied habitat impossible (Theobald et al., 1997). These affects are of particular concern in small populations. Small populations have an increased risk of extinction due to demographic stochasticity, decreased heterozygosity, genetic drift, inbreeding, and low effective population size (Caughley, 1994), all of which can be exacerbated though road construction and expansion-related barrier effects. Social organization may also be affected by spatial change leading to population instability (Krausman et al., 2004).

Low population densities and large home ranges make carnivores particularly vulnerable to the effects of habitat fragmentation by roads (Whittington et al., 2005). A highway was found to restrict gene flow in a Cleveland, Ohio coyote population and direct the movements of migrants towards urbanizing centers (Rashleigh et al., 2008). Riley et al. (2006) found that coyote and bobcat populations in southern California separated by a major freeway exhibited genetic differentiation, suggesting that the freeway is a barrier to dispersal. Even when they do not constitute an absolute physical barrier, high-use roads can lead to avoidance behavior in canids affecting their ability to move across a landscape (Kaartinen et al., 2005, Paquet and Callaghan, 1996, Whittington et al., 2004). For those that do cross, heightened territorial behavior along roadways can discourage reproductive success, again limiting gene flow (Riley et al., 2006). The degree to which a road affects canid survival is dependent on the specific situation, and sometimes no detrimental effects are observed, as is the case with a California population of San Joaquin kit foxes (Cypher et al., 2009). Some documentation exists regarding wolves in the vicinity of highways. A study tracking gray wolf dispersal in Minnesota found that wolves were willing to cross major highways to colonize areas in Wisconsin and Michigan (Mech et al., 1995). For gray wolves (*Canis lupus*), a 4-lane unfenced highway in Wisconsin seemed to not influence wolf movements (Kohn et al., 1999). In contrast, a 4-lane fenced highway in Banff National Park in Alberta, Canada, appears to hinder wolf movements (Paquet and Callaghan, 1996), although crossing structures mitigated its barrier effect to some degree (Clevenger and Waltho, 2000, 2005). In Spain, wolves whose home ranges were greater than 5 km from the highway crossed a 4-lane, fenced highway via vehicle bridges (Blanco et al., 2005), however

those living in close proximity to the highway (<5 km) crossed the highway only after severe habitat disturbance. Gray wolves in Canada and Spain seem to prefer large, open wildlife overpasses (Forman et al., 2003). In general, a large void exists in addressing factors that affect how large carnivores use passages. Major transportation corridors bisect and potentially fragment most of the major ecosystems that still support wide-ranging carnivores. Increased concerns expressed by transportation and natural resources agencies regarding mitigation planning for large carnivores highlight the need for more information and research in this area (Forman et al., 2003).

The use of wildlife crossing structures can mitigate some of the negative effects associated with highways (Forman and Alexander, 1998). The appropriate type of crossing structure to mitigate road effects varies with species (Mata et al., 2008). A study monitoring the success of multi-species highway underpasses following the highway-widening just west of this current study area found that bobcats, black bears, and foxes utilized underpasses (McCollister and van Manen, 2010), however there were no confirmed detections of coyotes or red wolves using the underpasses. Because the red wolf population of both this study and the one cited above is the only wild red wolf population, there does not exist literature on the preference of red wolves for particular crossing structures. However several studies have found that while gray wolves will use wide tunnels and underpasses (Clevenger and Waltho, 2000, Kusak et al., 2009), they prefer open overpasses (Forman et al., 2003, Kusak et al., 2009). In Banff, wolves select for taller underpasses close to town (Clevenger and Waltho, 2000). Coyotes on the other hand have been found to use underpasses of a wide variety of sizes, from pipe culverts to wide underpasses, as long as they did not connect developed areas (Ng et al., 2004). Likewise, a study in Virginia found that coyotes readily used a variety of underpasses (Donaldson, 2007). The Wildlife Crossing Structure Handbook published in 2011 by the Federal Highway Administration recommends that underpasses geared towards large mammals (deer, bears, and wolves) and high mobility medium sized mammals (coyote, fox, and likely the category red wolves would be placed) should be greater than 32 ft. in width and greater than 13 ft. in height and that overpasses be at least 50 ft. wide (Clevenger and Huijer, 2011). If designing mitigating structures solely for high mobility medium sized mammals, underpasses and culverts with a diameter of 4ft. have been effective (Clevenger and Huijer, 2011). However, it appears that the structural components of crossing structures play a larger role in determining success for ungulates (Clevenger and Waltho, 2005; Gagnon et al., 2011) while habitat connectivity plays a larger role in the successful use of crossing structures for carnivores (White and Ernst, 2004; Singleton et al., 2005; Riley et al, 2006; Kindall and van Manen, 2007).

Underpasses can function as effective crossing structures for wolves, but high variability in use indicates that consideration of social interactions, placement, construction specifications and distance between crossings is essential for success (Paquet and Callaghan, 1996). Animals do not treat all sections of a roadway indiscriminately, so crossing funnel areas and natural habitat linkages at the landscape level must be identified. White and Ernst (2004), Singleton et al. (2005), and Kindall and van Manen (2007) all stress the need to identify habitat linkages across barriers to properly place crossings. In addition, Roger and Ramp (2009) discuss the importance of species-specific habitat use data in determining roadway impacts. Thus, it is imperative not only that wildlife underpasses be constructed in areas identified as high use for crossings (Scheick and Jones, 1999), but habitat variables at crossing locations be collected as well to

model what landscape factors predict crossings. Often times it is also necessary to install exclusionary fencing in addition to a crossing structure to guide animals to the crossing point and discourage crossing at road-level (Baker, 2005).

Indeed, one study in Portugal found that fencing had a funneling effect, directing larger animals towards culverts (Ascensao and Mira, 2006). Similarly, fencing along a highway reduced elk-vehicle collisions by 97% and other wildlife-vehicle collisions by 64% in Arizona (Gagnon et al., 2010) and likely lead to a decease in white-tailed deer-vehicle collisions in North Carolina (Jones et al., 2010). A study in Germany found that fencing successfully reduced wildcat road mortality by 83% (Klar et al., 20009) and fencing along with culverts lowered wildlife-vehicle collisions by 93.5% in Paynes Prairie State Preserve (Dodd et al., 2004). Ungulate-vehicle collisions were reduced by 80% following the installation of roadside fencing in Banff National Park, Canada (Clevenger et al., 2001). Jaeger and Fahrig (2004) developed a model to look at the trade-off between reductions of road kill and increased barrier effect due to fencing installation. They found that below a certain traffic volume, the barrier effect of fencing is harmful to a population and therefore they only recommend the use of roadside fencing when traffic volume is high (e.g. high risk of road mortality) and the target species does not show behavioral avoidance of roads (Jaeger and Fahrig, 2004). Both Clevenger et al. (2001) and McCollister and van Manen (2010) found that while fencing reduced wildlife-vehicle collisions close to underpasses, wildlife-vehicle collisions increase approaching fence ends. McCollister and van Manen (2010) found that road mortality was higher in fenced highway segments as compared to unfenced segments due to the increased mortality where roadside fencing ends. Therefore, if non-continuous fencing is used, it may be necessary to modify fence ends to direct wildlife away from the highway (Clevenger et al., 2001). Ungulates are the focal species for most studies that successfully demonstrate the effectiveness of roadside fencing. Fencing may be less effective for carnivores as they often go over (e.g. black bears) or under (e.g. coyotes) fencing (Clevenger et al., 2001). Indeed, the use of fencing did not increase culvert use by bobcats in Texas (Cain et al., 2003) and actually lead to an increase in wolf road mortality in Spain (Colino-Rabinal et al., 2011). Burying roadside fencing can help to discourage some species from digging under the fence (Clevenger et al., 2001).

Clearly, an understanding of red wolf activity patterns, movements, and habitat use are all needed in the vicinity of US 64 and across the Albemarle Peninsula. This study assessed red wolf home range, habitat selection, and highway crossing patterns along the US 64 corridor with the use of GPS collars and remote cameras to determine important red wolf habitat and to identify significant red wolf highway crossing locations. In addition, this research examined which landscape attributes promote red wolf use of crossing locations to increase the success of mitigating structures.

Background Information

The North Carolina Department of Transportation (NCDOT) is planning a highway improvement project for US 64 in Tyrrell and Dare Counties North Carolina, which will extend across the full length of the Albemarle Peninsula when completed, separating the northern section of the 5 county (Washington, Tyrrell, Dare, Hyde, and Beaufort counties) red wolf recovery zone. The effects of the highway widening on red wolf recovery and conservation could

be substantial, potentially creating a barrier to movement and gene flow of red wolves and other wildlife from one side of the highway to the other. In addition, the habitat loss associated with a highway widening likely will disrupt red wolves living adjacent to the existing highway causing a shift in current home ranges. Any shifts in home ranges have the potential to affect social order. Even in the absence of a barrier effect, the project may lead to an increase in vehicle related deaths as wolves attempt to cross a wider highway with increased speed limits. In addition, there is a potential to concentrate prey and herbaceous food sources at highway edges, attracting wolves, coyotes, black bears, white-tailed deer and other wildlife, increasing the risk of vehicle collisions. Highway barrier effects, habitat loss, social disruptions, and road mortality resulting from the highway widening may culminate in reduced red wolf population viability.

Problem Need/Definition

Viable populations of wildlife depend, in part, on dispersal to maintain genetic diversity. Whether natural or man-made, barriers to dispersal are of concern to wildlife managers. For restored or recovering populations, potential barriers such as highways or large fenced areas magnify in importance because of their potential to restrict or retard growth and genetic diversity in small wildlife populations. Roads, in particular, recently received attention with respect to large carnivore population dynamics related to increased direct (vehicle collisions) and indirect (changes in behavior that affect food acquisition) mortality (Trombulak and Frissell, 2000). Forced spatial change also may affect area-wide social organization and thus population stability, and increased noise or activity levels may initially affect wildlife behavior (Krausman et al., 2004).

For the past several years the North Carolina Department of Transportation (NCDOT) has been planning a proposed project to widen US 64 from 2 to 4 lanes from Raleigh to Manteo, North Carolina. With respect to the segment of US 64 already widened and elevated between Plymouth and Columbia by 2005, preliminary data collected by the U.S. Fish and Wildlife Service indicates red wolf (*Canis rufus*) movements and gene flow, including dispersal and home range size, may already be restricted by that highway segment. Remaining sections of US 64 planned for widening are the approximate 15.5-mile section from Columbia to Alligator River, and 11.8-mile section that runs through Alligator River National Wildlife Refuge.

The nature of the US 64 widening project calls into question important ecological and regulatory considerations that, together, mean data collection is needed to assist with science-based decisions and project design. Red wolves will be involved in two federal regulatory processes pertinent to widening of US 64, namely, project consultation under Section 7 of the U.S. Endangered Species Act of 1973, and assessment of "refuge compatibility" under the National Wildlife Refuge System Improvement Act of 1997 (Public Law 105-57), along with the National Wildlife Refuge System Administration Act of 1966 (16 U.S.C. 668dd-668ee), as amended. These processes allow cooperation toward achieving a project that takes into account human safety, traffic management, and wildlife concerns that include passage, mortality, large-sized animals, and multiple wildlife refuge values. Refuge considerations include endangered species conservation, waterfowl management, wildlife habitat with associated species, hydrology, wetlands, reptiles and amphibians, public use, fire management, exotic species management, etc.

The effects of US 64 widening on red wolf recovery and conservation could be substantial. Widening US 64 may be accompanied by increased speed limits, and likely will create a barrier to movement of red wolves and other wildlife from one side of the highway to the other. Thus, it is imperative that wildlife crossing structures be constructed in areas identified as high use crossings by red wolves, bears, deer, and other species (Scheick and Jones, 1999). Completed and planned phases of the US 64 widening project extend across the full length of the Albemarle Peninsula, separating and otherwise affecting the entire northern quarter of the 5-county red wolf experimental population area.

Construction of the highway itself most likely will directly disrupt the red wolf population, along with other wildlife populations (e.g., black bear, white-tailed deer) living adjacent to the existing highway during the 1-2 year construction period. These disruptions may cause red wolves to shift out of their current home ranges or territories during the construction phase and move into areas already occupied by other red wolves, causing social disruptions and ripple effects across the Albemarle Peninsula. While the disruption due directly to construction will be short-term, effects on the red wolf population may be long lasting and even permanent. Habitat loss, social disruptions, and ripple effects, as a result of direct, indirect, and cumulative effects of a highway widening, may result in a reduction of the red wolf population, its gene flow, and gene diversity, by some unknown quantity.

Vehicle strike mortality significantly impacts the wild red wolf population on the Albemarle Peninsula in North Carolina (USFWS, 2007). Of 166 known adult red wolf loses since 1999, 23 were killed in vehicle strikes. Vehicle strikes are three times higher in non-breeder (19%) vs. breeder (6%) red wolves in the designated experimental population area. This is partly explained by single red wolves dispersing or roaming over large distances.

Studies are needed to assess how the red wolf population has utilized the area since restoration began. An examination of which landscape attributes promote red wolf use would be helpful, along with a thorough assessment of site-specific habitat availability.

More specifically, the potential problems or benefits examined for red wolves in association with US 64 widening should include the following concerns.

1. Vehicle mortality of red wolves and associated human safety.
2. Reproduction and survival.
3. Considerations of placement of underpasses or overpasses.
4. Changes in red wolf habitat, prey, home range size, dynamics, and associated landscape fragmentation.
5. Effects upon red wolf activity, movements, gene flow, dispersal, territory dynamics, social organization, pack integrity, habitat use, and land occupancy.
6. Ripple effects throughout the red wolf population, across the Albemarle Peninsula.
7. Changes in red wolf numbers pre-project, during project, and post-project.
8. Influences on eastern coyotes, a competitor and threat to red wolves.
9. Effects upon monitoring of red wolves and eastern coyotes.

It is important to understand the effect of canid activity and movements out of or into the experimental area along the expanded highway in western portions of the Albemarle Peninsula. Possible study topics include coyote/red wolf interactions and retrospective examination of adaptability of coyote/hybrids vs. red wolves in the face of significant habitat change and/or significant project construction.

Research Objectives

The objectives of this research project are to:

1. Evaluate wolf habitat use along the entire US 64 corridor from Plymouth to the US 64/264 intersection

2. Evaluate the significance of red wolf habitat changes anticipated from the proposed highway project from Columbia to the US 64/264 intersection in terms of movements, survival, reproduction, home range shifts, and social organization.

3. Identify significant red wolf crossing areas to determine where wildlife crossing structures or other design features could be placed to minimize adverse project effects on red wolves.

Study Area

The only wild population of red wolves occurs on more than 2,567 mi^2 of federal, state, and private lands in 5 counties (Beaufort, Dare, Hyde, Tyrrell, and Washington) in northeastern North Carolina (Figure 1), known as the Red Wolf Recovery Zone (RWRZ). Two of the northern counties within the RWRZ, Tyrrell and Dare Counties, were the focal point of this study because they contain the remaining 27.34 mi of US 64 to be widened. Federal lands within the study area include Pocosin Lakes National Wildlife Refuge, Alligator River National Wildlife Refuge, and a bombing range shared by the Navy and Air Force. State land consists of numerous game management properties, while private lands are primarily made-up of timber plantations, agricultural fields, and a few developed residential and commercial properties.

The most prevalent land cover types within the study area, as identified by the North Carolina Gap database (2009), are agricultural fields (~30%) planted primarily with wheat, corn, soybean, cotton, and potatoes; commercial pine plantations (~15%); pocosin (~15%); non-riverine swamp forests (~10%); and saltwater marsh or open water (~10%). Climate within the study area is characterized by 4 full seasons of nearly equal length with annual precipitation averaging 50 in. Temperatures range from a mean of 41°F in winter to 80.6°F in summer. Elevation ranges from sea level to 164 ft. (Beck et al., 2009). Carnivores that co-occur with red wolves within the study area include gray foxes (*Urocyon cineroargenteus*), red foxes (*Vulpes vulpes*), coyotes (*Canis latrans*), feral dogs (*Canis lupus familiaris*), bobcats (*Lynx rufus*), black bears (*Ursus americanus*), and various mustelids.

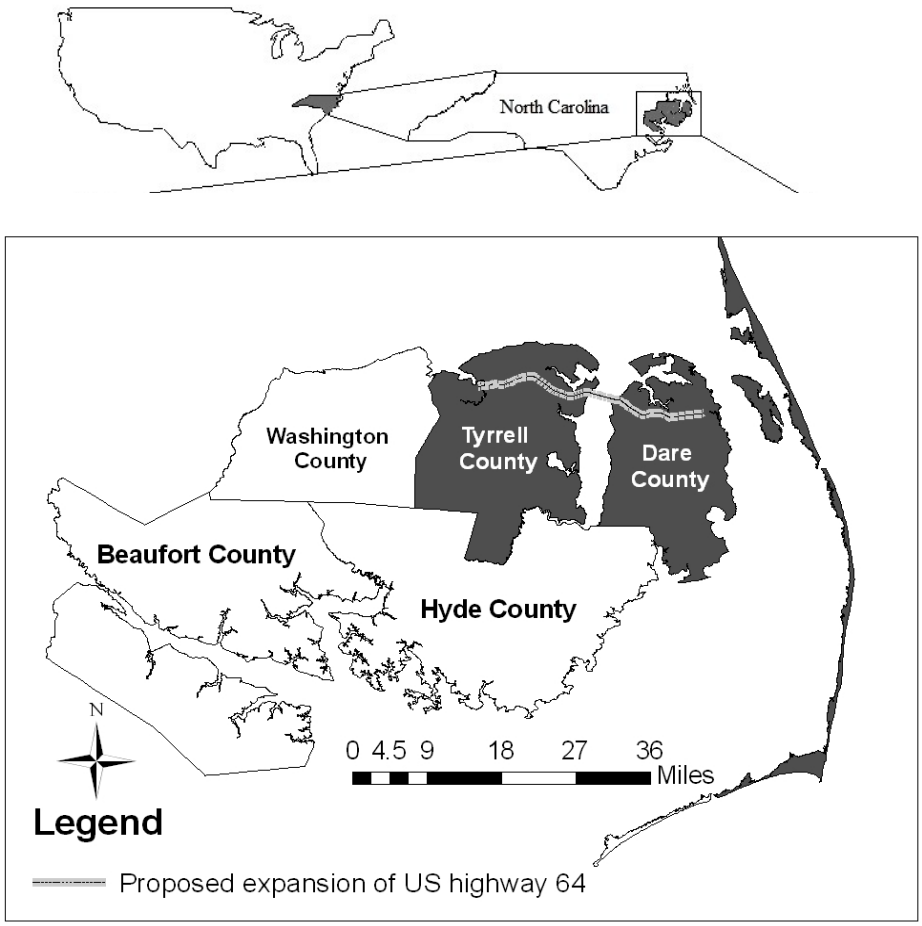


Figure 1. The study area (highlighted in gray) is located within 2 of the northern counties, Tyrrell and Dare, of the 5 county red wolf recovery zone in northeastern North Carolina. The study area focuses on the remaining 27.3 mi section of US 64, between Columbia, NC and the US 64/264 intersection, to be expanded from a 2- to 4-lane highway.

Methods

Capturing and collaring of animals*:* From January 2009 to April 2011, adult and juvenile red wolves were captured by USFWS biologists and fitted with mortality-sensitive Lotek GPS 4400S collars (Lotek Wireless, Inc., Ontario, Canada). Red wolves > 2 years old were classified as adults, < 2 years old as juveniles, and < 9 months old as pups. Pups were not fitted with GPS collars because typically they were too small to safely wear collars. Prior to deployment, GPS collars were remotely programmed to record locations every 5 hours with a nested program to collect a position every 30-minutes for a 5 hour period daily. The nested 30-minute program was scheduled to rotate around the 24-hour clock to capture detailed movements. Each collar emitted a VHF locator beacon each day from 0900 – 1200, allowing us to locate collared animals every 12 weeks on the ground and remotely download stored data.

Objective 1: Evaluate wolf habitat use along the entire US 64 corridor from Plymouth NC to the US 64/264 intersection

***Independence of animal movements*:** To address the issue of correlation of GPS location data between pack mates, we calculated home ranges (Getz et al., 2007) for all collared wolves in a single pack then associated locations for each animal with the corresponding isopleth. Next, Spearman correlation matrices were used to determine the similarity of home ranges and habitat use among all collared animals within the pack. This determined if animals within a pack should be treated separately or if habitat use, selection, and home range of one collared animal was representative of the entire pack.

***Home range analyses*:** Following the conclusion of field work, rarefaction curves of cumulative weekly home ranges were calculated on all complete data sets for each collared animal to determine the relationship between length of time collar was deployed and when size of home range stabilized (Bekoff and Mech, 1984). Starting by calculating size of home range of an animal during the first week of collar deployment, we calculated size of home range of the animal during the second week of collar deployment and so on until the complete data set for that animal was included in calculating size of home range. Ninety-five percent home range isopleths were constructed using adaptive nearest neighbor convex hull methods (Getz et al., 2007). Animals whose home ranges did not stabilize in size were excluded from subsequent analyses. Given the varying age, dominance, and sex of the animals that were collared, and that home range composition between packs with collared animals may vary; we assumed that all factors influencing stabilization of size of home range were captured sufficiently. For individuals whose home range stabilized, monthly home ranges were constructed according to Getz et al. (2007) to examine short-term and seasonal variations in home range composition and size.

Overall and monthly home ranges were overlaid onto habitat maps developed by NC GAP to determine percent composition of home ranges. Habitat types included agricultural fields, wetlands, upland forests, lowland forests, successional fields, and pocosin (areas covered with evergreen vegetation and inundated with water). We used one-way ANOVA to test for differences in overall home range size among age classes and Student's *t*-tests to test for a difference in home range size between sexes. Student's *t*-tests were also used to determine if seasonal variation in monthly home range size and composition for each habitat type were

significantly different. Following previous studies (Phillips et al., 2003; Chadwick et al., 2010; Hinton et al., 2010), we recognized a summer (April – September) and winter (October – March) season. Significance was set at $\alpha \leq 0.05$.

***Habitat use and selection analyses*:** Resource selection functions (RSFs; Manly et al., 2002) were used to examine 2nd order (home range) and 3rd order (within home range) habitat use by red wolves (Johnson, 1980). Resource selection functions were developed using use/availability data with a binomial distribution (Manly et al., 2002).

For 2nd order habitat use, we considered the entire 5 county red wolf recovery area as available habitat and all locations of each GPS-collared animal occurring within its respective 95% home range (Getz et al., 2007) as used habitat. For 3rd order habitat use, the entire 95% home range (Getz et al., 2007) was considered to be available. All locations of each animal contained within its respective 95% home range were combined to examine 2nd and 3rd order habitat use for the entire population. An equal number of random points, compared to locations, were generated within the available areas for 2nd and 3rd order habitat use, respectively. Distance to road and water, human density (people per square mile), and habitat type were determined for all used and random locations. Habitat types were the same as those for determining home range composition. After combining used and random locations for each order of habitat use, RSFs were developed for each order of habitat use which contained habitat type, distance to roads and water, human density, and all biologically meaningful interactions (habitat type by distance to roads, habitat type by human density, and distance to roads by human density). Animals were monitored for varying lengths of time, had different numbers of locations, were of different age classes, and different sexes. Therefore each animal could have potentially influenced the RSFs more or less than another animal. Thus to make sure that no animal biased the RSFs, preliminary 2nd and 3rd order RSFs were developed using a sampling with replacement method in which each animal was excluded once from calculation of a RSF while all other animals were included. For the 3rd order RSF, a random effect for animal was included in the RSFs to account for differences in habitats available to each animal. Akaike's information criterion corrected for small sample sizes (AICc) was used to choose the most parsimonious RSF from the global (all possible variables included) RSF and all possible subsets for each order of habitat use (Burnham and Anderson, 2002). Twenty-five percent of used and random locations for each order of habitat use were not used in developing all RSFs to evaluate fit of most parsimonious RSFs using cross-validation (Johnson et al., 2006). The most parsimonious RSFs that were shown to have a good fit to the data were projected in a GIS to create habitat suitability maps depicting areas of high, medium, and low quality habitat and probability of occurrence of red wolves.

AICc weights of most parsimonious 2nd and 3rd order RSFs were compared to determine whether habitat type, distance to roads and water, and density of humans were scale dependent for red wolves. The RSF with the greatest AICc weight demonstrated the scale at which the variables of interest and associated interactions influenced habitat use the most. Statistical analyses were conducted in R 2.11.1 (R Development Core Team 2010) and spatial analyses using ArcGIS 10 (ESRI® ArcMap™ 10, Copyright © 1999-2010 ESRI Inc.) and Geospatial Modeling Environment 0.5.3 (Beyer, H. L., Copyright © 2001-2010 Spatial Ecology LLC).

Objective 2: Evaluate the significance of red wolf habitat changes anticipated from the proposed highway project from Columbia NC to the US 64/264 intersection.

***Quantifying barrier effects using passage rates*:** Following Dodd et al. (2007), we quantified the barrier effects of US 64 by calculating a permeability index. A permeability index is a passage rate measuring an individuals willingness to attempt a road crossing and is calculated by using the following equation: #crossings/(#crossings + #approaches), where an approach is defined as a red wolf entering into a 164 ft. buffer zone around the highway without crossing (see Figure 2). The 164 ft. (50 m) buffer zone was determined by measuring the distance between US 64 and the boundary of the closest red wolf home range (95% MCP) to the highway. This was done to exclude movements within a home range from being counted as an approach. The permeability index ranges from 0 to 1, with 0 indicating an impermeable road and 1 indicating 100% permeability. Permeability indices were calculated for the 30-minute and 5-hour data sets separately. An overall permeability index (using total number of crosses and approaches from all study animals) for the duration of the study was calculated as well as monthly permeability indices. We used a paired t-test to compare monthly permeability indices calculated using the 30-minute and 5-hour data sets.

Using 30-minute monthly permeability indices, regression analysis was then used to determine if a relationship existed between monthly permeability indices and monthly traffic flow along the existing US 64.

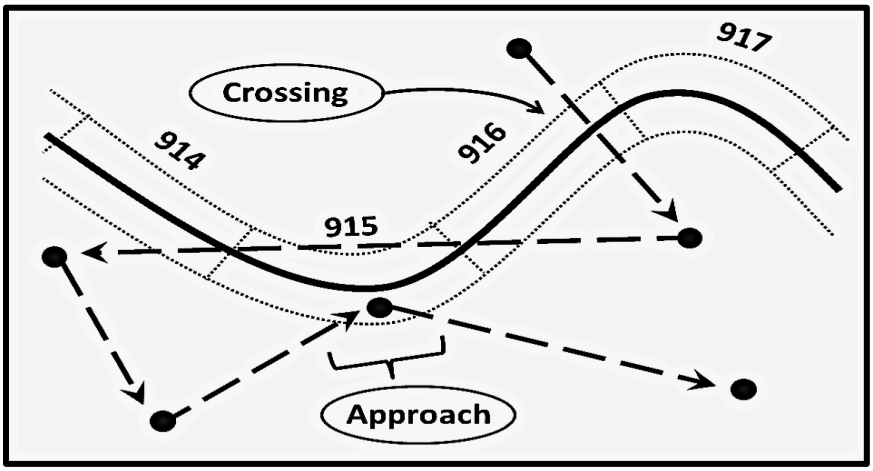


Figure 2. A **crossing** was defined as a line connecting two points on opposite sides of a road that intersects the roadway. An **approach** was defined as any excursion from a point further than 164 ft. from the road to a point within 164 ft., and then back, *without* crossing.

Assessing the effect of the highway widening on current red wolf territories: To determine the potential for the highway widening to displace current red wolf packs, buffers at ~ 164 ft. (50 m) intervals were constructed around the current US 64. The buffers were then overlaid on current red wolf home range locations and the number of home ranges intersected by each buffer was counted. Where the buffers intersected home ranges, the percent of total home range intersected was calculated. As with the home range analysis above, only one home range per pack was used when the movements among individuals of a pack were correlated.

Assessing the effect of the highway widening on important red wolf habitat: To determine the potential for the highway widening to affect important red wolf habitat, buffers around the current US 64 at ~164 ft. (50 m) intervals were overlaid on a habitat map. The area of available red wolf habitat was then calculated within each buffer zone.

Objective 3: Identify significant red wolf crossing areas to determine where wildlife crossing structures or other design features could be placed to minimize adverse project effects on wolves.

***Determining crossing locations and rates using GPS collars*:** Because of the occurrence of different collar schedules, wolf locations were sub-sampled into both 5-hour and 30-minute intervals. The following methods were used to analyze data collected for each frequency, 5-hour and 30-minute, respectively. Using ArcGIS v9.3 (ESRI® ArcMap™ 9.3, Copyright © 1999-2010 ESRI Inc.), we divided the 27.3 mi-section of US 64 into 273 segments, each 0.10 miles long. To determine road crossings, we used the Home Range Tools v9 extension for ArcGIS to calculate the travel path of each individual by connecting consecutive GPS fixes. We then overlaid the travel paths on the segmented highway layer and counted the number of crossings per highway segment for each individual. A crossing was defined as two consecutive fixes on opposite sides of the highway (see Figure 2). Crossing rates for each individual were determined by dividing the number of crossings by the number of days the collar was actively collecting data for each collection frequency sub-sample. Total crossing frequencies per segment were plotted in a histogram to identify the location of key red wolf crossing areas.

***Statistical Analysis*:** To test the hypothesis that the crossing distribution calculated using GPS collar locations was different from a random crossing distribution, an equivalent number of random line segments were drawn between the GPS locations for each red wolf. To approximate actual red wolf movement, random segment lengths were constrained to less than or equal to the maximum distance moved by a red wolf for the 30-minute and 5-hour data sets, respectively. Crossing frequencies for the random segments were calculated for each highway segment following the methods above. The distributions for the GPS crossing frequencies and the random crossing frequencies were compared using a Kolmogorov-Smirnov test (Clevenger et al., 2001). We used a t-test to test for differences in crossing rates between male and female wolves and a one –way ANOVA to test for differences in crossing rates among age classes.

Determining crossing locations using Camera Traps: Even with 30-minute locations, the GPS collars likely did not catch all red wolf crossing events. To capture additional crossing events, remote cameras were placed at canal crossings along the 27.3 mi stretch of US 64 within 328 ft. (100 m) of the roadside. Because drainage canals exist along the entire length of US 64, canal crossings serve as an access point for animals to reach the highway. We used both film and digital remote cameras triggered by laser or heat disturbance. All cameras were active 24-hours per day to maximize the number of crossings captured. Cameras were active from July 2009 to March 2011. However, the number of trap nights varied for each camera station so captures were reported per 100 trap nights. To avoid pseudoreplication, consecutive photos of an individual animal were considered a single event.

Using GPS locations, camera stations were associated with one of the 273 segments along US 64. Not all segments had camera stations. Total crossing frequencies per segment were plotted in a histogram to identify the location of key red wolf crossing areas as identified by cameras.

Evaluating habitat characteristics at crossing sites identified by GPS collar locations: Using the NC GAP habitat map, we extracted the habitat type for each of the 273 highway segments at 164 ft. (50 m) intervals starting at the road to a distance of 656 ft. (200 m) perpendicular to the segment (ArcGIS v9.3). Segments that had at least one crossing were coded with a 1 and segments without crossings were coded with a 0. Logistic regression was used to evaluate 5 *a priori* models developed using site-specific habitat type at different distance intervals and the occurrence of a red wolf crossing. The most parsimonious model was chosen using AIC corrected for small sample size (AICc) (Burnham and Anderson, 2002), with models ranked using ΔAICc.

Evaluating habitat characteristics at crossing sites identified by camera traps:
Using the NC GAP habitat map, we extracted the habitat type for each of the camera stations at 164 ft. (50 m) intervals starting at the camera sites to a distance of 656 ft. (200 m) perpendicular to US 64 (ArcGIS v9.3). In addition, the width of the access road/trail was measured at each camera station. Camera sites that captured red wolves were coded with a 1 and camera sites that did not capture red wolves were coded with a 0. Logistic regression was used to evaluate 5 *a priori* models developed using habitat variables and trail width at camera placement. The most parsimonious model was chosen using AIC corrected for small sample size (AICc) (Burnham and Anderson, 2002), with models ranked using ΔAICc.

Results

Capturing and collaring of animals: Between January 2009 and April 2011, the USFWS Red Wolf Team deployed 32 of 40 collars. Due to a decrease in red wolf population in Washington County, North Carolina, the 8 collars reserved for red wolves living in the vicinity of the previously expanded portion of US 64 could not be deployed. Thirteen of the 32 collars deployed were placed on females (8 adults, 5 juveniles) and 19 on males (8 adults, 11 juveniles). The average collar deployment was 14.8 months (range: 4 to 30 months) and average collar success in obtaining GPS locations was 86.0% (range: 63.6% to 97.5%). In total, 39, 573 successful red wolf locations were collected. We used 6 different collar schedules: 30-minute locations for 5 hours per day, 5-hour locations, 5-hour locations with the nested 30-minute schedule for 5-hours per day, 11-hour locations, 12-hour locations, and 23-hour locations (Table 1).

Table 1. Summary of collar statistics for collared red wolves in Dare, Tyrrell, Washington, Beaufort, and Hyde Counties, NC.

Pack/Area	Collar ID	Sex	Birth Year	Length of Collar Deployment (months)	Reason for Removal	Collar Schedule	Collar Success (%)
Milltail	974	M	2005	30	Found Dead	5hr RO*	96.20
Milltail	1779/1883	M	2006	28	Died	30 min w/5hr RO	90.80
Milltail	1912/1896	F	2004	28	On recovery	30 min w/5hr RO	
Bombming range	1910	F	2007?	6	Found Dead	5hr RO	79.80
Milltail	1777/1893	F	2008	21	Shot	30 min w/5hr RO	91.10
Milltail	1913/1905	M	2008	22	Collar Broken	30 min	
Milltail	1911/1889	F	2008	21	Breeding Female	30 min	82.60
Tyson	1778	M	2008	21	Going to be paired w/F	5hr RO	80.20
F2	1916	F	2007	22	Breeding Female/ paired w/M	5hr RO\23hr RO\30 min w/5hr RO	85.50
Sunnyside	1915	M	2007	23	Collar in Recovery	30 min w/5hr RO	85.40
Timberlake	1901	F	2004	18	Breeding Female	5hr RO\30 min w/5hr RO	86.50
Waupaupin	1894	M	2007	17	On recovery	11hr RO\30 min w/5hr RO	
Gator	1895	F	2000		Still Deployed	12hr	
Davis Fields	1880	F	2001	7	Shot	5hr RO	69.00
Mannings	1881	M	2006	7	Not near any roads	5hr RO	63.60
L-Block	1892	F	2006	5	Breeding Female	30 min w/5hr RO	80.60
Columbia	1906	M	2005	12	On recovery	5hr RO\30 min w/5hr RO	
Bishops	1902	F	2008	9	Breeding Female/ paired w/M	30 min w/5hr RO	94.00
Columbia	1900	F	2007	12	Breeding Female/ paired w/M	30 min w/5hr RO	72.20
Lil' Alligator	1882	M	2008	10	Going to be paired w/F	30 min w/5hr RO	91.50
Frying Pan	1909	F	2008	16	Breeding Female/ paired w/M	30 min	94.50
Tyson	1884	M	2006		Still Deployed	30 min	
Milltail	1891	M	2009	4	Hit by Car	30 min	97.50
Swindell	1887	M	2009		Still Deployed	30 min w/5hr RO	
Milltail	1904	M	2008	11	Died	30 min	84.40
Beech Ridge	1897	M	2008		Still Deployed	30 min w/5hr RO	
Swindell	1908	M	2009		Still Deployed	30 min w/5hr RO	
Beech Ridge	1903	F	2008	14	Breeding Female	30 min w/5hr RO	84.40
East Lake	1777	M	?	9	On recovery	30 min w/5hr RO	
Camerons	1898	M	2008	1	Shot	30 min	95.60
Killkenny	1907	M	2009	13	Management Purposes	30 min	94.30
Killkenny	1888	M	2009	12	Management Purposes	30 min	92.80

* RO = Rollover. A rollover schedule collects locations continuously at a set time interval without resetting at the start of each day.

Objective 1: Evaluate wolf habitat use along the entire US 64 corridor from Plymouth NC to the US 64/264 intersection

***Home range analyses*:** Movements of individuals within the same pack were highly correlated (r_s = 0.87–0.91); therefore only 1 animal per pack (chosen randomly) was used in the following analyses. After removing those individuals where multiple animals in a pack were collared, we calculated cumulative weekly home ranges for 21 of 32 animals (Figure 3). Following analysis, we removed 5 (1 juvenile, 2 dispersers, 2 adults) additional individuals from our sample due to an inadequate number of locations to capture a complete home range. Overall home range varied between 2.61 mi^2 and 38.19 mi^2 with a mean of 12.93 ± 9.50 mi^2

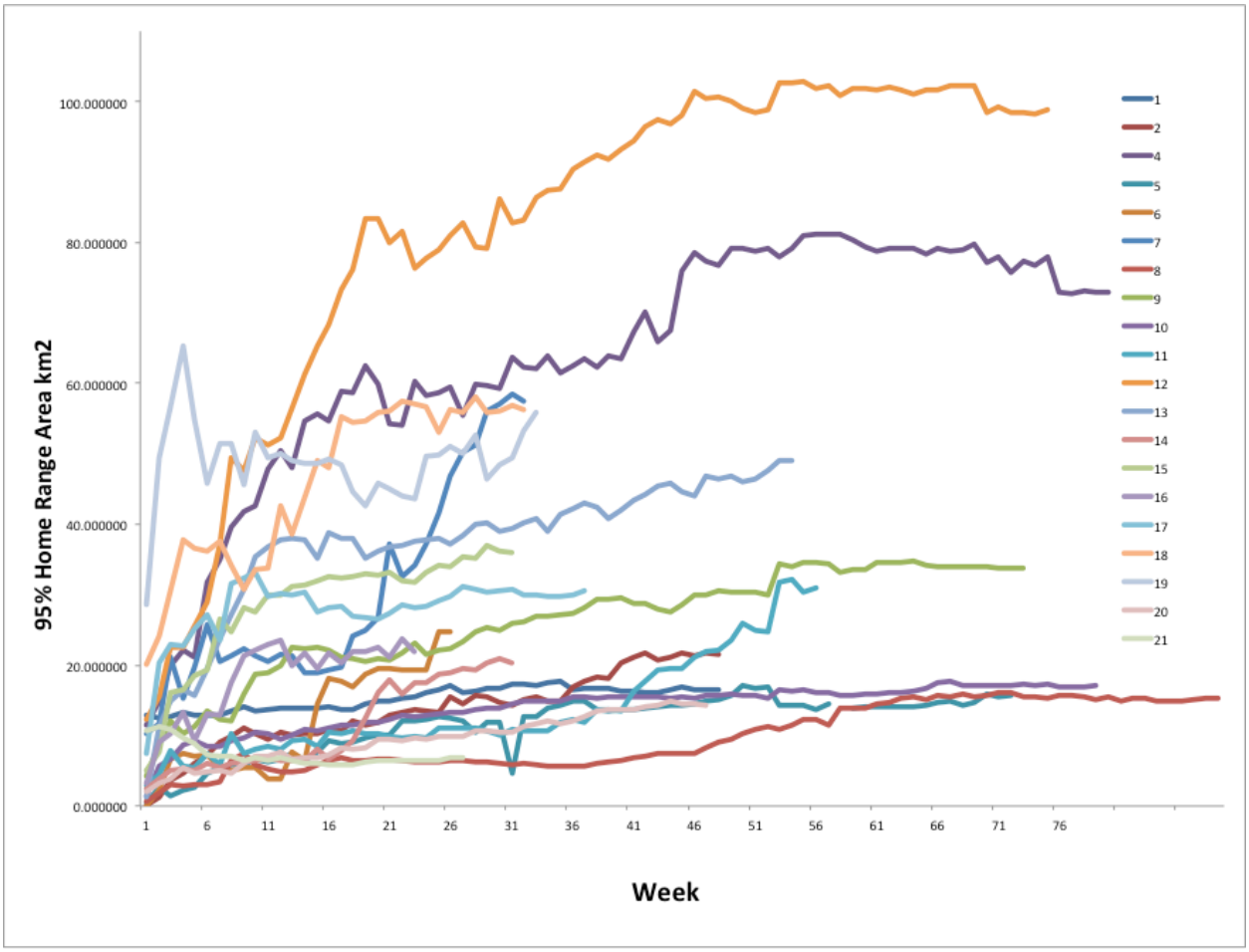


Figure 3. To determine if an adequate number of locations were obtained from each wolf to capture home range area, rarefaction curves of cumulative weekly home ranges were calculated for 21 red wolves of different age groups and sexes collared from January 2009 to April 2011. A home range is considered to be at equilibrium at the point that the home range area no longer increases and reaches a plateau (Bekoff and Mech, 1984). Home range did not reach equilibrium for 5 of the 21 wolves in our sample (6, 7, 11, 13, 14), thus they were excluded from further home range analyses. Collared red wolves were located in Tyrell, Dare, Washington, and Hyde Counties, NC.

Although home range size among age classes (F =2.71, P =0.14) and between sexes (t_{10} = 2.10, P = 0.57) did not differ significantly (Tables 2 and 3), the home range size of dispersers tended to be larger than those of juveniles or adults. Five of 8 animals that died while collared were dispersing and 2 additional dispersers were removed from further home range analyses due to inadequate data.

Table 2. Average and range of 95% home range areas for three age classes of red wolves. A local convex hull method was used to calculate home range from GPS collar locations. The home range analysis was generated from 16 red wolves collared in Washington, Tyrell, Dare, Hyde, and Beaufort Counties, NC from January 2009 to April 2011.

	Juvenile	Disperser	Adult
n	3	3	10
Average (mi^2)	9.15	21.86	15.29
Min (mi^2)	5.93	21.61	2.61
Max (mi^2)	11.95	22.21	38.19

Table 3. Average and range of 95% home range areas for male and female red wolves. A local convex hull method was used to calculate home range from GPS collar locations. The home range analysis was generated from 16 red wolves collared in Washington, Tyrell, Dare, Hyde, and Beaufort Counties, NC from January 2009 to April 2011.

	Male	Female
n	9	7
Average (mi^2)	14.54	12.11
Min (mi^2)	2.61	5.52
Max (mi^2)	38.19	22.21

Home ranges were composed primarily of agricultural fields with 95% home range isopleths on average containing 55% agricultural fields (Table 4). Summer home ranges were between 0.77 and 3.09 mi^2 smaller (t_{10} = -4.84, P < 0.01) than winter home ranges (Table 5). Average monthly home range percent composition was different between summer and winter. Red wolves increased their use of pocosin (t_{10} = -2.65, P =0.03), wetlands (t_{10} = -4.29, P < 0.01), and upland forests (t_{10} = -4.17, P < 0.01) in late winter and increased use of agricultural fields (t_{10} = 3.44, P < 0.01) in summer months (Table 6). Agricultural fields and successional fields account for over 65% of habitat composition regardless of season.

Table 4. Average composition of 95% home ranges for 16 red wolves collared in Washington, Tyrell, Dare, Hyde, and Beaufort Counties, NC from January 2009 to April 2011.

Habitat Type	Average %
Pocosin	6
Lowland Forests	6
Successional Fields	13
Upland Forests	12
Wetlands	8
Agricultural Fields	55

Table 5. Average monthly 95% home range areas for 16 red wolves collared in Washington, Tyrell, Dare, Hyde, and Beaufort Counties, NC from January 2009 to April 2011.

Month	95% isopleth (mi^2)
January	7.56
February	5.97
March	5.71
April	4.31
May	4.54
June	4.98
July	4.84
August	4.84
September	5.73
October	6.60
November	6.54
December	6.36

Table 6. Average monthly percent habitat composition calculated using a 95% home range for 16 red wolves collared in Washington, Tyrell, Dare, Hyde, and Beaufort Counties, NC from January 2009 to April 2011.

Month	95% range isopleth percent habitat composition					
	Pocosin	Lowland Forests	Successional Fields	Upland Forests	Wetlands	Agricultural Fields
January	10	4	16	5	6	59
February	5	4	15	16	8	51
March	6	7	13	12	8	54
April	3	4	13	11	5	64
May	2	3	14	9	4	67
June	2	3	16	7	3	69
July	1	2	13	5	2	76
August	1	3	14	7	3	71
September	3	5	13	7	5	66
October	3	4	15	8	6	64
November	2	3	17	7	5	66
December	5	4	16	7	7	59

***Habitat use and selection analyses*:** We used 29,680 locations of red wolves to construct the 2nd and 3rd order resource selection functions (RSFs), respectively (Johnson, 1980). Second order RSF predicted a patchy distribution of red wolves across the 5-county red wolf recovery area (Figure 4). Third order RSF predicted a relatively equal probability of habitat use by red wolves across a given home range (Figure 5). RSFs calculated for each individual wolf included the same variables as the most parsimonious 2nd and 3rd order RSFs. Thus, despite the fact that collars were deployed on wolves of all ages and both sexes over a range of collar deployment periods (2009, 2010, and 2011) and deployment lengths (4 to 30 months), no one animal was considered to bias the RSFs in a unique way different from other animals. The most parsimonious 2nd order RSF contained: habitat type, distance to roads and water, human density, an interaction between distance to road and habitat type, and an interaction between human density and habitat type (Table 7). The AICc weight of the most parsimonious 2nd order RSF was 0.98. The next most parsimonious RSF included an interaction between human density and distance to road, and had a ΔAICc of 8 and an AICc weight of 0.02. Agricultural fields were more likely to be used than all other habitat types. Likelihood of habitat use by red wolves decreased as human density increased, distance to road increased, and distance to water sources (e.g. steams and ponds) decreased. As distance to road increased, lowland forest, pocosin, and wetland habitats were disproportionately less likely to be used by red wolves than other habitat

types. As human density increased, upland forests and wetlands were more likely to be used by red wolves than other habitat types.

The most parsimonious 3rd order RSF contained: 5 habitat types, distance to roads, and distance to water sources (e.g. steams and ponds) (Table 8). The AICc weight of the most parsimonious 3rd order RSF was 0.75. The next most parsimonious RSF included habitat type, distance to water, and human density, and had a ΔAICc of 2 and an AICc weight of 0.25. Again, agricultural fields were more likely to be used than all other habitat types. Likelihood of habitat use by red wolves decreased as distance to roads and water increased.

To test the validity of our selected 2nd and 3rd order RSF models, we overlaid 9,893 red wolf locations withheld from the initial analysis on the resulting probability maps (Figures 4 and 5). The GPS-collar locations (observed) overlapped areas identified as high probability of red wolf occurrence (expected) for both 2nd ($t_1 = 0.79$, $P > 0.05$) and 3rd order ($t_1 = 1.06$, $P > 0.05$) RSFs.

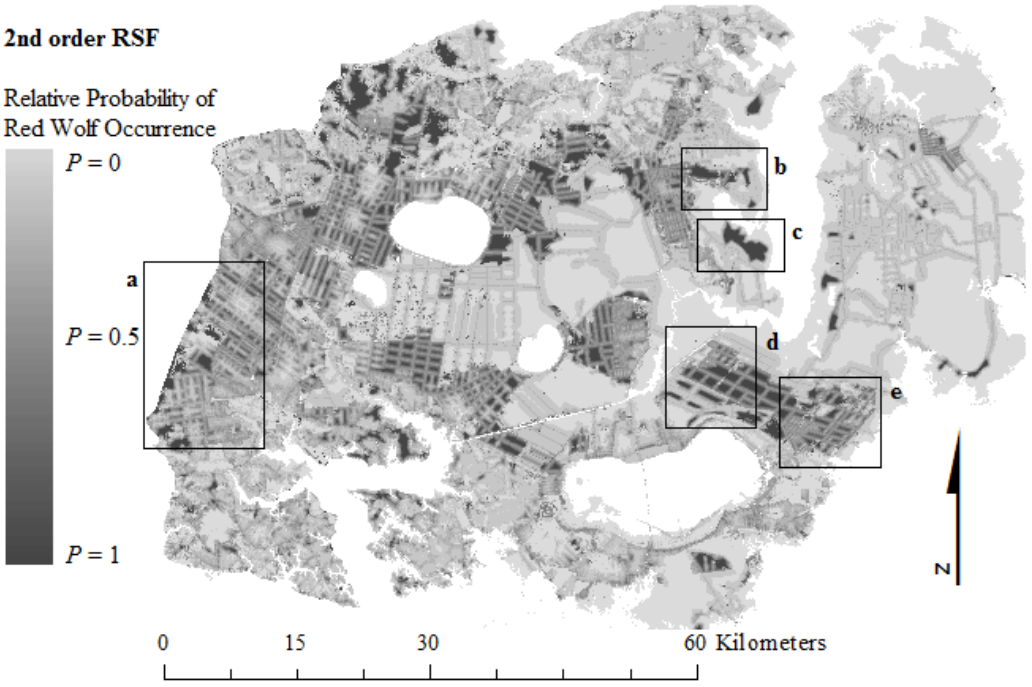


Figure 4. Relative probability of occurrence of red wolves (*Canis rufus*) across Washington, Tyrrell, Dare, Hyde, and Beaufort Counties, North Carolina with respect to 2nd order habitat use, 2009-2011. a) Relative location of packs no longer in existence but identified as habitat with high relative probability of occurrence of red wolves; b-e) Relative location of packs not represented in our dataset but in existence at the time of this study.

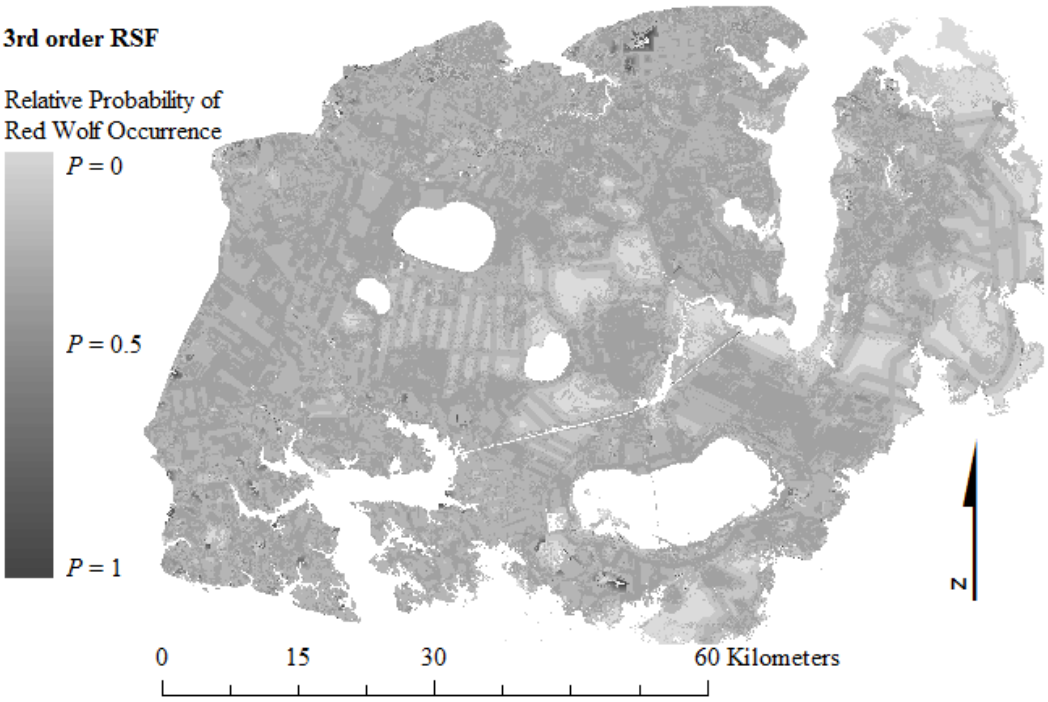


Figure 5. Relative probability of occurrence of red wolves (*Canis rufus*) across Washington, Tyrrell, Dare, Hyde, and Beaufort Counties, North Carolina with respect to 3rd order habitat use, 2009-2011.

Table 7. Most parsimonious 2nd order RSF, according to AICc, for habitat use of red wolves in Washington, Tyrrell, Dare, Hyde, and Beaufort Counties, North Carolina from 2009-2011.

2nd order RSF (AICc weight = 0.98)				
Coefficient	Estimate*	SE	Lower CI	Upper CI
Intercept	0.62	0.04	0.54	0.7
Successional Field	-0.21	0.09	2.68E-03	3.02E-03
Lowland Forests	-0.82	0.11	-1.04	-0.59
Pocosin	-0.67	0.09	-0.84	-0.5
Upland Forests	-0.95	0.08	-1.11	-0.79
Wetlands	-0.81	0.08	-0.96	-0.66
Dist. to Road	-1.29E-03	1.10E-04	-1.50E-03	-1.10E-03
Dist. to H20	2.85E-03	0.04	2.70E-03	3.00E-03
Human Density	-0.08	5.00E-03	-0.09	-0.07
Dist. To Road x Lowland Forests	-2.70E-03	3.40E-04	-3.37E-03	-2.04E-03
Dist. To Road x Pocosin	-2.79E-03	2.16E-04	-3.21E-03	-2.37E-03
Dist. To Road x Wetlands	-2.48E-03	2.08E-04	-2.88E-03	-2.07E-03
Human Density x Upland Forests	0.09	0.01	0.08	0.1
Human Density x Wetlands	0.08	0.01	0.07	0.1

*The estimate is the logistic regression coefficient which describes the size and direction of the influence of each variable

Table 8. Most parsimonious 3rd order RSF, according to AICc, for habitat use of red wolves in Washington, Tyrrell, Dare, Hyde, and Beaufort Counties, North Carolina from 2009-2011.

3rd order RSF (AICc weight = 0.75)				
Coefficient	Estimate*	SE	Lower CI	Upper CI
Intercept	0.58	0.01	0.56	0.6
Successional Fields	-0.07	0.01	-0.09	-0.05
Lowland Forests	-0.1	0.01	-0.13	-0.08
Pocosin	-0.11	0.01	-0.13	-0.08
Upland Forests	-0.1	0.01	-0.12	-0.08
Wetlands	-0.12	0.01	-0.14	-0.1
Dist. To Road	-4.49E-05	2.56E-05	-9.50E-04	-1.80E-05
Dist. To Water	-1.28E-04	2.25E-05	-1.72E-04	-8.37E-06

*The estimate is the logistic regression coefficient which describes the size and direction of the influence of each variable

Objective 2: Evaluate the significance of red wolf habitat changes anticipated from the proposed highway project from Columbia to the US 64/264 intersection.

***Quantifying barrier effects using passage rates*:** Though 3 times as many crossings were recorded using the 30-minute collar schedule compared to the 5-hour schedule, the overall permeability for US 64 calculated from both collar schedules was approximately 100% (Table 9). No difference in monthly permeability index was found between the 30-minute and 5-hour collar scheduled ($t_{10} = 0.045$, $P = 0.48$). No relationship ($F=0.021$, $P=0.89$, $r^2=1.0$) was found between monthly permeability and monthly traffic flow (Figure 6).

Table 9. Permeability index for US 64 between Columbia, NC and the US 64/264 intersection in Manns Harbor, NC. The permeability index was calculated by dividing the number of highway crossings by (the number of highway crossings + the number of approaches). Road crossings were determined using red wolf GPS-collar locations collected between January 2009 and April 2011. A permeability index of 1 represents a highly permeable road while an index of zero indicates impermeability.

Collar Schedule	No. of Wolves	No. of Crossings	No. of Approaches	Permeability Index
5-hour	6	25	0	1.00
30-minute	8	76	1	0.99

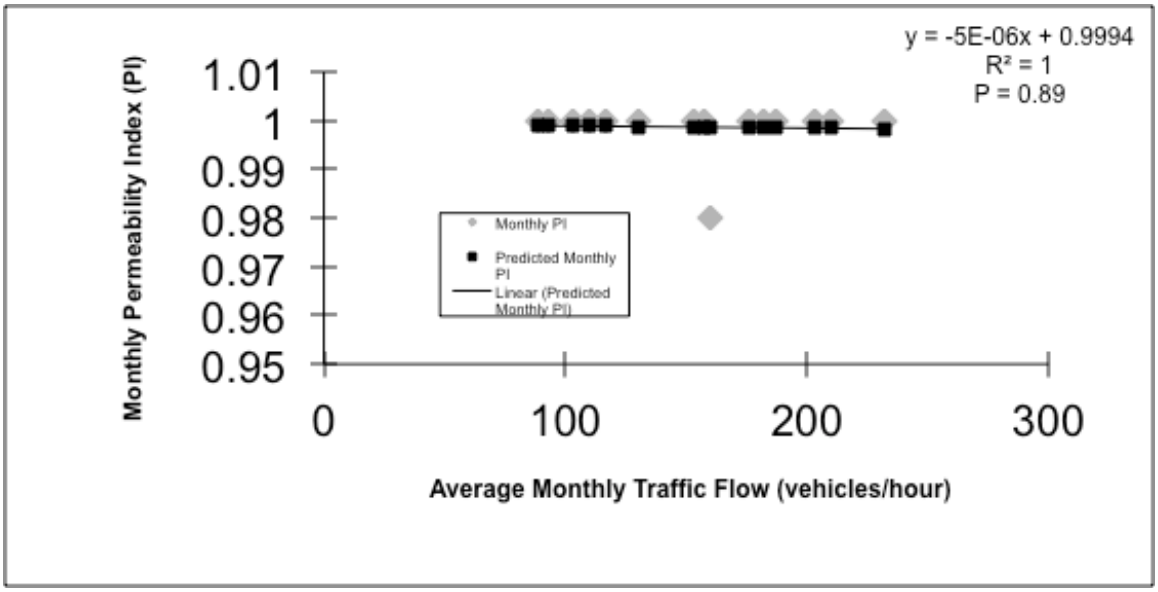


Figure 6. Regression analyzing the relationship between monthly permeability index and average monthly traffic flow rates (vehicles/hour). The monthly permeability index was calculated using GPS-collar data on the 5-hour schedule from 6 red wolves between March 2009 and May 2010 in Tyrrell and Dare Counties, NC.

Assessing the effect of the highway widening on current red wolf territories: Buffers around US 64 to a distance of 3281 ft. (1000 m) in 164 ft. (50 m) increments overlaid on a map displaying current red wolf home ranges showed that 2 red wolf packs would be directly affected by a highway widening. One pack is located north of the current 2-lane highway in Tyrrell County and the second is south of the highway in Dare County, the only existing pack in Alligator River National Wildlife Refuge. The proportion of home range to be affected in Tyrell County ranges between 0.11% and 6.63% (Table 10) and is located between 820 ft. (250 m) and 3218 ft. (1000 m) from the existing highway just east of Columbia, NC where the previously widened portion of US 64 narrows to a 2-lane highway (Figure 7). In Dare County, the proportion of home range that would be affected ranges between 0.01% and 20.31% (Table 11) and is located south of US 64 between River Rd. and Bear Rd. on Alligator River National Wildlife Refuge (Figure 8).

Assessing the effect of the highway widening on important red wolf habitat: Important red wolf habitat is defined as, following the results of the resource selection function analysis in objective 1, agricultural fields, successional fields, and upland forests. Buffers at 164 ft. (50 m) increments extending out to a distance of 3281 ft. (1 km) from US 64 overlaid on the NC GAP habitat map revealed that construction to the north of the current US 64 in Tyrrell County would remove more red wolf habitat than construction to the south. The opposite was found in Dare County, with more red wolf habitat at risk south of the current US 64 than north (Figures 9 and 10). If highway construction were to disturb the entire area between the existing US 64 and the 3281 ft. (1 km) buffer, a total of 0.16 mi^2 of red wolf habitat will be removed north of the highway vs. 0.09 mi^2 south of the highway in Tyrrell County. For Dare County, 0.04 mi^2 would be removed north of the highway vs. 0.07 mi^2 south of the highway if construction were disturb the whole area between the existing US 64 and the 3281 ft. (1 km) buffer.

Table 10. The proportion of a red wolf pack home range that will be directly affected by highway construction in Tyrell County between 820 ft. and 3218 ft. from the existing highway. The red wolf pack is located north of US 64 east of Columbia, NC where the previously widened portion of US 64 narrows to a 2-lane highway.

Distance from US 64 (ft)	Area of Home Range Intersected (ft^2)	Percent of Total Home Range Intersected
820	195312.38	0.11
984	603486.60	0.35
1148	1090902.45	0.64
1312	1643090.94	0.96
1476	2267019.48	1.33
1640	3024945.23	1.77
1804	3804239.09	2.22
1969	4595883.17	2.69
2133	5399701.05	3.16
2297	6215641.60	3.63
2461	7043620.94	4.12
2625	7883536.99	4.61
2789	8735389.60	5.11
2953	9599174.70	5.61
3117	10474842.94	6.12
3281	11335796.06	6.63

Table 11. The proportion of a red wolf pack home range that will be directly affected by highway construction in Dare County between 264 ft. and 3218 ft. from the existing highway. The home range is located south of US 64 in Alligator River National Wildlife Refuge between River Road and Bear Road.

Distance from US 64 (ft)	Area of Home Range Intersected (ft^2)	Percent of Total Home Range Intersected
246	13042.46	0.01
328	83853.62	0.04
410	216085.24	0.11
492	437479.56	0.23
574	748402.64	0.40
656	1263772.11	0.67
820	2790219.95	1.48
984	4548208.33	2.41
1148	6384017.38	3.39
1312	8293445.22	4.40
1476	10394240.80	5.51
1640	12531442.45	6.64
1804	14691958.47	7.79
1969	16867816.15	8.94
2133	19053292.57	10.10
2297	21293992.59	11.29
2461	23677537.88	12.55
2625	26280933.95	13.94
2789	28997590.89	15.38
2953	31868217.99	16.90
3117	34957184.80	18.54
3281	38297623.09	20.31

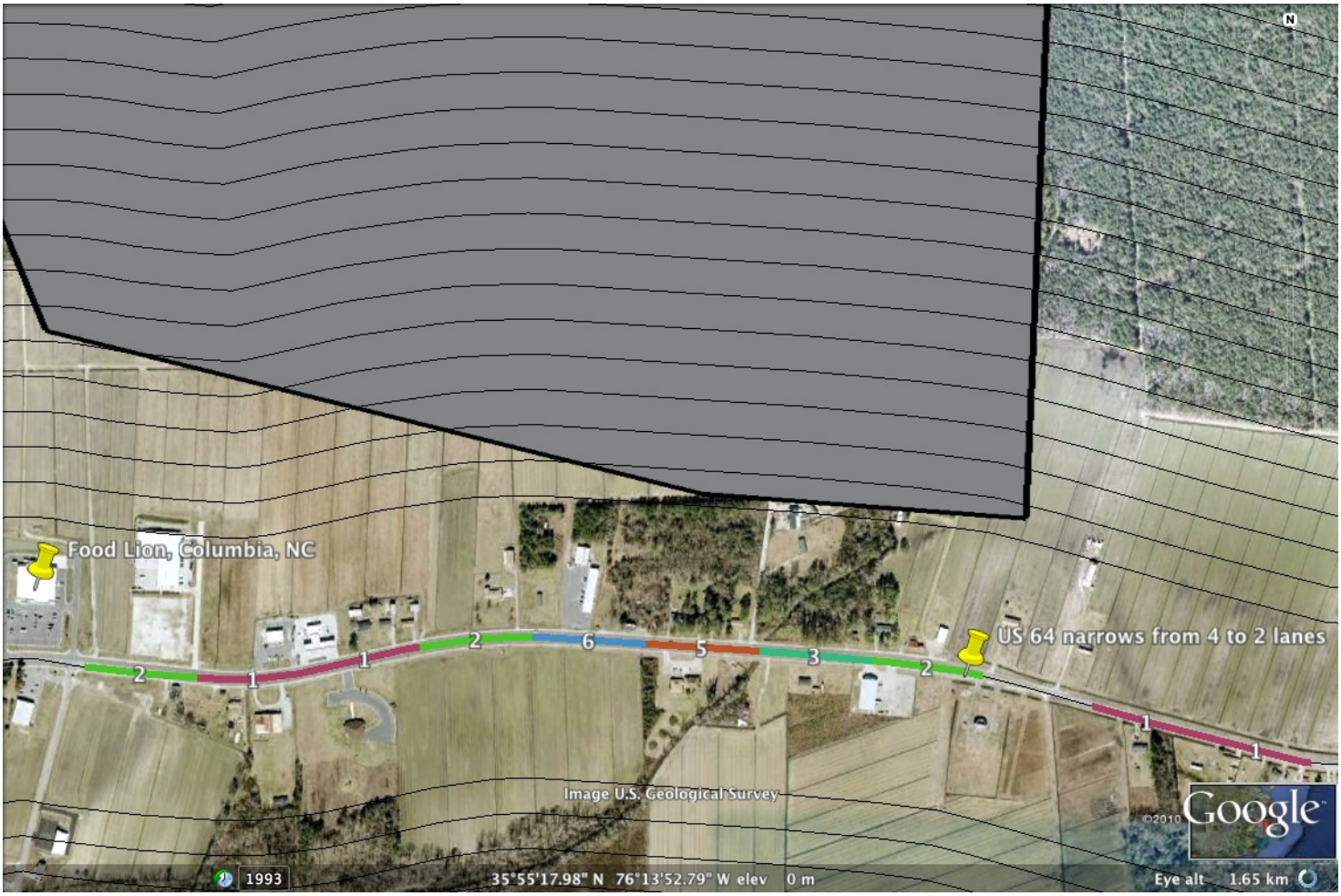


Figure 7. Location of the Tyrrell County red wolf pack home range with potential to be directly affected by highway construction. The home range extends to within 820 ft. from the existing highway where 4-lanes merge into 2-lanes just east of Columbia, NC. The highway buffer lines above (black lines) start at 820 ft. from US 64 and end at 3281 ft. in 164 ft. increments. If highway construction were to disturb the area between 820 ft. to 3281 ft. from the existing highway, 6.63% of this pack's home range would be removed. The numbers along US 64 indicate the number of red wolf highway crossings per 0.10 mi. segment captured using GPS-collar data collected between January 2009 and April 2011.

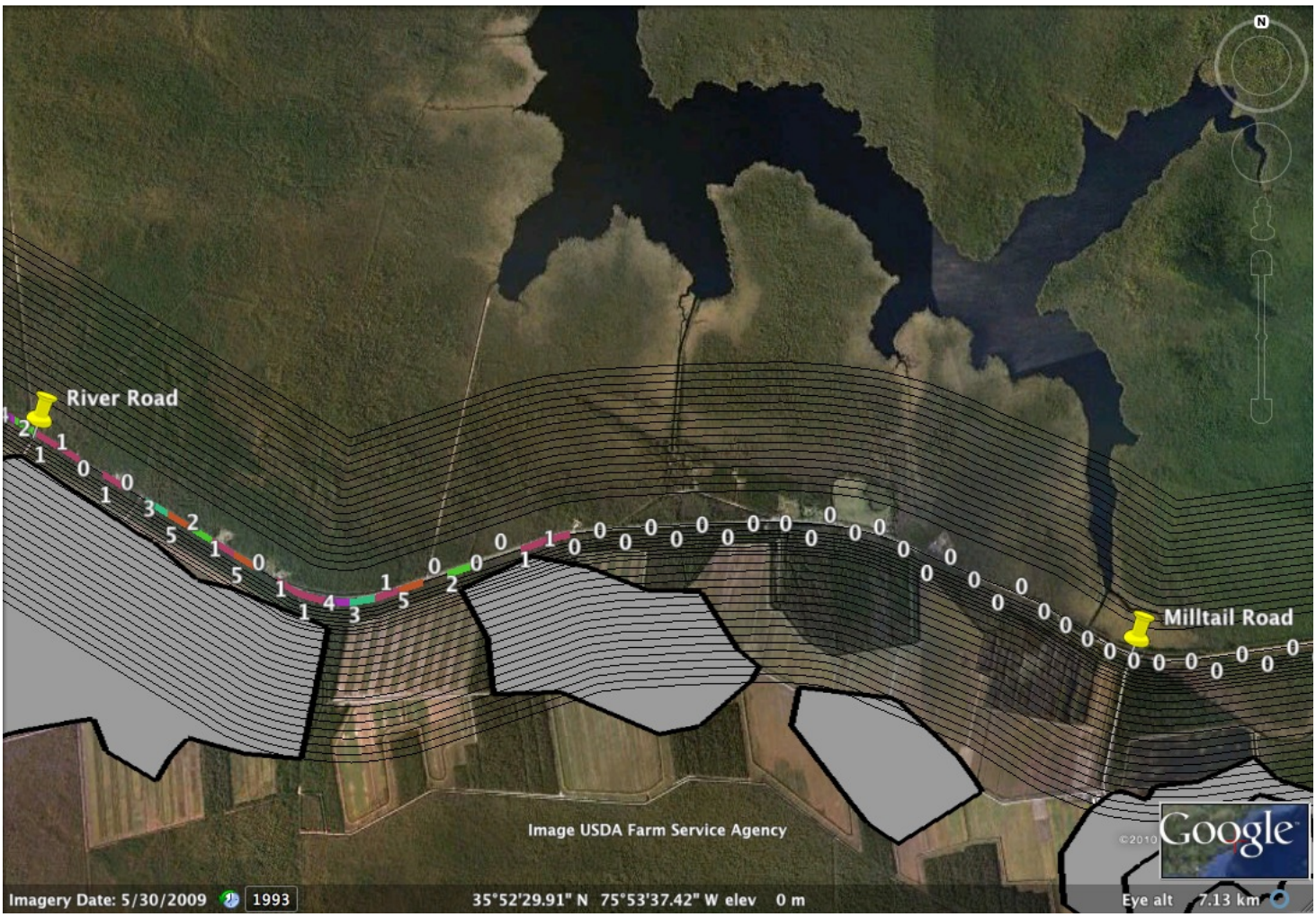


Figure 8. Location of the Dare County red wolf pack home range with potential to be directly affected by highway construction. The home range extends to within 264 ft. just south of the existing highway between River Rd. and Bear Rd. (east of Milltail Rd – not pictured) on Alligator River National Wildlife Refuge. This is the only red wolf pack on the refuge. The highway buffer lines above (black lines) start at 264 ft. from US 64 and end at 3281 ft. in 164 ft. increments. If highway construction were to disturb the area between 264 ft. to 3281 ft. from the existing highway, 20.31% of this pack's home range would be removed. The numbers along US 64 indicate the number of red wolf highway crossings per 0.10 mi. segment captured using GPS-collar data collected between January 2009 and April 2011.

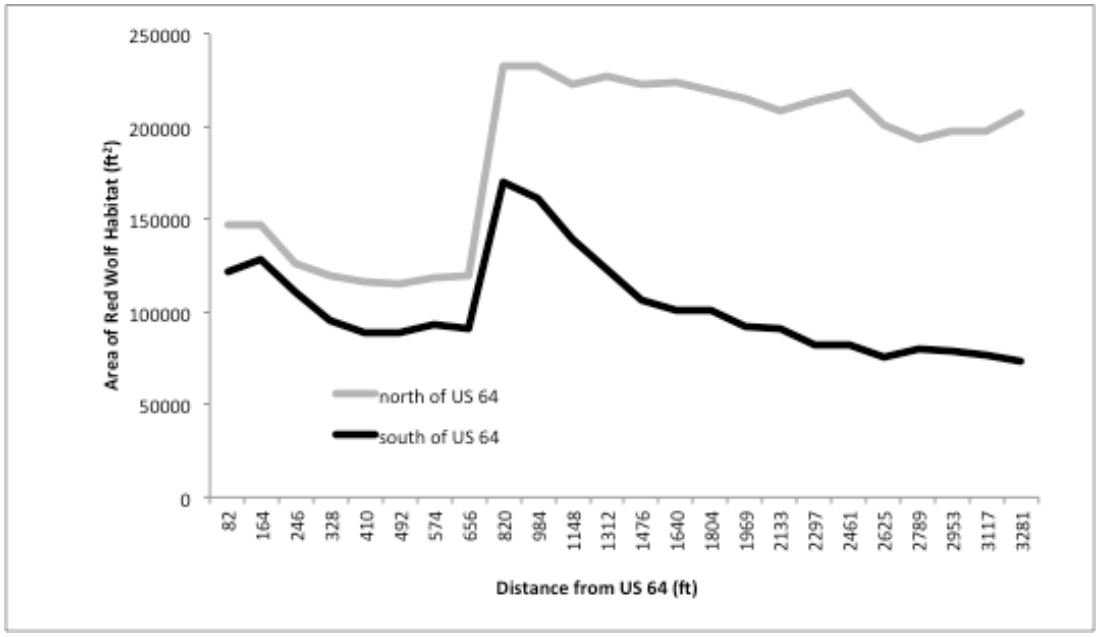


Figure 9. The area of important red wolf habitat per 164 ft. buffer for Tyrrell County, NC. Important red wolf habitat for eastern North Carolina includes agricultural land, upland forests, and early successional fields.

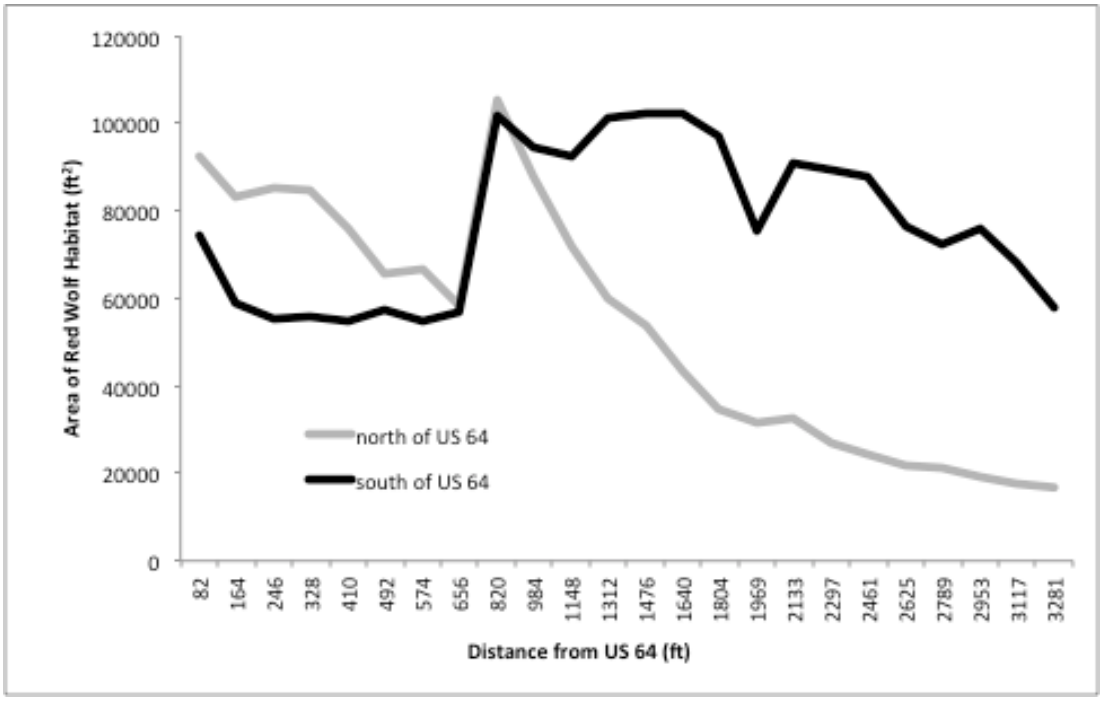


Figure 10. The area of important red wolf habitat per 164 ft. buffer for Dare County, NC. Important red wolf habitat for eastern North Carolina includes agricultural land, upland forests, and early successional fields.

Objective 3: Identify significant red wolf crossing areas to determine where wildlife crossing structures or other design features could be placed to minimize adverse project effects on wolves.

***Determining crossing locations and rates using GPS collars*:** Six wolves on the 5-hour schedule (3 M: 3 F) and 8 on the 30-minute schedule (4 M: 4 F), with 3 wolves that started on the 5-hour and were switched to the 30-minute schedule, displayed crossing activity around US 64 out of a total of 32 collars. Only wolves with home ranges along US 64 crossed the highway. Wolves on the 5-hour schedule crossed between 2 and 9 times while wolves on the 30-minute crossed between 2 and 20 times. Five wolves (1 M: 4 F) on the 30-minute schedule, subsampled every 5-hours for a paired t-test, crossed 53 (30-minute) and 19 times (5-hour), respectively (*P=0.030),* showing that the 30-minute schedule captured nearly 3 times the road crossings as compared to the 5-hour rollover.

An additional 5-hour wolf, (8-year-old female #1880; Figure 11), crossed the highway 266 times. On reviewing the distribution of her points, which extended about 11 miles along the highway, it was determined that US 64 bisected the core of her home range (Figure 12). Additionally, her movements in a narrow band surrounding the road increased the likelihood of "false crossings," where the line connecting consecutive points on either side of the highway did not necessarily represent the true crossing location. For these reasons, and because 1880 represented an unusual circumstance that heavily skewed the rest of the data, this wolf was considered an outlier and removed from all further analysis of US 64 GPS-collar data.



Figure 11. Photo of wolf #1880 (adult female) obtained by camera trap along US 64 in Tyrrell County, North Carolina in July 2009.

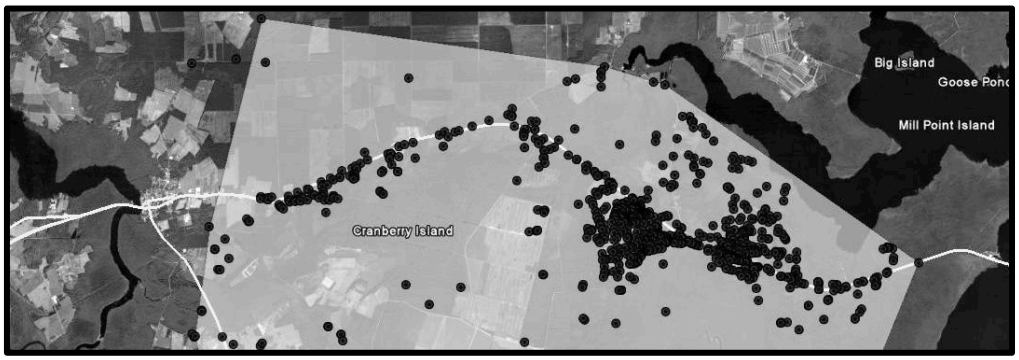


Figure 12. GPS-collar locations collected between April 2009 and November 2009 of wolf #1880 along US 64, Tyrrell County, North Carolina within its 95% MCP home range.

Although observed red wolf crossings and randomly generated crossings were both normally distributed, observed red wolf crossings occurred at a significantly lower frequency (*t=1.196, P=0.03*) and were bimodal as compared to the random crossings (Figure 13). Data from both the 5-hour and 30-minute schedules pointed to 2-crossing locations (Figures 14 and 15, respectively), 1 east of Alligator River in Dare County between miles 8 and 10 and 1 to the west in Tyrrell County centered on mile 28. However, the 30-minute data were more tightly concentrated and obvious. The two clusters of crossings identified by the GPS-collar data (Figure 16) coincided with where home ranges approached US 64.

Using the 30-minute collar data, red wolf highway crossing rates did not differ by wolf age (*F=5.14*, *P* = 0.13, *n = 13*; 3 juveniles, 3 dispersers, 7 adults) or sex (*t=0.32, P* = 0.76; *n = 13*; 7 males, 6 females).

Determining crossing locations using Camera Traps: Crossing data were collected at 39 camera stations along US 64 accumulated over 8,154 trap nights. The average and median number of trap nights per station was 204 and 160, respectively. The number of trap nights per station ranged from 35 to 617 nights. Four red wolf crossing sites were identified from camera data, 3 west of Alligator River in Tyrrell County at miles 19, 20.5 and 23 - 24 and 1 east of Alligator River in Dare County between miles 9 and 10 (Figure 17). The crossing site in Tyrrell County between miles 23 – 24 and the crossing site in Dare County between miles 9 – 10 were considered one location each due to proximity and habitat continuity.

The combined GPS and camera crossing data indicated 5 important crossing sections along US 64 between Columbia, NC and the US 64/264 intersection, 4 west of Alligator River in Tyrrell County and 1 east of Alligator River in Dare County (see Figures 17 - 19). The crossing site in Dare County identified by the cameras overlaps with the crossing site identified using GPS-collar locations, however that was not the case in Tyrrell County. The 3 crossing sites identified in Tyrrell County using cameras are from crossings made by wolf #1880, the wolf excluded from collar analyses. The crossing site in Tyrrell County identified with the GPS-collar data occurred in an area where no cameras were placed, within the town limits of Columbia, North Carolina.

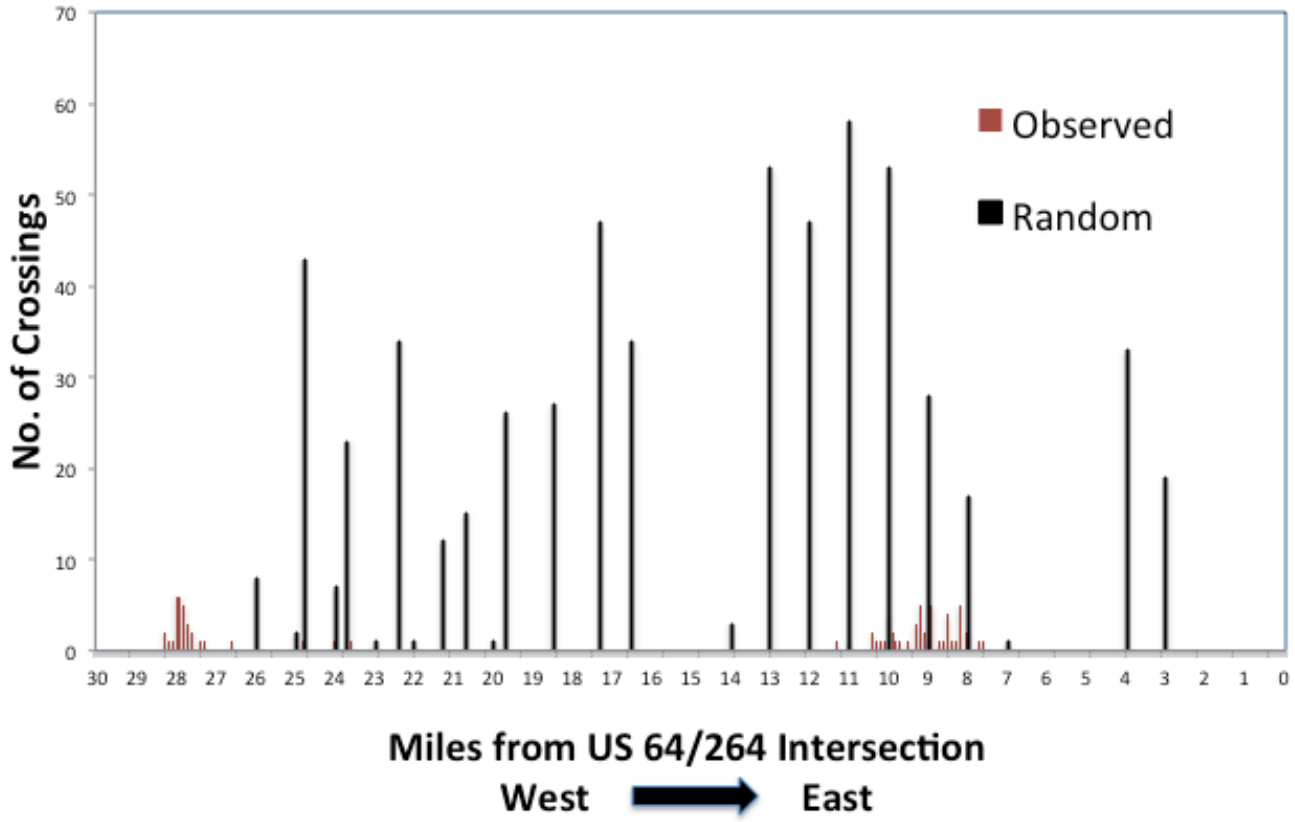


Figure 13. Observed red wolf crossings (red bars) occurred at a significantly lower frequency (*t=1.196, P=0.03*) and were bimodal as compared to the random crossings (black bars). Observed crossings are based on GPS locations taken at 30- minute intervals from red wolves in Washington, Tyrrell, Dare, Hyde, and Beaufort Counties, North Carolina collared between October 2009 and March 2011. An equivalent number of random line segments were drawn between the GPS locations for each red wolf. To approximate actual red wolf movement, random segment lengths were constrained to less than or equal to the maximum distance moved by a red wolf for the 30-minute data sets.

Determining crossing locations using historical road kill data: From May 1988 to February 2009, 58 wolves (31 M, 27 F) died as a result of vehicle collisions in the recovery zone, with an average of nearly 3 wolves per year. Twelve of these occurred on US 64. While not significant, the locations of current known road-kills appear to be generally clustered around crossing sites identified in this analysis, particularly on US 64 (Figures 18 – 19). However many of the historic road kill events highlight the location of packs no longer present.

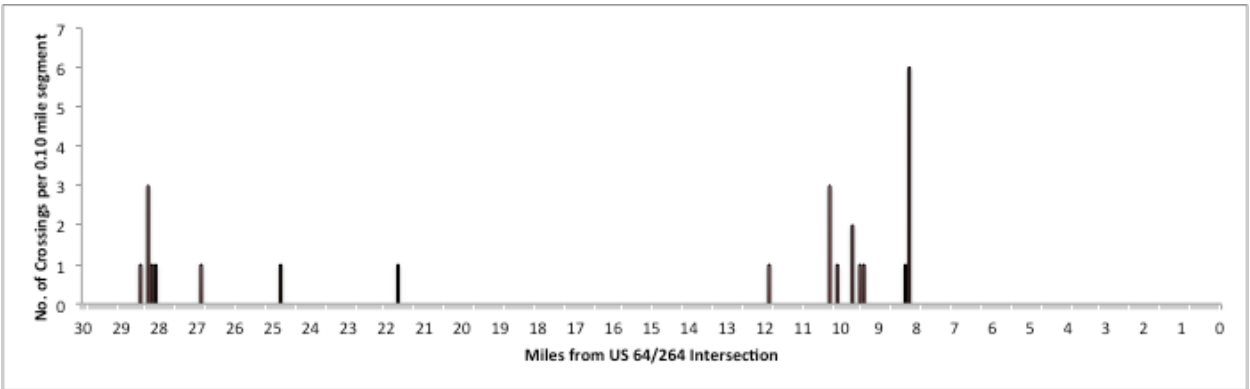


Figure 14. The number of red wolf crossings identified by GPS locations per 0.10 mile segments along US64 between Columbia, NC and the US64/US264 intersection. Crossings are based on GPS locations taken at 5- hour intervals between January 2009 and March 2011.

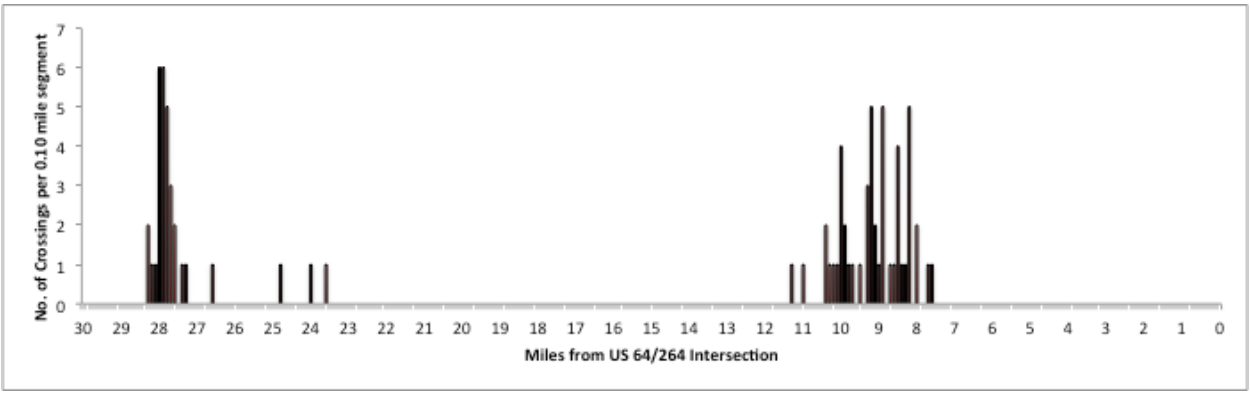


Figure 15. The number of red wolf crossings identified by GPS locations per 1 mile segments along US64 between Columbia, NC and the US64/US264 intersection. Crossings are based on GPS locations taken at 30- minute intervals between October 2009 and March 2011.

a)

b)

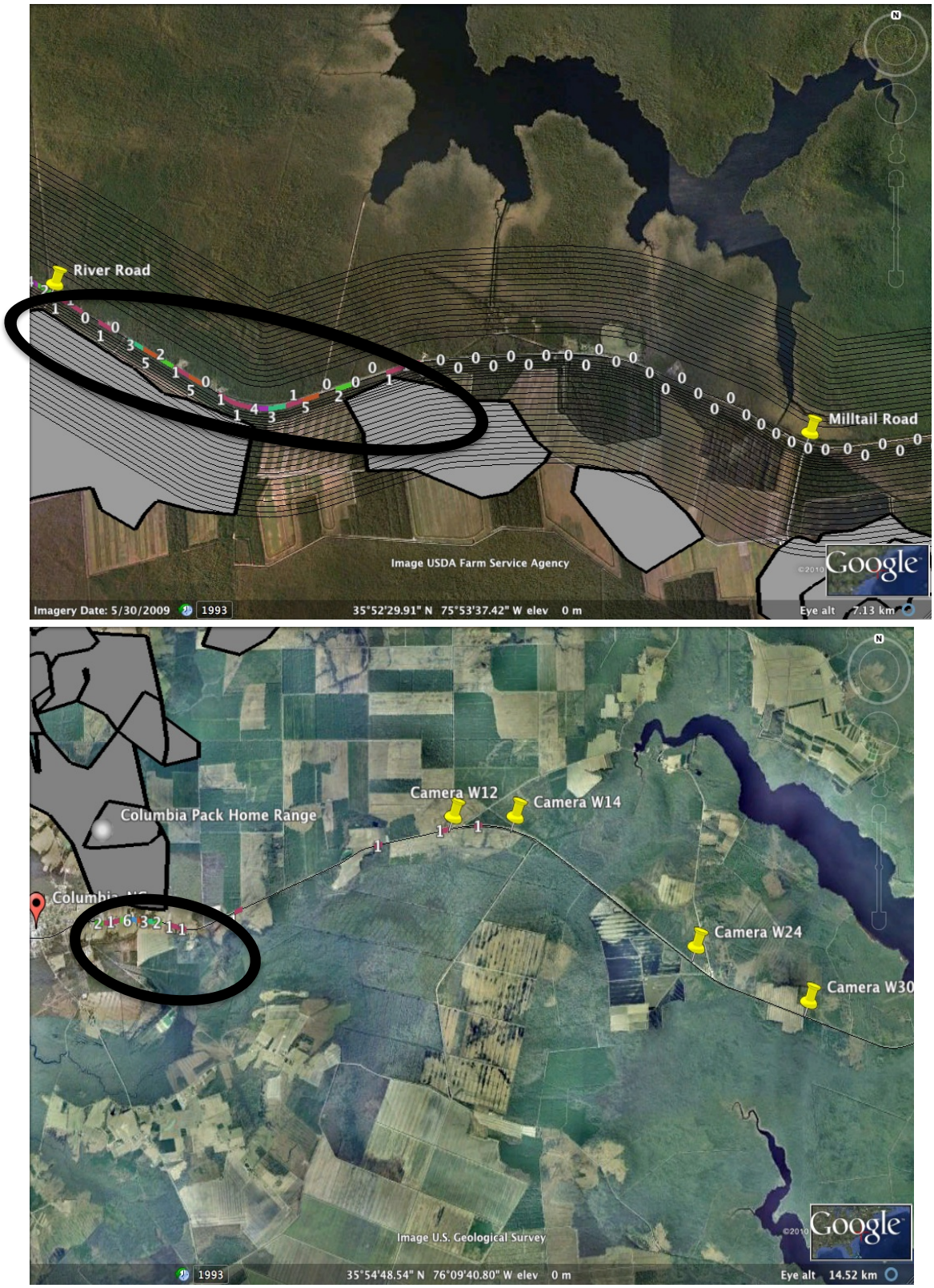


Figure 16. The two clusters of crossings identified by the GPS-collar data in both a) Dare and b) Tyrrell Counties, North Carolina coincided with the location where home ranges approached US 64. Crossings are based on GPS locations taken at 30- minute intervals between October 2009 and March 2011.

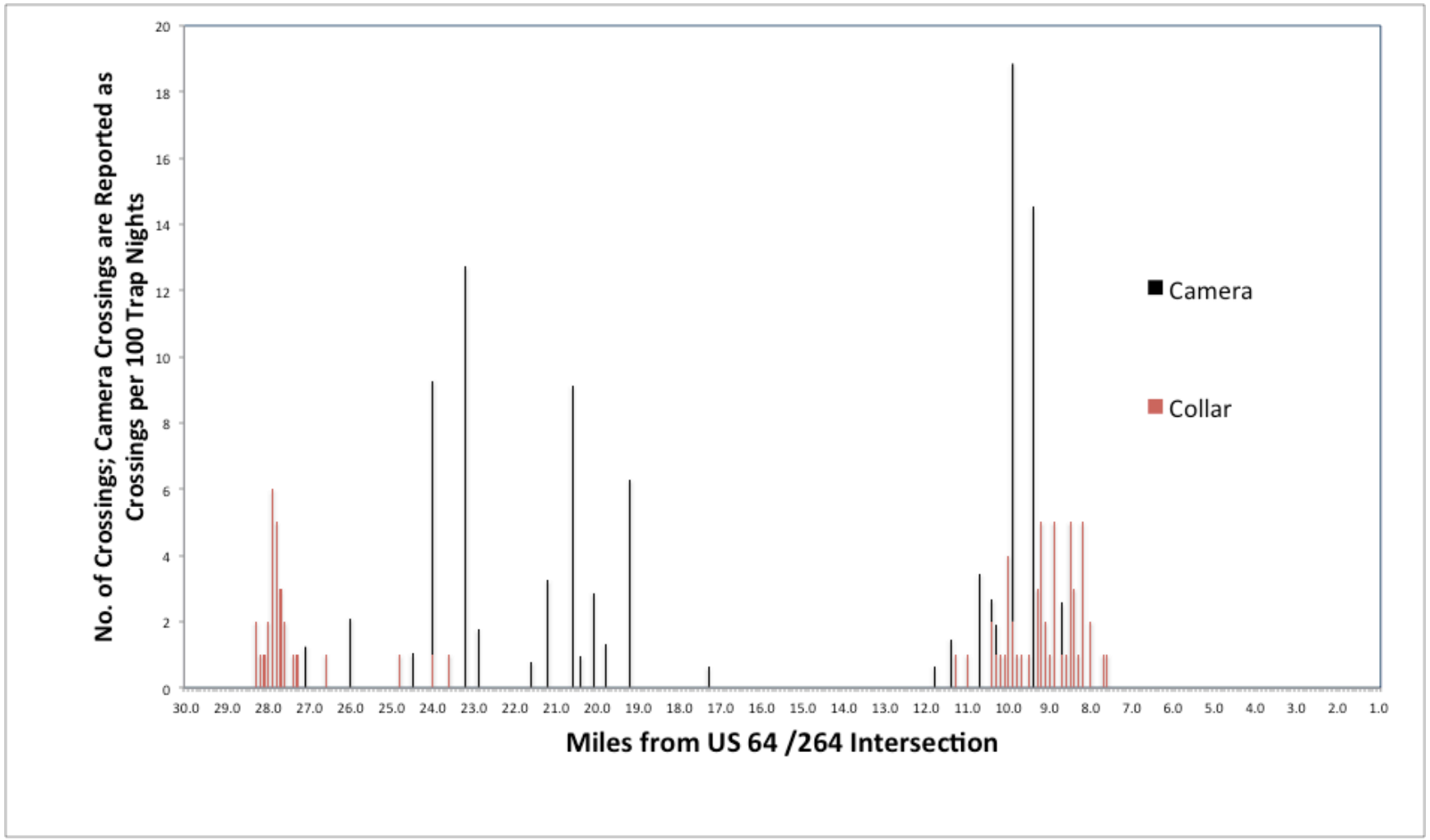


Figure 17. Combined GPS- collar (red bars) and camera (black bars) data, collected from 2009 – 2011, revealed 5 areas along US 64 currently used by red wolves as crossing sites, 4 in Tyrrell County west of Alligator River and 1 in Dare County east of Alligator River, North Carolina. Camera data are presented as number of captures per 100 trap nights. The red wolf crossing site identified by camera data in Dare County (miles 9 – 10) overlaps with the crossing identified by GPS-collar data (miles 8 – 10). However, crossing sites identified by camera data in Tyrrell County (miles 19, 20.5 and 23 – 24) do not overlap with the crossing site identified using GPS-collar data (mile 28). The crossing site in Dare County between miles 9 – 10 and the crossing site in Tyrrell County between miles 23 – 24 were considered one location each due to proximity and habitat continuity.

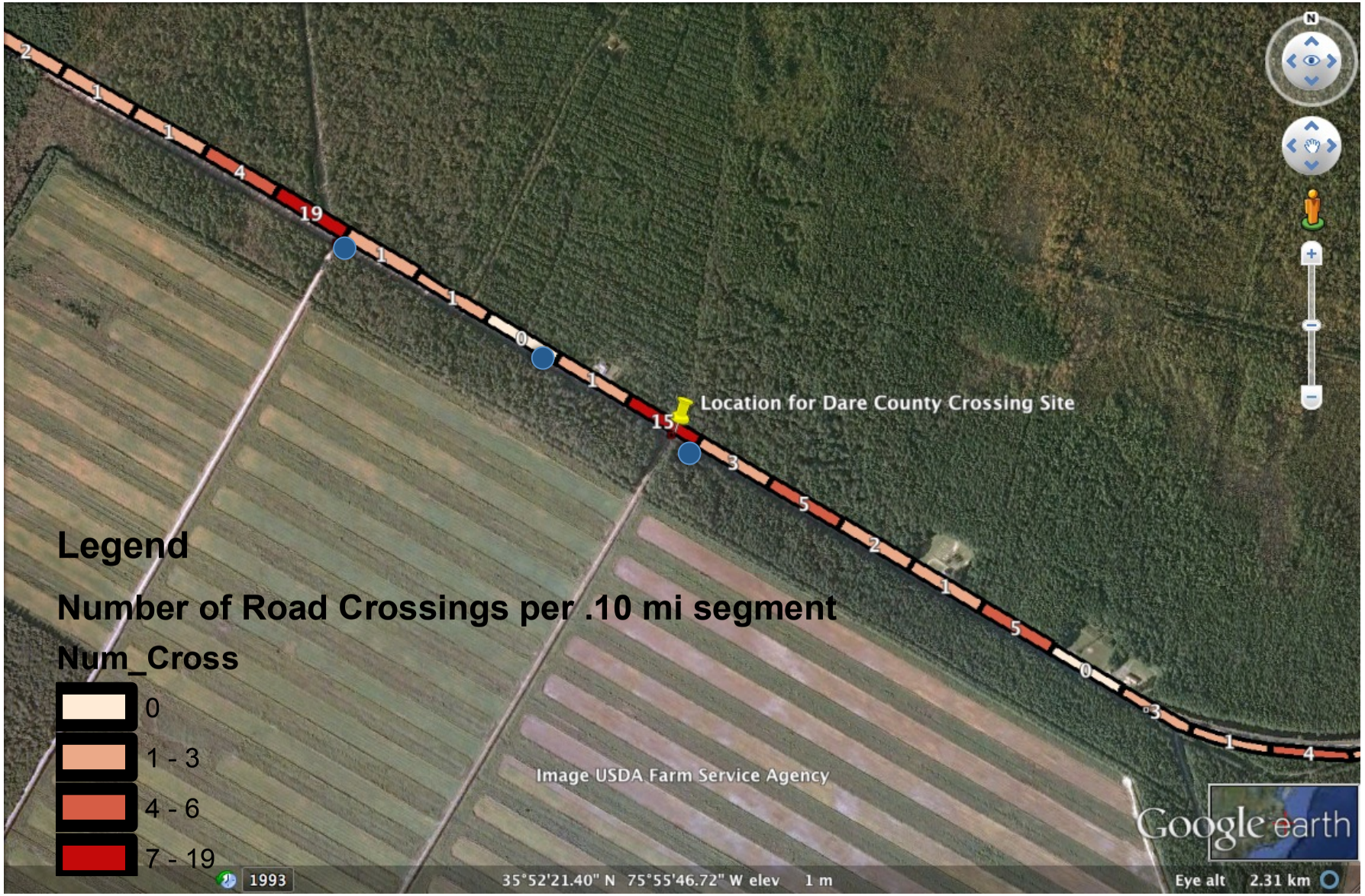


Figure 18. Map of red wolf highway crossing locations along US 64 in Dare County, NC. Crossing locations were calculated from GPS collar and remote camera data. The numbers indicate how many crossings per 0.10 mi. segment were recorded. The yellow marker shows the suggested location for a red wolf crossing structure in Dare County. The blue points indicate the location of a red wolf road mortality event.

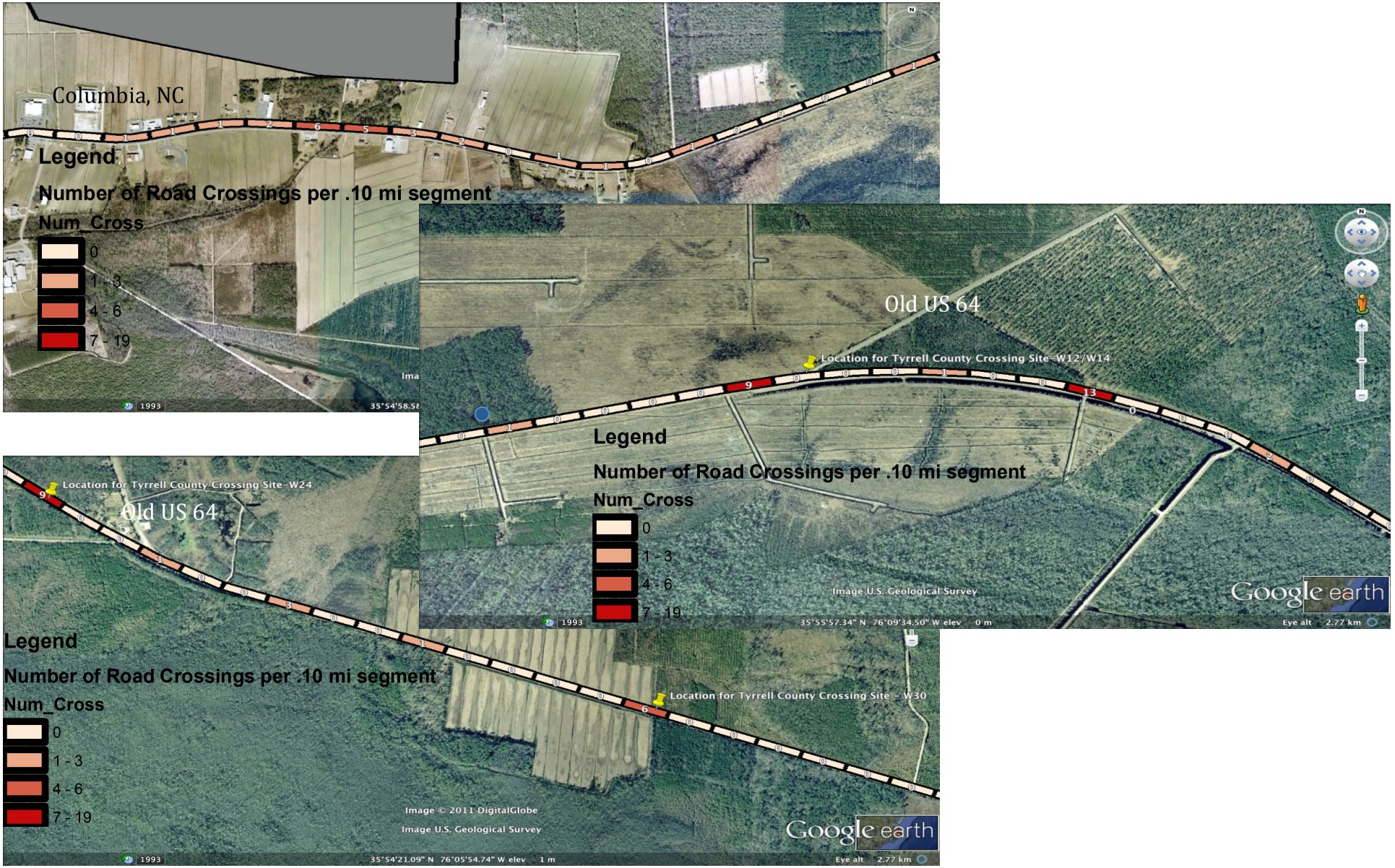


Figure 19. Map of red wolf highway crossing locations along US 64 in Tyrrell County, NC. Crossing locations were calculated from GPS collar and remote camera data. The numbers indicate how many crossings per 0.10 mi. segment were recorded. The yellow markers show the location of the 3 suggested locations for red wolf crossing structures in Tyrrell County. The blue point indicates the location of a red wolf road mortality event.

Evaluating habitat characteristics at crossing sites identified by GPS collar locations: The most parsimonious habitat model at crossing locations determined using GPS-collar data included habitat type at distances of 328 ft. and 492 ft. from the crossing site (Table 12). The AICc weight of the most parsimonious habitat model was 0.69. The second most parsimonious model included habitat type at 656 ft. from the crossing site and had a ΔAICc of 3.19 and an AICc weight of 0.07. The habitat types at distances of 328 ft. and 492 ft. from crossing locations correspond to those identified by resource selection functions for red wolves: agriculture, upland forests, and early successional fields.

Evaluating habitat characteristics at crossing sites identified by camera traps: The most parsimonious habitat model at crossing locations determined using camera trap data included width of the road/trail at the camera location (Table 13). The AICc weight of the most parsimonious habitat model was 0.89. The second most parsimonious model included road/trail width and habitat type at 164 ft. from the camera site and had a ΔAICc of 6 and an AICc weight of 0.03. The trail widths (which ranged from 1.64 ft. to 65.6 ft.) at camera trap locations with recorded red wolf crossings were 26.24 ft. or wider.

Table 12. Most parsimonious habitat model for red wolf crossing sites in Tyrrell and Dare Counties, NC identified using GPS-collar data collected between January 2009 and April 2011.

Model	AICc	ΔAICc
Habitat 329 ft from US 64 + Habitat 492 ft from US 64	42.99	0.00
Habitat 656 ft from US 64	46.18	3.19
Habitat 164 ft from US 64 + Habitat 328 ft from US 64 +Habitat 492 ft from US 64 + Habitat 656 ft from US 64	46.84	3.85
Habitat 164 ft from US 64 + Habitat 328 ft from US 64	55.19	12.20
Habitat 164 ft from US 64	55.42	12.43

Table 13. Most parsimonious habitat model for red wolf crossing sites in Tyrrell and Dare Counties, NC identified using camera trap data collected between March 2009 and April 2011.

Model	AICc	ΔAICc
Trail/Access Road Width	40.08	0.00
Trail/Access Road Width + Habitat 164 ft from US 64	46.03	5.95
Habitat 656 ft from US 64	52.95	12.87
Trail/Access Road Width + Habitat 328 ft from US 64 + Habitat 492 ft from US 64	73.48	33.40
Habitat 164 ft from US 64 + Habitat 328 ft from US 64 + Habitat 492 ft from US 64	74.32	34.24

Discussion

Objective 1: Evaluate wolf habitat use along the entire US 64 corridor from Plymouth NC to the US 64/264 intersection

Understanding of basic species survival needs is required before completing any wildlife management plan. This study used data from 16 wolves from 16 different packs to estimate home range size and habitat selection of red wolves (*Canis rufus*) in eastern North Carolina. The home range sizes we calculated (2.61 mi^2 – 38.19 mi^2) were smaller than those reported in 2 earlier studies that followed 3-red wolf packs each (Phillips et al., 2003: 13.40 mi^2 - 78.10 mi^2; Chadwick et al., 2010: 31.51 mi^2 - 57.72 mi^2). However, if the red wolf pack with the largest home range size in the Phillips et al. (2003) study is excluded, the home ranges for the remaining 2 packs fall within the range of our findings (13.40 mi^2 - 30.00 mi^2). In addition, Phillips et al. (2003) used minimum convex polygons to determine home range size where as we used α-NNCH, a more conservative method of home range estimation (Getz et al., 2007), which could account for the discrepancy in home range sizes between the two studies. Chadwick et al. (2010) tracked males 2 – 3-years in age, two of which were brothers, and therefore may have been dispersing individuals. Though not significantly different, our study showed that dispersing animals tended to have larger home ranges than adults or juveniles, which could account for the differences in home range size between our study and the one completed by Chadwick et al. (2010). Small sample size likely accounts for no significant difference in home range size among age classes. Seven dispersers were eliminated from this study, 5 due to death and 2 because of inadequate data. Summer (June – September) home range size (4.84 mi^2 – 5.73 mi^2) averaged for all 16 packs over 2-years (2009 and 2010) corresponded to summer home ranges reported (1.34 mi^2 – 4.72 mi^2) for one red wolf pack monitored during the summer of 2005 (Hinton et al., 2010). We did not look at the influence of pack size on home range size, as previous research suggests that a relationship does not exist between pack size and home range size in gray wolves (Jedrzejewski et al., 2007).

Similar to Phillips et al. (2003) and Chadwick et al. (2010), our study revealed that home range size varied with season, being smaller during summer months and larger in winter with monthly home range size peaking in January. Smaller home ranges in summer are likely due to the presence of pups (Phillips et al. 2003; Chadwick et al., 2010). Mating, den preparation and whelping for red wolves typically occurs between February and April (C. Lucash, per. comm.), which coincides with the reduction of monthly home range sizes. This study found that monthly home range continually reduced in size starting in February and continued until reaching the smallest size in April. Monthly home ranges remained small until September when they started a steady increase that peaked in January. Jedrzejewski et al. (2001) showed home range size and movement patterns of gray wolf (*Canis lupus*) packs were also influenced by reproductive cycles.

Habitat and prey availability also may influence seasonal fluctuations in home range size. We found that habitat in the home ranges was primarily composed of agricultural fields

year round. However, the percentage of agriculture within home ranges was highest in summer and lowest in winter. Increased use of agricultural fields in summer could be due to increased food resources available to prey species of red wolves such as white-tailed deer. A recent study found that red wolves readily prey on adult white-tailed deer (*Odocoileus virginianus*) and fawns during summer months (Dellinger et al., *In Press*). Growth of crops in agricultural fields in summer could help concentrate prey (Vercauteren and Hygnstrom, 1998). Additionally, the birth of fawns in early summer could provide a source of prey that is easier to catch, thus allowing red wolf packs to gather adequate food in a smaller area. Variation in home range size due to prey availability also has been shown in gray wolves (Ballard et al., 1987).

A decrease in percentage of agricultural fields making up home ranges in winter may be related to the harvesting of crops. Harvesting eliminates food resources available to prey and eliminates potential cover for red wolves. This study found an increase in non-agricultural habitats, such as upland forests, pocosins, and wetlands, during the fall and winter months (Table 6). Chadwick et al. (2010) noted that increased use of non-agricultural habitats corresponded to the harvesting of row crops between September and November and with the onset of the hunting season. Although this study showed that red wolves typically selected against non-agricultural habitats, cover types such as early successional fields, upland forests, and pocosins could be providing essential cover for red wolves after crop harvesting. Also, red wolves tend to prefer cover types with denser ground vegetation for den sites (Phillips et al., 2003), thus leading to a switch in habitat use during late winter and spring months.

Another important habitat finding is the selection for areas closer to roads. Most roads in the red wolf recovery zone are unpaved gravel or dirt roads used for agricultural purposes (C. Lucash pers. comm.). Red wolves likely used the road network as travel corridors, which could allow for packs to persist in areas where habitats are highly interspersed and large parcels of quality habitats are few.

Conclusion: White and Ernst (2004), Singleton et al. (2005), and Kindall and van Manen (2007) all stress the need to identify habitat linkages across barriers to properly place crossings. Thus, it is imperative not only that wildlife underpasses are constructed in areas identified as high use for crossings (Scheick and Jones, 1999), but also that crossings are placed in a manner that connects habitat being selected by the species of concern. This study suggests that red wolf crossing structures should connect agricultural landscapes that are interspersed with upland forests, successional fields and pocosins. In addition, avoiding the aforementioned cover types during construction will minimize direct impacts to the red wolf population.

Objective 2: Evaluate the significance of red wolf habitat changes anticipated from the proposed highway project from Columbia NC to the US 64/264 intersection.

This was the first study to employ the use of a permeability index to a non-seasonal migrating species. This provided a challenge in determining what could be considered a

road “approach”, as we had to be careful not to include normal movements within a home range as an approach. The resulting buffer width of 164 ft., which is similar to the buffer width suggested for gray wolves (Paquet and Callaghan, 1996), illustrates the willingness of red wolves to establish home ranges in close proximity to the current 2-lane highway. The resulting permeability indices calculated for the 2-lane section of US 64 using both 5-hour and 30-minute data were 1.0 and 0.99, respectively. This suggests that the current 2-lane highway is not discouraging the red wolf population from attempting to cross US 64. However, it is important to note that only 14 of the 32 collared red wolves crossed a highway within the 5-county recovery zone, and 8 of those only crossed either once or during dispersal. Just 6 wolves from 3 packs crossed a highway regularly, and all 3 packs had home ranges that were adjacent to or straddled US 64.

The original goal was to compare permeability indices between the previously widened 4-lane section of US 64 in Washington County to the permeability index for the 2–lane section. However, a decrease in and near disappearance of the red wolf population to the west of Columbia, NC, prevented the collaring of red wolves where the widening to a 4-lane highway already was completed.

Although the current 2-lane highway is not discouraging wolves from attempting to cross, it is important to note that most roads exhibit a distinct trade-off between permeability and road kill (Forman and Alexander, 1998). A highly permeable road might result in a high level of wildlife/vehicular collisions, whereas an impermeable road might have few road kill events. Yet this decrease in road kill comes at the expense of habitat connectivity. This trade-off indeed holds true for US 64. Though the 2-lane portion of US 64 may not be hindering attempts to cross, road mortality is the second leading cause of death among red wolves accounting for 14% of mortalities (USFWS, 2007).

Permeability was expected to behave inversely to traffic flow, decreasing during the busy summer months and increasing during the winter. However, due to the high permeability of the highway, no such relationship existed. In addition, time of day may play an instrumental role in the event that crossing times (typically at night) do not coincide with peak traffic hours (midday). Such a pattern could be determined by separating traffic flow and permeability data by time. It should also be noted that while traffic fluctuates heavily on US 64 between summer and winter, the highway experiences relatively low traffic volume (maximum 250 vehicles per hour during the peak season) in comparison to other highways in the vicinity of the Outer Banks outside of the study area (~791 vehicles per hour; Currituck Development Group, 2011). The Federal Highway Administration reports that relatively few animals avoid crossing the road at traffic volumes below 2,500 cars per day and, that while road avoidance increases at moderate volumes (2,500 – 10,000 cars per day), it is not until traffic volume surpasses 10,000 cars per day that a large portion of animals will avoid highway crossing attempts (Clevenger and Huijer et al., 2011). The average daily traffic volume for the study site is 1,995 cars per day with a peak of 6,500 cars per day in July, placing the focal section of US 64 in the low to moderate traffic flow category as defined by the Federal Highway Administration.

Construction north of the current US 64 in Tyrrell County has the potential to remove a maximum of 0.16 mi^2 of red wolf habitat and 6% of the home range area used by a current red wolf pack while construction to the south will directly impact only 0.09 mi^2 of red wolf habitat and will not displace any current red wolf packs. East of Alligator River in Dare County, a widening of the current highway to the south has the potential to lead to a loss of 0.07 mi^2 of red wolf habitat and 20% the home range used by the only existing red wolf pack in Alligator River National Wildlife Refuge. Construction to the north of US 64 in Dare County will only remove up to 0.04 mi^2 of red wolf habitat and will not overlap with any current packs. Therefore, limiting construction to the south of the existing US 64 in Tyrrell County and north of the highway in Dare County will avoid direct effects to the current red wolf population.

We highlight that these results quantify only direct effects on current wolf home ranges. Road construction can have many indirect effects through changing hydrology; air, water, noise, and light pollution levels; wind flow; humidity; temperature; vulnerability to invasive species; and habitat continuity (Forman et al., 2003; Coffin, 2007). These indirect effects of the construction can disrupt red wolves living adjacent to the existing highway causing a shift in current home ranges. Any shift in home ranges has the potential to affect social order, mating, and ability to locate prey. At this time we are not able to quantify these effects, but these potential indirect effects may be measured in the "during-" and "post-" construction phases of the project.

Conclusion: Road permeability, calculated using GPS-collar data, was 100%, thus the current 2-lane highway does not discourage the red wolf population from attempting to cross US 64. This does, however, increase the risk of road mortality events. A decrease in the red wolf population to the west of Columbia, NC, prevented collaring of red wolves where widening to a 4-lane highway was completed. Therefore, we were not able to compare highway permeability between 2- and 4-lane highways. To avoid any direct effects to the current red wolf population, highway construction should be limited to the south of the existing US 64 in Tyrrell County and north of the highway in Dare County. Potential indirect effects of highway widening activities were not quantified, as they could not be quantified using GPS or camera data. It is important to note that indirect effects can negatively effect the red wolf population.

Objective 3: Identify significant red wolf crossing areas to determine where wildlife crossing structures or other design features could be placed to minimize adverse project effects on wolves.

Movement patterns obtained through tracking of GPS locations and remote camera traps clearly demonstrate that red wolves crossed US 64 and two other highways in the red wolf recovery zone, with some frequency. This implies there is potential for one of two outcomes of widening the road from 2 to 4 lanes: (1) either increased traffic or the increased width itself may increase road mortality, or (2) these factors may decrease road permeability. The degree to which these threats are deemed relevant and serious will have a significant bearing on NC DOT's planning and execution of the construction project.

The distribution of GPS-collar locations and camera trap photos along US 64 revealed 5 distinct red wolf crossing sites, 4 west of Alligator River in Tyrrell County and 1 east of the river in Dare County. Though they do not overlap completely, GPS-collar data and camera trap data are in accordance for the location of the crossing site in Dare County. However, that is not the case in Tyrrell County. GPS-collar data revealed 1 crossing site in Tyrrell County, while camera trap data identified the 3 additional crossing sites. Two factors contributed to the 2-methods not overlapping in Tyrrell County. First, due to the number of false crossings, GPS-collar data from wolf #1880 was eliminated from our analysis, thus eliminating GPS-collar data along the section of US 64 coinciding with the cameras. False crossings were obtained from this wolf because US 64 bisected her home range (Figure 12). Secondly, cameras were not set up where GPS-collar data identified a crossing location in Tyrrell County due to increased risk of camera theft within the town limits of Columbia, NC.

The potential for "false crossings," which may suggest that a crossing took place in a different location from where it actually occurred, exists in the remainder of the GPS-collar data as well. However, the presence of such distinct activity clusters, particularly under the 30-minute schedule, suggests that our results captured real movement trends. Although we captured nearly 3 times as many crossing events and the data displayed tighter clustering with better defined locations using the 30-minute collar schedules, the location of crossing sites identified using GPS-collar data was generally consistent between the 2 schedules (5-hour and 30-minute).

The red wolf crossing site identified in Dare County is within the Alligator River Wildlife National Wildlife Refuge and is centered on Hickory Road. This matches the location of an important black bear crossing site (Vaughan et al., 2011), and therefore is a candidate site for the placement of a multi-species crossing structure for large wildlife. Likewise, the 3 red wolf crossing sites in Tyrrell County located via camera trap data overlap with candidate areas for large wildlife crossing structures identified in an earlier study by University of Central Florida (UCF) (Smith, 2011). The red wolf crossing site between miles 23 and 24 (cameras W12 and W14) overlaps with "Area 1" of the UCF study (Smith, 2011), which is centered on the western intersection of Old US 64 and US 64. The red wolf crossing sites at mile 20.5 (camera W24) and mile 19 (camera W30S) overlap with "Area 3"and "Area 5" of the UCF study, respectively (Smith, 2011) and are located near the eastern intersection of Old US 64 and US 64. Using the eastern intersection of Old US 64 and US 64 as a reference point, "Area 3" is 0.31 miles west of the intersection and "Area 5" is 1.16 miles east of the intersection.

The red wolf crossing site in Tyrrell County identified using GPS-collar locations is located within the town limits of Columbia, NC where US 64 narrows from 4 to 2 lanes. Placement of a crossing structure here may not be practical because of proximity to residential areas.

Crossing rates suggest that there is no difference in highway crossing behavior between sexes or among ages. As with the home range analysis, the lack of any significant difference in either sex or age class might simply be a function of low sample size, and it

is possible that a real relationship could be hidden by an interaction between the two variables, which we were unable to test for the same reason. This possibility is supported by data on road mortality, which has impacted dispersers hardest among the age classes. Although road mortality accounts for 14% of deaths for the red wolf population over all, when broken down by age class, road mortality accounts for 19% of dispersers but only 6% of breeding adults (USFWS, 2007). Low sample size and high expense per individual is a common hurdle in research involving large carnivores, as was true for this study. In addition, the status of the red wolf as critically endangered puts a major constraint on population size from which to draw a sample.

In addition to identifying the location of important red wolf crossing sites, we also investigated which habitat variables were correlated with those locations. The presence of agricultural fields, successional fields, and/or upland forests 328 ft. to 492 ft. (100 to 150 m) from the road best predicted where a red wolf chose to cross when using GPS-collar data while trail/road greater than 26.24 ft. (8 m) provided the best explanation for the location of crossing sites identified by remote camera traps. The presence of agricultural fields, successional fields, and upland forests as well as proximity to maintained agricultural/forest roads at crossing sites corresponds to habitat selection results.

Conclusion: The distribution of GPS-collar locations and camera trap photos along US 64 revealed 5 distinct red wolf crossing sites, 4 west of Alligator River in Tyrrell County and 1 east of the river in Dare County. Four of the 5 red wolf crossing locations we identified are suitable for crossing structures. The most western crossing site is located within the town of Columbia, NC where retro fitting a wildlife underpass may be impractical. All 4 crossing sites suitable for placement of a crossing structure overlap with large wildlife crossing locations identified in previous studies. The 1 red wolf crossing site located in Dare County is centered on Hickory Road and the 3 crossing sites in Tyrrell County are approximately where US Old 64 intersects with US 64. Although no significant difference in crossing behavior was found during this study, high road mortality among dispersers suggests they may cross the highway more frequently than adults or juveniles. The most parsimonious models looking at the relationship between habitat variables at 164 ft. increments from US 64 and road/trail widths measured at road access points where cameras were placed (e.g. dikes, logging roads, public property access roads) indicates that well maintained trails at least 26.24 ft. (8 m) in width leading to and from underpasses and connect habitats selected for by red wolves (e.g. agriculture, successional fields, and upland forests), will optimize efficacy.

The data presented here are reflective of the current population's behavior. In the event that wildlife crossing structures are deemed necessary, our results identify locations where crossing structures would have the greatest effect on the red wolf population. This project is only one of several examining the use of US 64 by numerous wildlife species. The results of those studies, in addition to this one, should be taken into account in determining the need for mitigation, the type of mitigation to use, and the layout that would be most compatible with all target species. The direct and indirect effects of the road widening project remain difficult to predict, yet the potential for a negative effect on the red wolf must be considered. Careful monitoring of the red wolf population

throughout and following the construction process will be crucial to ensuring red wolf survival and will aid management decisions in future road issues.

Literature Review

Red Wolves: Past, Present, and Future

Red wolves (*Canis rufus*) were originally described in 1851 by Audubon and Bachman and considered a subspecies of the gray wolf. However, red wolf heritage came under debate in the mid-1900's when Goldman suggested that all of the southeastern wolf subspecies should be combined into the distinct species of *Canis rufus*, separate from gray wolves. Many supported this decision until the advent of genetic methodologies in the 1990's. Genetic studies in the 1990's provided support for the hypothesis that red wolves evolved from a natural hybridization between gray wolves and coyotes (Wayne and Jenks 1991; Wayne 1992; Roy et al. 1994, 1996; Wayne and Gittleman 1995; Wayne et al. 1998; Reich et al. 1999). However, Wilson et al. (2000) suggested that red wolves and Algonquin wolves (*Canis lupus lycaon*) diverged from gray wolves 1.2 million years ago and then diverged from coyotes 150,000 to 300,000 years ago. Work by Hendrick et al. (2000) investigating major histocompatibility complex genetics data indicates that red wolves are more closely related to coyotes than to gray wolves, adding support to the claims made by Wilson et al. (2000).

The current stance that the red wolf is a species in its own right, separate from gray wolves, coyotes, and domestic dogs is based on mtDNA sequencing of 340 base pairs showing a unique sequence for red wolves (Adams, 2002; Adams et al., 2003). However, the debate over red wolf taxonomy is far from over. Both Wilson et al. (2000, 2003) and Kyle et al. (2006, 2007) now suggest that red wolves and Algonquin wolves are genetically similar enough to be combined into one species, the eastern wolf (*Canis lycaon*). In 2007 Murray and Waits, while acknowledging the genetic similarity between red wolves and Algonquin wolves and the plausibility that they are conspecifics, argue that combining the two species would hinder red wolf conservation efforts and the ability to secure conservation funds because red wolf extinction would become an issue of population extinction rather than species extinction. In 2008, Kyle et al. rebutted the article by Murray and Waits stating that taxonomy embracing conservation agendas rather than scientific scrutiny should be avoided. Kyle et al. (2008) go on to say that while they agree with Murray and Waits (2007) that there are instances in which genetically unique populations warrant protection, that the genetic uniqueness of the red wolf population is not supported scientifically. Red wolves and Algonquin wolves are only separated genetically by one mtDNA haplotype differing by one base pair (Wilson et al. (2000, 2003). Kyle et al. (2008) suggest that any difference between red wolves and Algonquin wolves may be an artifact of a low effective population size, a founder effect, a by-product of artificial selection, and/or because of current management strategies that remove individuals that are <80% red wolf from the breeding population (potentially removing important red wolf genes from the population). For now, the taxonomy of red wolves remains under debate.

The historical range of red wolves was originally described as occurring from south central Texas east to Florida and then north to the Ohio River (Nowak, 1979). The historical range was then extended north to Pennsylvania in 1995 (Nowak) and then north again to south central Maine in 2002 (Nowak) in support of the theory that there is one eastern wolf species. Red wolves declined initially with European colonization (USFWS, 2007). Predator control programs and habitat fragmentation in the 1960's dramatically reduced red wolf populations. By the 1970's, red wolves were reduced to remnant populations along the Texas and Louisiana coast. In 1973, the red wolf achieved endangered status with the passing of the Endangered Species Act of 1973. The United States Fish and Wildlife (USFWS) Service worked to capture the remaining wild red wolves between 1974 and 1980 to establish a captive breeding population as a last ditch effort to save the red wolf (USFWS, 2007). The USFWS successfully captured 17 individuals, 14 of which were used as founders for the captive breeding program (USFWS, 2007). As a result of capturing the remaining wild animals, red wolves were declared extinct in the wild in 1980.

Through the establishment of a captive red wolf breeding program with the Association of Zoos and Aquariums (AZA), enough red wolves were bred in captivity to attempt a reintroduction in 1987. The reintroduction began with the release of 4 breeding pairs on the Alligator River National Wildlife Refuge. By 1988, the first pups (2 litters) were born post reintroduction (USFWS, 2007). The USFWS started two additional red wolf reintroduction programs; in 1991 at the Great Smoky Mountains National Park at the Tennessee/North Carolina border and in 1993 at the Pocosin Lakes National Wildlife Refuge in North Carolina just 27 miles west of the original reintroduction site. The reintroduction in the Great Smoky Mountains did not succeed, but the reintroduced populations at Alligator River National Wildlife Refuge and the Pocosin Lakes National Wildlife Refuge continued to expand and merged to form the current, and only, red wolf population in the wild. The current red wolf recovery zone has expanded to 5 counties in North Carolina's Albemarle Peninsula (Dare, Tyrrell, Washington, Beaufort, and Hyde Counties – see current range in Figure 1) and contains between 100 and 130 red wolves forming 20 packs (USFWS, 2007). Red wolves remain listed under the Endangered Species Act of 1973 (USFWS, 2007) and are recognized by IUCN as one of the most endangered canid species in the world (IUCN, 2006). The re-introduced population is designated as non-essential experimental.

The USFWS has a population goal of 220 individuals, yet the population has fluctuated between 100 and 130 individuals over the past 12 years (USFWS, 2007). USFWS biologists with the Red Wolf Recovery team feel that the population can still expand further west allowing population growth to continue. However, non-USFWS researchers on the Red Wolf Implementation Team believe that the red wolf population may have reached carrying capacity within the recovery zone (USFWS, 2007). Models suggest that carrying capacity for red wolves within the current 5 county recovery zone is approximately 138 individuals (Murray, unpublished data). Starting in 2002, to help bolster the wild population, captive-born pups have been fostered to wild parents with similarly aged pups (USFWS). However, a better understanding of habitat requirements is needed to determine the ability of the peninsula to hold more animals.

Management of the red wolf gene pool and genetic fitness are the primary focus of the red wolf recovery and species survival plan due to a low effective population and potential founder effects. Genetic drift and inbreeding depression are of concern with small populations (Caughley, 1994). A study by Kalinowski et al. (1999) reported to find no evidence of inbreeding depression within the captive red wolf population. Long and Waddell (2006) reported that the captive population retained 89.65% of the genetic diversity of the founding captive population. Despite these results, there have been reports of physical anomalies in the captive red wolf population such as progressive retinal atrophy, malocclusion and undescended testicles (USFWS, 2007). Although a study by Miller et al. (2003) showed that only a few individuals per generation were needed to maintain sufficient genetic diversity in a grizzly bear population, further studies are needed to determine if genetic drift and inbreeding depression are impacting the wild red wolf populations.

For now, management of the reintroduced red wolf population focuses on a different genetic problem, the introgression of coyote genetics. Kelly et al. (1999) reported interbreeding between coyotes and red wolves resulting in coyote gene introgression into the wild red wolf population. As a result, an adaptive management plan was developed (Fazio et al., 2005). The plan calls for either the complete removal of coyotes and hybrids or the sterilization of hormonally intact coyotes and hybrids via vasectomy and tubal ligation, depending on the location within the recovery zone. In Zone 1 of the plan, all coyotes and hybrids are removed. In zones 2 and 3, coyotes and hybrids are sterilized and then used as territorial "place-holders" until replaced by wild red wolves. The sterilized coyotes and hybrids cannot interbreed with wild red wolves and they exclude intact coyotes or hybrids from the territory they hold. The idea is that these sterilized animals act as "place-holders" until red wolves replace them either naturally via displacement or through management actions to make room for translocation of a red wolf pair. The effectiveness of the management plan is evaluated via non-invasive genetic monitoring of canid scats (Waits 2004; Waits and Paetkau, 2005; Adams, 2006; Adams and Waits 2007). Through continued genetic monitoring, Adams noted strong evidence that a single hybridization event in 1993 resulted in most introgression of coyote genes into the red wolf population observed to date. From this evidence, Adams (2006) infers that hybridization with coyotes has had less genetic impact on the restored red wolf population than originally thought by Kelly et al. (1999), largely because backcrossing has been rare in the population.

Due to the immediate attention required to address the hybridization of red wolves and coyotes, less is known about red wolf home range, habitat, and diet requirements. Two recent studies examined red wolf home range and habitat use. The first study (Hinton and Chamberlain, 2010) used VHF collars to follow two red wolf packs during summer 2005 (July to September), one with pups and one without pups. This study found that the pack with pups had a smaller average home range size than the pack without pups, 5.74 km^2 vs. 9.55 km^2 for diurnal home range and 8.24 km^2 vs. 9.40 km^2 for nocturnal home ranges, respectively (Hinton and Chamberlain, 2010). Although it is important to note that the larger averaged home range calculated for the non-breeding pack is likely driven

by one male whose home range was 2-3 times larger than any other wolf in the study. Adults in both packs increased home range size nocturnally (1800-0559 hours) and both packs spent approximately 98% of their time in agricultural fields, defined as corn, soybean, and cotton (Hinton and Chamberlain, 2010).

The second study investigating red wolf home range and habitat use employed GPS collars to monitor 4 male wolves from 3 packs over a period ranging from 11 to 18 months (Chadwick et al., 2010). Chadwick et al. (2010) corroborated the finding that red wolf packs primarily utilize agricultural fields during summer and early fall months, with highest use of agricultural fields occurring July through September. However, they noted a seasonal switch to grass/brush and forested habitats during winter and early spring months, November to May (Chadwick et al., 2010). Though results of both studies showed similar summer habitat preferences, the home range size estimates calculated by Chadwick et al. (2010) were several magnitudes larger than those calculated by Hinton and Chamberlain (2010). Home ranges reported in Hinton et al. (2010) ranged from 3.48 km^2 to 12.24 km^2 while those calculated by Chadwick et al. (2010) ranged from 81.6 km^2 to 148.1 km^2. Both studies employed kernel density estimators to estimate home range size. Chadwick et al. (2010) did mention that they found a 40 to 63% reduction in home range size during summer months, but that places their summer home range estimates between 51.4 km^2 and 59.24 km^2, still considerably larger than those estimated by Hinton and Chamberlain (2010).

Though Hinton and Chamberlain (2010) did calculate home range size for both sexes and all age classes, they only collected point locations for a period of 3 months and the number of daily locations varied. Chadwick et al. (2010), while focusing only on nocturnal movements of males, collected point locations over a period of 11 to 18 months and were able to consistently collect 4 locations per day with the use of GPS collars. This suggests that the discrepancy in home range estimates between the two publications may be the result of Hinton and Chamberlain (2010) not collecting enough locations to accurately capture the entire home range size. Until data on all sexes and age classes collected covering the entire 24-hour period and across all seasons is made available, conclusions concerning red wolf home range and habitat requirements cannot be made.

Phillips et al. (2003) reports that the primary prey species of red wolves include: white-tailed deer, raccoon, rabbits, nutria, and other small rodents. A more recent diet assessment via scat analysis lists white-tailed deer as the primary prey item of red wolves (Dellinger et al. in review). However, packs will increase the amount of small rodents and human-sourced foods (e.g. hog pits) in their diet during periods of increased energy demands such as pup rearing (Dellinger et al., in review).

For red wolf management to move forward, the current gaps in knowledge of red wolf natural history need to be filled. Furthermore, before model building to predict the effect of a highway widening through the red wolf recovery zone starts, base knowledge of home range and habitat selection is required.

Road Ecology

Accompanying the rapid expansion of our transportation network was a growing concern over the environmental effects of roadways. The emergence of road ecology, coined by Richard T.T. Forman (1998), as a distinct discipline has brought together scientists from many disciplines (e.g. landscape ecology, wildlife biology, toxicology, hydrology, limnology, etc) and engineers to tackle the ecological challenges posed by transportation systems. For several decades now, researchers have studied the effects of roads on both the abiotic and biotic components of ecosystems. As a result, we now know that roads affect hydrology, air, water, noise, light pollution levels, wind flow, humidity, temperature, vulnerability to invasive species, and habitat continuity (Forman et al., 2003; Coffin, 2007). Such large-scale and multifaceted changes to ecosystems have many detrimental effects on wildlife (Jackson, 1999), including direct mortality (Lalo, 1987; Harris and Scheck, 1991; Schwabe and Schuhmann, 2002), habitat destruction (Theobald et al., 1997; Angelsen and Kaimowitz, 1999), barrier effects (Forman et al, 2003), and increased human land use activities (Bjurlin and Cypher, 2003; Coffin, 2007).

Before road mortality can be effectively mitigated, it is important to understand the factors that influence wildlife-vehicle collisions to occur in the first place. Jaarsma et al. (2006) modeled several road, traffic, vehicle, and species characteristics to find which had the greatest influence on the occurrence of a wildlife vehicle collision event. They found that traffic volume and the animal's traversing speed were the greatest predictors in determining a road mortality event, with higher traffic volumes and slower crossing speeds more likely to lead to a collision (Jaarsma et al., 2006). Two separate studies investigating the relationship among road kill events, body size, and diet found that carnivores were less likely to be hit along a road as compared to herbivores and omnivores (Ford and Fahrig, 2007, Barthelmess and Brooks, 2010). Those same two studies found a peaked relationship between road mortality and body size, with small (<1 kg) and large (>10 kg) body animals less like to be killed by vehicles as compared to medium (1 – 10 kg) sized animals (Ford and Fahrig, 2007, Barthelmess and Brooks, 2010). All three of the above cited articles suggest that direct mortality resulting from roads may not have a significant negative impact on carnivore populations as many carnivores are faster moving and larger bodied.

However, a study in southern Texas that looked at the influence of habitat variables on the location of bobcat road mortality events found that suitable habitat adjacent to the highway best explained the location of mortality events (Cain et al., 2003). These results were corroborated by another bobcat study in southern Illinois (Kolowski and Nielsen, 2008). Likewise, red wolves in northeastern North Carolina cross highways at locations adjacent to preferred habitat and established home ranges (Proctor, unpublished data). These results are similar to studies evaluating the use and success of highway crossing structures. The most successful wildlife crossing structures are the ones that connect preferred habitats of the targeted species (Ng et al. 2003, White and Ernst 2004, Singleton et al., 2005, Kindall and van Manen, 2007).

When vehicle strikes do occur, they account for a low percentage of mortality in

carnivores and do not translate into population level effects. Even for endangered San Joaquin kit foxes, road mortality rarely accounted for over 10% of mortality, with predators accounting for most mortality events (Bjurlin and Cypher, 2003). In a 3-year study that followed 60 radio collared kit foxes that lived in close proximity to a 2-lane paved highway, only one was lost to a vehicle strike (Cypher et al. 2009). However, prior to mitigation efforts, road mortalities did account for 49% of mortality in Florida panthers (Maehr et al., 1991). The carnivore populations with the highest reports of road kill events in the United States are black bears. In Virginia, black bears and white-tailed deer account for the most frequently recorded road kill events (Donaldson, 2007). Two studies in Florida found increased road mortality of black bears in areas of higher road density (Hostetler et al., 2009, McCown et al., 2009). These results differ from studies focusing on other carnivore populations where an increase in road density lead to increased road avoidance rather than increased mortality events (Dickson et al. 2005, Chetkiewicz and Boyce 2009). However, the studies by Ford and Fahrig (2007) and Barthelmess and Brooks (2010) did find that omnivores are more likely to be stuck by vehicles as compared to carnivores. Although black bears are classified as carnivores, their diet is omnivorous.

A barrier effect blocking access to resources, dispersal, and gene flow is the greatest impact of highways and roads on carnivore population in the United State. A study in southern California found that while cougars often made use of dirt roads, they actively avoided paved roads (Dickson et al., 2005). Similar results were found in another study with cougars negatively associated with roads, particularly during winter months (Chetkiewicz and Boyce, 2009). Riley et al. (2006) found that coyote and bobcat populations in southern California separated by a major freeway exhibited genetic differentiation, suggesting that the freeway is a barrier to dispersal. For those that do cross, heightened territorial behavior along roadways can discourage reproductive success, again limiting gene flow (Riley et al., 2006). Likewise, a study found that a highway in southern Canada is acting as a dispersal barrier for grizzly bears at the US-Canada border, as evidenced through genetic differentiation between the two populations (Proctor et al., 2005). The result is the creation of two vulnerably small populations (Proctor et al., 2005). A highway was found to restrict gene flow in a Cleveland, Ohio coyote population and direct the movements of migrants towards urbanizing centers (Rashleigh et al., 2008). Even when they do not constitute an absolute physical barrier, high-use roads can lead to avoidance behavior in canids affecting their ability to move across a landscape (Kaartinen et al., 2005, Whittington et al., 2004). The degree to which a road impacts canid survival is dependent on the specific situation, and sometimes no detrimental effects are observed, as in the case with San Joaquin kit foxes (Cypher et al., 2009).

The amount to which a road constitutes a movement barrier for black bears is dependent of the level of traffic volume (McCown et al., 2009). A study documenting the movements of two black bear populations along the same highway in Florida found that the population living in the area with lower traffic volume crossed the highway more often (McCown et al., 2009). In Maryland, black bears avoided the larger primary highways, but readily crossed all other road classes (Fecske et al., 2002). In the northern

Rockies, just under 50% of collared black bears were willing to cross a highway at least once were (Lewis et al. 2011). A study in North Carolina found that site occupancy of black bears deceased from 0.81 to 0.35 a highway in the study area was widened from 2-lanes to 4-lanes (Nicholson and van Manen 2009). For black bears, roads appear to exhibit the distinct trade-off between permeability and road kill discussed by Forman and Alexander (1998).

Though the last 10 years has documented many adverse effects of highways and roads on carnivore populations, there have been positive developments as well. Highway crossing structures have been successful at mitigating some negative impacts of highways on carnivore populations. In Texas, bobcats did make use of culverts to cross a highway when the culverts were placed adjacent to suitable habitat (Cain et al., 2003). A study in California found that a large variety of species, including reptiles, small mammals, carnivores, and mule deer use highway underpasses, even underpasses not designed specifically for wildlife (Ng et al., 2004). A study investigating wide variety of structures, including culverts, modified box-culverts, underpasses, and overpasses, found that culverts were the least used preferences between underpasses and overpasses varied with species (Mata et al., 2008). A study in Portugal found that red foxes, badgers, genet, and Egyptian mongooses used underpasses and culverts without preference (Grilo et al., 2008). However, a study of wildlife underpasses in Virginia revealed that while they were effective for foxes and coyotes, they did not find evidence of black bears utilizing highway underpasses (Donaldson, 2007). Likewise, a study monitoring the success of multi-species highway underpasses following a highway-widening project found that bobcats, black bears, and foxes utilized underpasses, but not coyotes or red wolves present in the area (McCollister and van Manen, 2010).

In all documented success of highway crossing structures, the authors noted that the successful structures connected areas of suitable habitat for the target species. The non-detection of all area carnivore species in the multi-species crossing structures may be the result of not being located in an area that contains suitable habitat for all species. Though multi-species structures may be may appear to be more cost effective initially, a lower success rate will decrease the cost effectiveness in the long run.

While the subjects above have gotten considerable coverage in the peer-reviewed literature, relatively little research has been directed at determining the placement of highway underpasses. In may be beneficial to focus future research efforts on determining the effective placement of highway crossing

Of the studies that focused on placing mitigating structures, methodologies have varied widely and range from non-invasive to the capture and handling of target species. Non-invasive techniques include the use of track/trail counts (Van Dyke et al., 1986; Rodriguez et al., 1996; Alexander and Waters, 1999; Scheick and Jones, 1999, 2000; Barnum, 2001, 2003), remote cameras (Scheick and Jones, 1999, 2000), barbed wire hair traps (Wills and Vaughan, 2005), road kill surveys (Clevenger et al., 2003b; Mazerolle, 2004; Smith et al., 2009), and GIS based modeling (Smith et al. 1998; Klein, 1999; Kobler and Adamic, 1999; Sheick and Jones, 1999, 2000; Clevenger et al., 2003a; Lloyd

et al., 2005). Non-invasive techniques are relatively inexpensive and can be effective, however all are time intensive. A constraint of track counts is the requirement of an appropriate substrate, the use of sand, or, in some areas, the presence of fresh snow. Remote camera traps provide crossing location, date, time, and work for a wide variety of species. Yet, cameras cannot cover the entire length of the highway simultaneously. Running barbed wire the length of the study area provides crossing location and, with the addition of genetics, crossing frequency on the level of the individual. Drawbacks of using barbed wire include the added cost of genetics and the limited number of mammals this technique is appropriate for. Road-kill surveys to detect crossing hotspots are an excellent method for collecting data on a wide range of species simultaneously. However rate of decay, scavenger activity, and method of survey (driving vs. walking) can affect results and must be considered in planning survey interval times. Road kill surveys may also miss animals that wander away from the collision site before dying. It has also been suggested that while road kill events do represent failed attempts to cross, they do not necessarily indicate important linkage areas. The primary weaknesses of the GIS-based techniques are data availability and data quality. GIS models are most effective when data on habitat use patterns of the subject species are well known and where the habitat is diverse and heterogeneous. A limitation of non-invasive techniques as a whole, with the exception of GIS based models, is inherent bias unless the entire length of the proposed highway construction project is covered. Many of the studies cited here established transects or plots rather than surveying the entire study area, thus missing crossing activity at sites not surveyed.

The more invasive techniques involve capturing and collaring target species in order to track movements. These techniques are especially useful when the study is focused on a particular species as opposed to a generalized group. A few studies employed the use of VHF radio collars to identify road-crossing locations and the influence of highways on animal movements (Beringer et al., 1990; Chruszcz et al., 2003; Riley et al., 2003; Dickson et al., 2005; Wray et al., 2005). Though radio telemetry is a more affordable method of telemetry, it is time intensive and often long time intervals exist between locations. Low-resolution movement data may inaccurately depict crossing sites, or miss crossings altogether. In addition, accessibility to collared animals can be limited due to terrain, road condition, and/or private property. GPS telemetry, though more expensive, allows the tracking of animal movements via satellite and reduces accessibility issues. In addition, GPS collars can be programmed to collect data in short time intervals, improving resolution. High-resolution movement data is essential for pinpointing road-crossing locations. Though GPS collars may cost more up front, they provide more accurate locations, and save money by reducing man and vehicle hours required for data collection (Rodgers et al. 1996, Mech and Barber 2002). GPS collars have successfully been used to identify road-crossings for many large mammals such as grizzly bears (Waller and Servheen, 1999, 2005), black bears (McCoy, 2005), and elk (Dodd et al., 2007).

All of the techniques described above identify cross-locations for the placement of mitigating structures, but do not measure the extent to which a road is acting as a barrier. Most studies use genetic sampling to measure whether or not a road is acting as a barrier

to gene flow in a population (Gerlach and Musolf, 2000; Epps et al., 2005; Riley et al., 2006). However, in 2007, Dodd et al. proposed the use of a permeability index to measure the barrier effect of a highway. A permeability index is a passage rate calculated by using the following equation: #crossings/(#crossings + #approaches, where an approach is defined as a red wolf entering into a 164 ft. buffer zone around the highway without crossing (see Figure 2). So far, this methodology has only been used on ungulates with seasonal migration patterns and not on species that remain in smaller defended territories.

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Coyote Depredation Permit

North Carolina Wildlife Resources Commission
Regulated Activities Permits Section
1707 Mail Service Center
Raleigh, NC 27699-1707

Tele: (919) 707-0061
FAX: (919) 707-0292

AUTHORITY

STATUTES
GS 113-274

RULES
15A NCAC 10B .0106

PERMITTEE/LICENSEE

Tom Harrison
[redacted]

Telephone: [redacted]

PERMIT NUMBER
DO09102018-1

EFFECTIVE	EXPIRES
10/01/2018	10/31/2018
COUNTY	**DISTRICT**
See Text Below	See Text Below

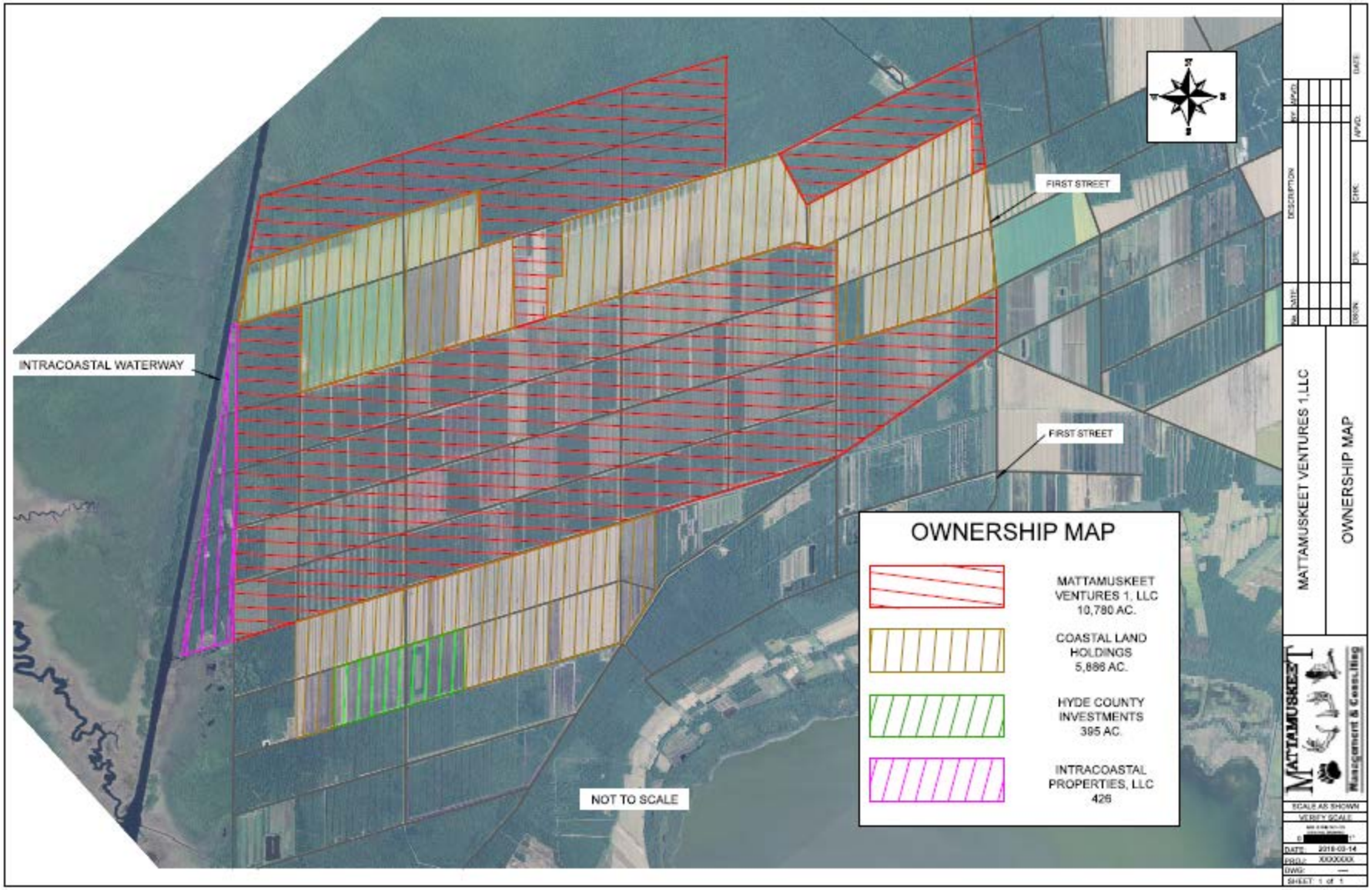
CONDITIONS AND AUTHORIZATIONS:

The above permittee and other individuals under written contract and under the supervision of the permittee are authorized to trap coyotes on the properties identified in **Attachment A** subject to the following conditions:

- Permit is valid for properties identified in **Attachment A**.
- This permit does not authorize access to any property, public or private.
- All individuals exercising the authority granted by this permit shall carry a copy of this permit and a letter of authorization from the permittee listed above while conducting trapping activities.
- Traps must be labeled as required by G.S. 113-291.6. Traps must be checked daily and any animals caught therein must be removed. All non-target wildlife must be released immediately onsite; however, any red wolf captured must be reported immediately to the Wildlife Resources Commission (WRC) at 800-662-7137 or the U.S. Fish and Wildlife Service to determine disposition of the red wolf.
- Coyotes being removed for depredation under this permit may only be trapped using legal foothold traps and the Collarum type trap as defined in G.S. 113-291.6. The reporting forms required for the use of Collarum type traps may be found at http://www.ncwildlife.org/Trapping/Laws-Safety. Collared animals must be reported immediately to the WRC at 800-662-7137 before final disposition is determined. All coyotes euthanized shall be disposed of in a sanitary manner. All collars from euthanized coyotes must be returned to the WRC.
- Permit holder must report the removal of coyotes to the WRC at 800-662-7137 or online at www.ncalvin.org/ckr/ckrmain.aspx within 24 hours of taking possession of each individual coyote. Each report must include the date; time; location; if the animal had a collar; and measurements of hind foot length and tail length taken from the carcass. Instructions for recording these measurements are enclosed and can be found at www.ncwildlife.org/Portals/0/License/Documents/Canid-Cooperator-Program-Instructions.pdf.
- A hair sample with follicle from each euthanized coyote must be submitted to WRC, Wildlife Management Division, 1722 Mail Service Center, Raleigh, NC 27699-1722.
- A report of all animals captured under this permit, date of capture, and their disposition is required within fifteen (15) days after the expiration of this permit. The report may be submitted by email to RAPSreporting@ncwildlife.org or by mail to Regulated Activity Permits Section, 1707 Mail Service Center, Raleigh, NC 27699-1707.

This permit/license is nontransferable and expires at midnight on the above specified expiration date.

ISSUED BY:	TITLE:	DATE:



ATTACHMENT A

STATE: North Carolina

GRANT TITLE: W79-Wildlife Management

PROJECT TITLE: Pilot Study – Using Fine Scale GPS Technology to Research Sympatric Canid Population Dynamics (Job 2.0?)

A. Problem and Need

The coyote (*Canis latrans*) is now abundant throughout the 100 counties in North Carolina (NC), and is managed as nongame with no closed season or bag limit (NC Wildlife Resources Commission 2016). Previously restricted to the West and Midwest regions of the United States, by the early 1990s coyotes had expanded their range into the Albemarle Peninsula (AP), which is situated in the northeast coastal plain region of NC (Hinton et al. 2012, Murray et al. 2014). In recent years as coyotes have increased their population, some have begun to make use of the Outer Banks region.

The United States Fish and Wildlife Service (USFWS) released a non-essential, experimental population of captive-bred red wolves (*Canis rufus*) on the Alligator River National Wildlife Refuge (ARNWR) in 1987 (Hinton et al. 2013). This population increased until 2008 and peaked at around 130 individuals (Group Solutions, Inc. 2016), short of the recovery goal of 220 in the wild (USFWS Red Wolf Recovery Program 2013). The AP has an estimated carrying capacity of 140-150 wolves (Hinton et al. 2013, Kelly et al. 1999, USFWS Red Wolf Recovery Program 2007). The exact number of red wolves is not known, but USFWS staff report a population estimate of 45-60 individuals with eight mortalities to date in 2016 (https://www.fws.gov/redwolf/index.html August 2016). Hybridization with coyotes and inbreeding depression are suspected factors that have affected red wolf population growth and viability since the inception of the Red Wolf Recovery Program (RWRP), while vehicular and gunshot mortality are known factors (Hinton et al. 2013). Because of hybridization between red wolves and coyotes, the AP supports a continuum of sympatric canids, hereafter referred to as "sympatric canids."

As part of a recent program review, the USFWS halted many aspects of the RWRP in 2015 and discontinued the coyote sterilization program, potentially affecting the spatial

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distribution and population dynamics of sympatric canids. Telemetry data from coyotes on the AP suggests that about 70% of coyotes are residents (i.e., those that defend set territories) while the other 30% are transients, with most being dispersing juveniles (Hinton et al. 2015). Transient coyotes do not defend set territories. Coyotes can travel long distances and become transient even as adults, especially when they lose their mate. Recently described as using "compensatory immigration," coyotes opportunistically fill spatial resource gaps by periodic transiency; when spots come open, individuals that do not yet have permanent territories and have been roaming in the area, are able to inhabit the new openings (Hinton 2016). These periods of transiency can sometimes bring coyotes into conflict with other canids and humans, especially when they are utilizing of anthropogenic resources.

Though a rural area, human land uses occupy a significant portion of space on the AP. The AP is comprised of approximately 30% agricultural fields, 50% forest and coastal marshes, and 20% "other" land cover types on federal, state and private lands (Dellinger 2011). Concerns about fear of attacks on humans and domestic pets, the effects of sympatric canids on white-tailed deer and other game populations, and homeowner property damage comprise many of the conflict calls regarding sympatric canids on the AP (Responsive Management, forthcoming data). Wildlife managers in this region frequently receive requests for information on canid management (C. Turner, personal communication, 2016).

The changes in state and federal canid management rules have resulted in confusion regarding residents' rights and options for management of property damage by sympatric canids. As a result, some citizens are unsure of the legal and most effective methods for canid conflict management. Adding to management complexity is the need to manage canids for conservation purposes, such as reducing predation on at-risk ground nesting species or reducing hybridization of sympatric canids.

In 2013, NCWRC and USFWS established a committee to oversee the collaborative management and conservation of sympatric canids on the AP. A USFWS and NCWRC joint memorandum documented detailed action items for the joint management of sympatric canids on the AP, including specific research objectives which this proposal seeks to address (Attachment 2). As sympatric canids on the AP increase in number, monitoring their

Commented [BA1]: I don't understand the assumption that dynamics would change

Commented [BA2]: Data from how many current coyotes? Doubt you could make this determination from the current or past data, only on the coyotes that happened to have been collared in specific areas due to managing the wolf population

Commented [BA3]: Is there any data showing that this even takes place?

Commented [BA4]: Coyote number may be increasing – suggests a need, if any, to focus on them, not an endangered species with so few in the population and therefore at greater risk to loss from management actions.

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movements, particularly in relation to individuals of differing ancestry, could provide important data to NCWRC and USFWS staff for science-based local and landscape-level decisions about sympatric canid populations and conflict management. Collection of finer temporal scale location data would help to manage interactions of sympatric canids with humans, as well as to support development of dynamic stochastic population models.

B. Objectives (after December 1, 2016-November 30, 2018)

Objective 1: Use GPS collar and proximity sensor technology to test performance under various conditions and evaluate the frequency and accuracy of the scheduled fix rates.

Objective 2: Use fine scale GPS data collection for investigating annual and seasonal spatial dynamics of sympatric canids: home range and core area sizes, amount of overlap in home range and core areas, movement pathways and daily activity patterns, and cover type selection and preference.

Objective 3: Use fine scale GPS data collection for investigating the number and age structure of offspring for family groups of collared sympatric canids.

Objective 4: Use fine scale GPS data collection for investigating sources of mortality for sympatric canids.

Objective 5: Use fine scale GPS data collection for preventing and mitigating canid conflicts with landowners.

Objective 6: Determine genetic profiles of sympatric canids through DNA identification of all captured individuals, parentage, and presence of hybridization.

At the end of this two-year pilot study, we will deliver an observational summary detailing the use of the GPS and sensor technology for spatial and population dynamics research on sympatric canids on the AP.

C. Expected Results and Benefits

As part of a pilot study, we will monitor the status of collared individuals by using a finer scale assessment of space and habitat use than previous studies. Earlier research focused on many of the same objectives we suggest investigating here, but during a time of intense, active

Commented [BA5]: This is a very vague statement – what decision are being sought out here, particulary that we don't have research and data on already, at least regarding red wolves.

Commented [BA6]: This objective should not be the basis for all the work suggested in this proposal on red wolves – too much potential risk. Test them on coyotes, or dogs.

Commented [BA7]: Has already been done – no need to reinvent the wheel, especially now. The time to do that was when there were significant numbers of both species on the ground. Can't get that now.

Commented [BA8]: Why? Of all things, this is not needed on red wolves for red wolf recovery.

Commented [BA9]: Done for red wolves. Focus on coyotes if anything.

Commented [BA10]:

Commented [BA11]: What conflicts?

Commented [BA12]: Again, how does this promote recovery of red wolves, and how would this be used for management

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management. Specific management techniques are no longer being carried out and dynamics between sympatric canids are expected to have changed substantially. The uncertainty regarding current dynamics presents a need for additional research in order to inform actions for the management of sympatric canids. Information gained from research may impact management rules and landowner's abilities to manage canids in some areas. Additionally, GPS technology has improved since earlier research was conducted allowing for more temporally detailed data collection and more nuanced analyses. Understanding how sympatric canids collectively use resources in areas of human-dominated landscapes will allow wildlife managers to tailor management options to local conditions. On the AP, row crop agriculture and hunting represent the primary and secondary land uses, respectively. Row crop agriculture is a significant nutrient resource on the landscape and, as opportunists, canids take advantage of such resources when they are available. Non-consumptive wildlife-driven tourism persists in all seasons and wildlife watching is a main draw for tourists in this area. For many tourists, the opportunity to see or hear large carnivores is the sole attraction for traveling to the AP. Information from this study will be provided to local constituents to establish a knowledge base regarding how sympatric canids use resources on private lands. Management and guidance could serve to prevent or minimize conflict while maximizing positive wildlife interaction opportunities for constituents. Development of a common understanding between wildlife managers and landowners based upon factual information is paramount for collaboratively achieving successful management of sympatric canids. The data collected in this pilot study is the foundation upon which this understanding and future management actions will be built.

The current level of hybridization between sympatric canids on the AP will be characterized using DNA gathered during this study. Body size exists as a continuum between coyotes and red wolves and has been documented as the most important factor for successful interspecific breeding pairs of these canids (Hinton 2014). Though both species have been found to use resources in similar manners, red wolves generally have more expansive home ranges and therefore may not use local resources as intensively as coyotes, depending on body size. Obtaining individual identification of study animals will allow managers, armed with spatial information, to infer how and why individuals in the canid species continuum exploit

Commented [BA13]:

Commented [BA14]: Lot of words here, but what type of management options would be considered for what resources?

Commented [BA15]: Take advantage of row crops?

Commented [BA16]: "large" – is that red wolves or coyotes, or both? Is there a suggestion of tourism based on coyote presence?

Commented [BA17]: Except that the numbers do not exist on the ground to do this, particulary on non-public lands where you would need to understand the "foundation". Takes out the need to do this refuges.

Commented [BA18]: So again, we already have this information – why risk on red wolves

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anthropogenic resources considering their life history traits.

In conjunction with prior research, data collected will contribute to knowledge on sympatric canid population dynamics on the AP. Estimating population size will allow managers to monitor population trends of sympatric canids and to examine the long and short-term impacts of different management strategies on their populations. While it is unknown whether sample size will allow for population estimation, obtaining population estimates for coyotes would provide wildlife managers with baseline data, when paired with annual mortality estimates, for monitoring changes in population abundance over time. Information on changes in abundance, reproductive dynamics, and habitat use could impact management strategies to influence long-term conservation outcomes. Results of this pilot study will allow managers to determine if future work will be necessary, what amount of effort will be required to achieve each objective, and whether or not population estimates will be an attainable goal.

Commented [BA19]: You can't do this in a 2-year study though – and are different management strategies being employed during this study and being incorporated.

D. Approach

The official Red Wolf Recovery Area (RWRA) covers approximately 6,900 square kilometers within Beaufort, Dare, Hyde, Tyrrell, and Washington counties (Wildlife Management Institute 2014). However, the USFWS has proposed the RWRA be constricted to the ARNWR and the Dare County Bombing Range in Dare county by the end of 2017. Due to these proposed RWRA changes, this study proposes to capture and radio-collar 25 sympatric canids within Dare, Hyde, and Tyrrell counties (hereafter referred to as "study area"); those counties being within and directly adjacent to the proposed new RWRA. The thematic subheadings below provide detailed descriptions of the approaches required for achieving the pilot study objectives.

Sampling Efforts

Trained NCWRC personnel will conduct live trapping of sympatric canids, with assistance from the USFWS RWRP biologists, and trained, experienced local trappers. NCWRC and USFWS wildlife personnel will select local trappers based on their past performance in trapping sympatric canids, but may also select trappers from the NCWRC coyote trappers list. NCWRC staff will train contracted trappers on specific trapping procedures before every trapping

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season. The project lead will supervise and coordinate all trapping activities including locations for installation and the operation of trap lines and handling of captured animals. Simultaneous personal trapping activities by contracted trappers will not be permitted while performing contracted trapping services, as specified in the draft service contract (Attachment 4).

Trapping efforts will follow a spatial capture-recapture (SCR) framework with a systematic targeted sampling design, focusing on areas that contain resources previously found to be used by sympatric canids (e.g. edge, agricultural fields, secondary roads, etc.) (Harris et al. 2013, Ivan et al. 2013), while attempting to sample a diversity of habitat types. This effort will allow us to increase the probability of detection of sympatric canids on the landscape (Tom 2012). While it is important to sample a wide range of habitats, the most important requirement for SCR is the number of collared individuals; this requirement provides flexibility in the other requirements for field sampling as needed (K. Pacifici, personal communication, 2016). We will initially focus trapping in areas of known red wolf packs, as advised by RWRP.

Trapping will take place during the breeding season when the likelihood of capturing females in the later stages of gestation or whelping females will be low. Capture efforts will be conducted from soon after 1 December 2017 – February 2018 and December 2018 – February 2019. Captured sympatric canids will be surrendered to NCWRC or the USFWS at capture sites. Trapping should occur on both public and private lands to obtain sampling coverage of the study area. Ideally, all federal and state lands would be accessible for trap and release (hereafter referred to as "capture") of sympatric canids, but it is most important to be able to trap and release on Alligator River NWR and the Dare County Bombing Range as those encompass the newly proposed RWRP recovery area and comprise the majority of land area for Dare county. Unlike Dare county, there are ample private lands that surround Pocosin Lakes NWR and Lake Mattamuskeet NWR in both Tyrrell and Hyde counties that may be utilized to effectively sample individuals who may use those federal lands, should they be excluded from capture activities. Capture on federal lands may require USFWS take permits and proposed activities may be subject to a compatibility assessment (P. Benjamin, personal communication, 2016). Scientific collection activities that take place on private lands will require agreements outlining conditions mutually decided by NCWRC and landowners (Attachment 3).

Commented [BA20]: Even if these areas were included, the numbers don't exist for this study. And I'll say it here, but if this is the last holdout for red wolves in the population, there isn't enough information to be gleaned from this study that in any way promotes recovery, especially on the refuge, and when the objectives are focused in large part on landowner conflicts and resources.

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To increase probability of detection of sympatric canids, the accessible study area will be partitioned by a grid, the cell size of which will based on the average annual home range size of resident coyotes previously reported for the AP, approximately 23 km^2 (Hinton et al. 2015). As a system of sampling, trap lines will be referred here as "traps," and the number of trap sets (i.e. the actual trapping device) and number of each trap set size may vary between traps as necessary. Sampling will be standardized within each grid cell by use of equal number of traps per cell, on average 3 per cell, each at an approximate length of 10 km (Andelt and Gipson 1979, Way et al. 2004).

Target canids will be captured by using Softcatch #3 Coyote 4x4 (Oneida Victor Inc. Ltd., P.O. Box 32398, Euclid, Ohio 44132, Hinton 2014, Schemnitz 1994), the EZ Grip #7 (Livestock Protection Company, P.O. Box 725, Alpine, Texas 79831, Frame and Meier 2007), or equivalent. Various lures and baits will be used to increase trapping efficiency (Frederick et al. 1989, Shipley 2012). Traps will be laid on the Monday of each week and will be opened at the time of deployment. Traps will be checked once daily at dawn, to reduce potential stress to trapped individuals and will not be operated on days where the temperature is expected to reach or exceed 80° F (R. Nordsven, personal communication, 2016) or during times of predicted inclement weather (e.g. snow, hail, high wind, etc., Sikes et al. 2011). To standardize effort and remain logistically realistic, traps should be open for three trap nights in a row before being removed. Trap sets that have been closed due to non-target bycatch or other circumstances may be reopened and all traps should be re-baited and lured as appropriate.

Trap set locations will be marked by NCWRC or USFWS personnel using handheld GPS units (Garmin GPSMAP 64S, 1200 E. 151st St., Olathe, KS 66062-3426) and given a sequential identification number. Traps will also be given an identification number and trap set points will be documented in ArcMap 10.4. Trappers will keep detailed records on trap set operation, non-target species trapped, and other relevant details. Non-target species will be released from traps after an in-field assessment of injuries, if any, and animals with life threatening injuries will be euthanized by the trap operator. Targeted recapture of collared canids will occur annually during the same months, to replace GPS collar batteries and drop-off collar release units in field. Trapping effort will be quantified (trap nights), the effective sample area will be

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estimated, the encounter (detection) probability will be estimated using a Gaussian detection model (Amundson et al. 2014), and an estimate of density for coyotes will be calculated using a modified Huggins closed-capture estimator in program MARK, if sample size allows (Harris et al. 2013, Ivan et al. 2013).

Animal Handling

Handling of canids will follow American Society of Mammalogists (ASM) guidelines (Sikes et al. 2011) and will be performed at the capture site. Chemical immobilization agents may be used depending on the number of field staff during processing (i.e., three or more staff required during non-chemical immobilizations, Craft 2007, M. Morse, personal communication, 2016).

Chemical Immobilization

Unless adequate numbers of personnel are available to safely employ mechanical restraint techniques, target animals will be anesthetized with the chemical immobilization agent BAM (Wildlife Pharmaceuticals, Inc., Windsor, CO 80550). BAM, a combination of Butorphanol tartrate, Azaperone tartrate and Medetomidine HCl., will be delivered by intramuscular injection by syringe pole to the hip. Dosage for canids is based on field trails performed by Wildlife Pharmaceuticals (Wildlife Pharmaceuticals, Inc. 2016) and the recommended dose for coyotes is 0.2CC and red wolves is 0.3CC, with adjunct doses of 0.1-0.2CC delivered if initial dosages do not cause induction (S. Kirschner, personal communication, 2017). Induction times for coyotes and wolves ranged from 5 to 10 minutes after initial and/or adjunct dosages (Wildlife Pharmaceuticals, Inc. 2016). After field handling is concluded the anesthesia will be reversed using two reversal agents, Atipamezole and Naltrexone, at double the CC of Atipamezole to BAM that was delivered (including adjunct doses, if given) and 0.5CC of Naltrexone. Recovery time from the reversal agents ranged from 10 to 25 minutes during field trails (Wildlife Pharmaceuticals, Inc. 2016). Field personnel will observe animals for signs of adverse effects for up to 30 minutes after reversal agents are delivered.

Mechanical Immobilization

Unlike other carnivore families, the submissive behavioral response of canids to

Commented [BA21]: Need to look at CFR on red wolves

Commented [BA22]: We've gone through testing on red wolves using various drug combination to find what works best – I'm not aware that this combination has been tested on red wolves? The field would not be the place to do this!

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perceived dominance reduces the need to use immobilization agents. Appropriate mechanical restraint techniques can reduce handling time of animals, allowing animals to reintegrate into social groups more quickly, subsequently reducing overall stress to the individual (Powell and Proulx 2003). Target canids will be mechanically restrained with a restraint pole, until two muzzles can be placed around the snout. While pinned with the restraint pole by one person, a second person will restrain the set of legs not in the trap against the ground and a third person will release the foot from the trap. This set of legs will then be restrained by the 3rd person as the restraint pole is removed. Once the restraint pole is removed the person restraining the front legs will also then restrain the head. The first person will then move forward with processing the captured animal.

Each animal will be placed on a towel or blanket to provide thermal protection from the ground, with eyes covered and lubricated with eye ointment; temperature will be monitored with a rectal thermometer. Overheating occurs at approximately 104-105°F for canids (AZA Canid TAG 2012) and the animal handling crew will monitor temperature at 5-minute intervals; if a temperature reading reaches 104°F, corrective actions will be taken and temperature will be monitored at 1-minute intervals. Should overheating occur, the individual will be removed from insulation to expedite the natural evaporative cooling process. During days that approach 80°F in temperature, measures will be taken to reduce heat stress, such as: wetting the animal with water, application of a cold pack to the groin area between the back legs, application of rubbing alcohol to foot pads, or immediate release (AZA Canid TAG 2012). If the injured individual is suspected to be a red wolf, based on morphometrics, USFWS staff will be contacted for a decision. In the event that trap caused injuries are determined to be life threatening through use of a trap injury score assessment (Frame and Meier 2007) the individual will be euthanized. In the event that NCWRC personnel cannot be present, trained USFWS personnel may collar and measure captured target animals and will provide data sheets to NCWRC staff. Target animals will not be vaccinated or otherwise treated for diseases, regardless of the presence of disease symptoms.

Commented [BA23]: Or tranponders, or previous genetic analysis – do not use morphometrics as the sole indicator of species.

Commented [BA24]: For red wolves, this should be the call of FWS – look at CFR

Non-target animals will be released on site. Captured domestic dogs will be immediately released from the trap set following an injury score assessment and only if no life-threatening

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injuries are present. If a domestic dog has sustained life threatening injuries and owner identification information is present on the dog, then the animal will be held in either a transportable kennel, or at a dog pen on a state game land that is equipped with such facilities, until the owner can retrieve the dog. The costs associated with injuries sustained to the dog will be the responsibility of the animals' owner. Law enforcement may be requested to help communicate with the animal's owner. If the animal does not have an identifiable owner and has incurred substantial life threatening injuries (i.e. compound fracture), the dog will be euthanized on site. Target animals showing signs of disease symptoms such as circling behavior, head tilt, muscle twitches, convulsions with jaw chewing movements and salivation ("chewing gum fits"), disorientation, incoordination, staggering caused by paralysis of the hind legs, seizures, and partial or complete paralysis will be euthanized and tested according to protocol set forth by the agency veterinarian, in order to determine if there may be a public health issue (M. Palamar, personal communication, 2016). USFWS will be contacted in cases of suspected red wolves. Staff involved in animal handling duties will have the pre-exposure rabies vaccination series completed prior to field work inception and will maintain rabies titer records through properly licensed medical services providers.

Commented [BA25]: Even if it is on their property?

Commented [BA26]: This is problematic on refuges.

Commented [BA27]: Not just contacted, but the decision needs to be FWS

If staff is bitten and skin is broken by an animal while performing handling duties, they will be advised to immediately visit a local hospital or clinic for evaluation by healthcare professionals. The field coordinator will immediately notify supervisory staff and an injury report and workers' compensation claim will be opened for the incident. The animal will be euthanized and the head will be sent to the state lab for rabies testing; the body may be sent to the Southeastern Cooperative Wildlife Disease Study (SCWDS) laboratory for additional disease investigation.

Capture Processing and Marking

During canid handling, NCWRC personnel will record age class, sex, weight, total body length, head width, ear length, and tail length, visually assess ectoparasite load, look for and disinfect with betadine or iodine as needed any minor trap caused injuries, and affix GPS collars (Knick 1990, Sikes et al. 2011). All captured canids will be fitted with appropriately-sized GPS collars in the field based on morphometrics previously indicated as reliable thresholds for

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species categorization: hind foot length, weight, width of head, and tail length (Hinton 2014); analysis of DNA samples collected during trapping efforts will help to assign captured canids to position along the species continuum post release. Age of individuals will be estimated based on physical characteristics, including weight and tooth replacement (Knick 1990, Hinton 2014, Gier 1968), and captured canids will be aged into one of three classes: > 2 years old as adults, < 2 but > 1 year old as juveniles, and > 6 months but < 12 months old as pups (Hinton 2014). Reproductive status will be determined based on estimated age class and presence of gonadal descent during the breeding season for males and the presence of nipple swelling or previous suckling for females (Hutson and Racey 2004, Magee 2008, Mengel 1971).

Captured individuals will be ear marked using a button tag (model 410, Ketchum Mfg. Co. [or equivalent], PO Box 10, 11 Town Shed Road, Lake Luzerne, NY 12846) placed along the middle of the ear where they are most protected from loss, with a pin-type applicator (485sa Pow-R-ceps plier, Ketchum Mfg. Co. [or equivalent]) (Silvy 2012). The puncture site will be treated with an antiseptic to deter infections. Each sympatric canid will also be marked with an individually-numbered, glass-encapsulated, passive integrated transponder (PIT model HPT12, 12.5 mm, 134.2 kHz, Biomark, Inc., 703 South Americana Blvd., Suite 150, Boise, ID; Gannon et al. 2007), using a syringe-type implanter and replaceable needle (model MK10 [implanter], model N125 [needle], Biomark, Inc.). Successful PIT placement will be verified with a mini portable reader (model GPR Plus, Biomark, Inc.). The implantation site will be prepared by swabbing with 70% alcohol (Mrozek et al. 1995) and a sterilized new needle will be used for each injection. The standard implantation site for transponders is subcutaneously on the dorsal midline of the back, cranial to the shoulder blades (Ingwersen 2000).

A skin biopsy will be taken from all captured target canids by puncturing the pinna of the ear with a biopsy punch in the same location where the ear tag will be placed (Palamar 2014). The biopsied area will be disinfected with alcohol after sampling. The skin biopsy will be placed in a labeled (ID, date, and sample type) cryogenic tube filled with 95% ethanol as buffer and then stored in a freezer until sent out to a lab for genetic analysis (Palamar 2014, Tom 2012). A selection of hairs with the root bulla attached will be pulled from the belly and placed in paper envelopes (Janecka et al. 2007). Hair samples will serve as back up to tissue samples

Commented [BA28]: Why? How does this fit into the study proposal? If not, no need to do it.

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for genetic testing. All samples will be sent to the Laboratory for Ecological, Evolutionary and Conservation Genetics, at University of Idaho (875 Perimeter Drive, MS 1136, Moscow, ID 83844) for genotyping to determine species as well as individual identification, hybridization presence, and parentage analysis following previously developed protocols (Adams et al. 2007, Hinton 2014, Miller et al. 2003). The appropriate genetic analyses that examine the coyote-hybrid-wolf species continuum will be performed.

Blood will be collected from all juvenile and adult target canids by venipuncture of the brachial or jugular veins using a 22-28-gauge needle (M. Palamar, NCWRC veterinarian, personal communication, 2016). As per NCWRC veterinarian recommendations, approximately 12 ml of blood will be collected for each animal for possible future testing for diseases of importance to sympatric canid species as well as the humans and domestic animals that they may come into contact with. A minimum of two 6 ml lavender top tube (for whole blood with EDTA) will be filled. Samples should be refrigerated at all times; a cooler with ice will suffice while in the field. Samples should be sent to the NCWRC within 48 hours or frozen for later shipping. Skin scrapes will be collected from animals presenting signs compatible with sarcoptic mange (lesions) for possible future diagnostic purposes. Lesions will be scraped until blood is drawn; the scrapings will be placed onto a slide and covered with a piece of clear tape for later visual confirmation.

Should overheating occur, processing will be performed in the following prioritization order and the first five items will need to be completed before releasing any individuals: 1) trap injury evaluation, 2) collaring, 3) DNA (skin biopsy) sample collection, 4) morphometrics, 5) aging, 6) PIT tagging, 7) weight, 8) ear tagging, 9) reproductive status, 10) ectoparasite evaluation, 11) blood collection, and 12) skin scrape collection.

Collaring

Vertex Plus GPS Collars will be attached to 25 sympatric canids captured on the study area, 10 of which will be equipped with proximity sensors (Vectronic Aerospace GmbH, Carl-Scheele-Str. 12, 12489 Berlin, Germany). Project staff will pilot test proximity sensor technology for utility in analysis of spatial and temporal community dynamics. Proximity sensors trigger increased GPS location acquisition during those time intervals when two collared individuals

Commented [BA29]: Why? What information is being collected and how would it be used to meet objectives?

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come within a set distance from each other (http://www.vectronic-aerospace.com/wildlife-monitoring/sensors/uhf-id-tags, accessed August 2016).

To avoid instances of collar induced strangulation, only adult (>2 years old) male and female individuals will receive collars (Hinton 2014). ASM guidelines recommends a collar weight of <5-10% of a canids bodyweight, we will observe these guidelines (Sikes et al. 2011). Sympatric canids not releasable at a capture site will not be collared and will not become study animals.

GPS radio-collars will have both VHF and GPS Iridium locational systems as well as store-on-board capabilities. Radio-collar units will be programmed to record GPS coordinates once every 1.75 hours producing approximately 13 locations per day while cycling through the 24-hour time cycle. These settings will allow for a GPS battery life of 300 to 552 days, averaging 431 days. The VHF beacon will be in operation from 0800 – 1600 hours daily. GPS locations will be sent via satellite once per day and each transmission with contain 12 locations. The use of an integrated drop off firing mechanism should allow the collars to drop off within a maximum of approximately 548 days after deployment. The drop off schedule once set cannot be changed. The drop off firing mechanism is wired to a battery unit independent of the collar battery, therefore should the collar battery become depleted, the drop off mechanism will not be affected (C. Akakpo, Vectronic Aerospace GmbH, personal communication, 2016). Unless a collared individual is recaptured before the collar battery dies, the drop off mechanism will fire at the scheduled time frame post collar deployment.

Observation of sympatric canid habitat use and movements will occur through GPS data obtained with combination GPS/VHF radio-collars. VHF relies on triangulation, the process of estimating the location of a transmitter by using two or more compass bearings obtained by using directional antennas at known locations remote from the transmitter's position (White and Garrott 1990), whereas GPS uses a satellite based system to obtain location coordinates. There have been many published studies where one or both of these methods were used, with mixed success for determining various aspects of carnivore ecology throughout the United States (Hinton et al. 2012, Schrecengost et al. 2009, Sparkman et al. 2012). While GPS technology has developed rapidly in recent history, the real time functional advantage of VHF

Commented [BA30]: How long is the battery life on the vhf beacon?

Commented [BA31]: This gets at the previous issues we had with managing a population of red wolves using an adaptive management plan but not having wolves collared for longer periods of time and losing contact, hence the inability to manage. You may gain data (though we already have what's being suggested here), but at the risk of the remaining few wolves in the population. In other words, I still don't see the rationale to even consider this proposal.

Commented [BA32]:

Commented [BA33]: Way to short – now no contact with wolves? Are you kidding?

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cannot be disregarded. When GPS technology falters or malfunctions, VHF can serve as replacement for data collection in addition to its use in real time monitoring of study animals. Canids will be minimally monitored for mortality approximately every 30 days by using VHF aerial telemetry techniques (Whitehouse and Steven 1977) as there may be a delay in satellite transmission of GPS location data due to weather, season, and animal behavior. Transient canids and individuals from breeding pairs that have lost a mate, have been found to use much larger areas versus paired residents, potentially increasing the opportunity for losing track of these individuals when GPS technology reaches its functional capacity or experiences malfunction. VHF data may also provide locations of canids in cover too dense for GPS units to function. Use of VHF telemetry techniques for data collection may be expanded as necessary for project needs.

Spatial Data Analyses

Both minimum convex polygon (MCP) and adaptive kernel (AK) home ranges (95%) and core use areas (50% and 25%) (Seaman and Powell 1996, Seaman et al. 1999) will be calculated from GPS data by using BIOTAS (Ecological Software Solutions LLC, 2016) and Geospatial Modelling Environment (Spatial Ecology, LLC, 2016) for ArcGIS 10.2.2 (Environmental Systems Research Institute, 2016) (Benson et al. 2006, Riley 2006, Tucker et al. 2008, Hinton 2014) for comparison to older studies. These estimations can also be calculated using VHF data, provided data minimum requirements are met. Spatial distribution in relation to habitat will also be estimated by dynamic Brownian bridge movement models as described by Hinton (2014) with R statistical software (R Core Team 2016) using the moveud package with habitat covariates important to each species (Bryne et al. 2014, Collier 2013, Kranstauber and Smolla 2013, C. Proctor, personal communication, 2016). Additionally, recent research into how canids shift their ranges will also be investigated for populations on the AP (Morin and Kelly, in review). Spatial overlap and co-occurrence will be assessed using methods described by Shipley (2012). Habitat and cover types will be estimated from digitized maps created by the SEGAP (Hinton 2014) or ortho files, as available (Shipley 2012). Percent composition of habitat and cover types within home ranges and core areas as well as edge density will be quantified (Shipley 2012). Habitat selection and cover type use effects on spatial distribution will be estimated at both the population (2nd order) and individual (3rd order) spatial scales using resource selection functions

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(Johnson et al. 2006, Manly et al. 2002, Shipley 2012). Effects of seasonality and time of day activity will also be explored. The spatial and temporal patterns of space use by sympatric canids will be studied using data generated from the interaction GPS collar sensors, particularly distance between individuals and duration of proximity.

Den Monitoring

Project staff will attempt to locate den sites for sympatric canids to get pup counts, morphometric measurements, age estimates, and skin biopsies. Project staff will also attempt to monitor pup survival during the pup rearing season by using remote cameras placed around the den site (Harrison and Gilbert 1985, Parks 1979, Way et al. 2001). Pups will be weighed, measured, and PIT tagged during May and June of each year when they become active but are still den-obligated (Gier 1968). We will investigate the use of remote camera traps for monitoring den behavior with a two-camera array around the den (H. Garbe, personal communication, 2016, Kays and Slauson 2008). This method has been successfully used to monitor kit fox pup survival (Kluever et al. 2013). Because coyotes have been found to be sensitive to den site disturbance, there is a general lack of data in the literature regarding this approach for monitoring pup survival. Approaching an experimental methodology systematically will be important for determining which methods are effective and which are not. As a starting point for testing this methodology, remote cameras will be placed two to five meters from main den entrances and set to take photos using a passive infrared sensor trigger (a beam that when broken by movement through it, triggers the camera to take a series of photos) with a time restriction between photo intervals to limit the number of photos taken and maximize the space on the memory card for the time period between camera checks (Kluever et al. 2013). Cameras will be checked six days after deployment and will be redeployed (i.e. new batteries and memory card, if required); cameras will remain at each den site until radio-collar data indicates the den site has been moved (Kluever et al. 2013). Cameras will be not be redeployed to a new coyote den site during a season if that breeding pair has already moved the den once due to the disturbance of camera presence/deployment.

Commented [BA34]: Based on past experience, will likely cause dam to move the den, or abandon pups

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Mortalities

If a collared animal dies during the project, the carcass will be sent to SCWDS for necropsy. Red wolves will be sent to the SCWDS laboratory for necropsy, unless it is determined to be a law enforcement case. In potential law enforcement cases, the NCWRC Division of Wildlife Management Chief and USFWS Ecological Services Raleigh Field Office Field Supervisor will be contacted and requested to contact the appropriate law enforcement personnel, immediately after determining the need for law enforcement involvement. The carcass and all relevant information will then be turned over to law enforcement; the GPS-collar will be removed and genetic samples will be taken from the individual prior to release to law enforcement.

Commented [BA35]: Not sure about this w/ES

Commented [BA36]: All mortalities have the potential to involve LE – this needs to be coordinated directly through FWS LE

Commented [BA37]:

Commented [BA38]: Was this not already done when handling initially? This sounds more like an attempt to collect material from canids not already involved in the study. ES material is owned by FWS – would need permit otherwise?

E. Project Personnel

Andrea Shipley has worked for the North Carolina Wildlife Resources Commission as a Canid Biologist since February 2016. Prior to that, she worked as a Wildlife Biologist for a non-profit located in northeastern Nevada as well as in several different field biologist oriented positions. Andrea has a background in carnivore and spatial ecology, having earned her MS in Biological Sciences from Eastern Kentucky University and BS in Biological Sciences from Rutgers University; Andrea will act as project lead and coordinator.

Brandon Sherrill has worked for the North Carolina Wildlife Resources Commission as a Mammalogist since December 2013. Prior to that, he worked as an educator at the North Carolina Museum of Natural Sciences and as a regional wildlife biologist for the South Carolina Department of Natural Resources. Brandon earned a BS and MS in Fisheries, Wildlife, and Conservation Biology from North Carolina State University; Brandon will act as project supervisor.

Krishna Pacifici, Research Assistant Professor at NCSU, will be the quantitative analysis collaborator on the project. Krishna's background and experience in quantitative ecology makes him well suited to consult and assist with advanced statistical analyses of spatial data.

Lisette Waits, Department Head and Distinguished Professor at the University of Idaho, will be the DNA analysis collaborator for the project, responsible for all DNA related sample processing and subsequent analyses.

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F. Schedule and Estimated Costs

The project will run from soon after December 1, 2017 through June 30, 2020. The estimated timeline for major tasks is as follows:

Year 1: Initiate field work soon after December 1, 2017 with assistance from 1-2 field technicians; 1 technician will be required for trapping and den monitoring efforts. Data collection will begin immediately after collar deployment and data will be managed by Andrea Shipley throughout the life of the project. Data analysis will be initiated after den monitoring season concludes, with guidance and assistance from Krishna Pacifici at North Carolina State University (NCSU). Report, manuscript and presentation production will be initiated concurrently with data analysis.

Year 2: Continue field work and data collection with assistance from 1-2 field technicians. Continue data analysis with guidance and assistance from Krishna Pacifici at NCSU. Continue and finalize report and manuscript production, and presentation at professional working groups and/or meetings.

GPS technology allows researchers to collect locational data at fine spatial and temporal scales through the deployment of collar units on wildlife study subjects. In this project, we propose to study a sample of sympatric canid populations with GPS radio-collars, in order to investigate the population parameters outlined in previous sections as well as species interactions. The purchase and use of this technology is critical to meeting the research objectives set forth in this document as well as in the document included in Attachment 1.

While GPS technology has evolved over the past 20 years, the cost of technology has plateaued. Upfront cost per unit remains relatively high, however project savings occurs at the back end when compared to older telemetry technology such as very high frequency (VHF)

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which require intensive labor to collect data at similar spatial and temporal scales. Pilot testing the proximity sensor enabled GPS-collars will allow investigation of the utility of this relatively new tool for community dynamics analysis by providing an increased locational data acquisition when individuals come within a set distance, or closer, from each other. Additionally, these sensors record the identities of the interacting individuals and the duration of their interactions. Using a trigger to temporarily switch GPS fix schedules will enable us to collect very fine scale data while conserving battery life, achieving project objectives in an efficient manner. Exploring the efficaciousness of this technology has the potential to positively impact future research projects requiring use of GPS-collars for data collection.

Aerial tracking will provide regular study animal surveillance useful to investigate cases of mortality, collar malfunction, or satellite data transmission delays, which can vary seasonally. In some situations, ground tracking could prove less expensive than aerial tracking. However, ground telemetry techniques require more than one biologist working in tandem to acquire accurate location estimates. This often translates to increased labor to collect data, particularly in large study areas. Aerial tracking will provide a more efficient and cost-effective method for surveilling study subjects in this large study area, requiring only one biologist and a contracted pilot. NCWRC personnel will perform aerial tracking along with the NCWRC pilot at a minimum frequency of every 30 days.

Use of local trappers to assist with sampling efforts provides several benefits. Local trappers have established, long-term relationships with private land owners, thereby providing access to private lands that might be otherwise difficult to secure. This will enable project biologists to obtain a representative sample of sympatric canids in the study area, as well as to operate more trap lines concurrently. This is particularly important when using a SCR sample design, as it will have direct implications on the resulting analyses and inferences.

As part of collaboration efforts, the project will contract the services of Krishna Pacifici, Research Assistant Professor in the Applied Ecology department at NCSU. Krishna's expertise is in quantitative ecology; consultation and assistance services provided will allow project biologists to make appropriate statistically relevant inferences from collected data.

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DNA analysis will be contracted to Lisette Wait's lab at the University of Idaho. Lisette's team at The Laboratory for Ecological, Evolutionary and Conservation Genetics has previous experience in analyzing red wolf and coyote hybrid molecular samples and has the most comprehensive DNA methodology for this sympatric canid species continuum in the nation. This expertise will facilitate expedient species identification on collared study animals besides landscape level population dynamics analysis.

	Commission	In-kind	Total
a. Personnel	$ 7,200.00	$ -	$ 7,200.00
b. Fringe Benefits	$ -	$ -	$ -
c. Travel	$ 30,000.00	$ -	$ 30,000.00
d. Equipment	$ 54,000.00	$ -	$ 54,000.00
e. Supplies	$ 61,500.00	$ -	$ 61,500.00
f. Contractual	$315,590.00	$ -	$315,590.00
g. Construction	$ -	$ -	$ -
h. Other	$ 6,000.00	$ -	$ 6,000.00
i. Total Direct Charges (sum of a – h)	$474,290.00	$ -	$474,290.00
j. Indirect Charges	$ 4,800.00	$ -	$ 4,800.00
k. Totals (sum of i and j)	$479,090.00	$ -	$479,090.00
Federal (75%)			$359,317.50
State (25%)			$119,772.50

Commented [BA39]: Really? This amount for what exactly?

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G. Geographic Location

Three counties of the Albemarle Peninsula of North Carolina (Dare, Hyde, and Tyrrell counties).

H. Related Federal Projects

NC-W-F15AF00726 (W-72) NC-Division of Wildlife Management Cooperative Projects

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I. Glossary

Abundance: Species abundance is the number of individuals per species, and relative abundance refers to the evenness of distribution of individuals among species in a community.

Adaptive kernel (AK): A probabilistic home range estimator based on the distribution and density of locations that has been collected over a period of time.

Adverse reactions: In pharmacology, any unexpected or dangerous reaction to a drug.

Aerial: Existing, happening, or operating in the air.

Annually: Once a year; every year.

Anthropogenic: Caused or influenced by humans.

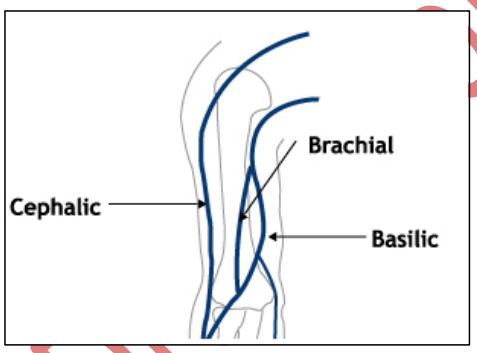
Apex: Having no natural predators in its ecosystem.

Ataxia: The loss of full control of bodily movements.

Beacon: A radio beacon whose purpose is the investigation of the propagation of radio signals.

Biopsy: The removal for diagnostic study of a piece of tissue from a living body.

Brachial vein: One of a pair of veins accompanying the brachial artery and uniting with each other and with the basilic vein to form the axillary vein.



Breeding pair: A pair of animals which cooperate over time to produce offspring with some form of a bond between the individuals.

Carrying capacity: The maximum population size of the species that the environment can sustain indefinitely, given the food, habitat, water, and other necessities available in the environment.

Compensatory immigration: Individuals emigrating from areas with lower mortality to those with higher mortality; filling a deficiency of individuals in a population experiencing higher mortality. The increase in size or activity of one part of an organism or organ that makes up for the loss or dysfunction of another.

Composition: The combining of distinct parts or elements to form a whole.

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Co-occurrence: Refers to observation of the spatial overlap between two (or more) different individuals over a period of time.

Coordinates: Any of the scales or magnitudes that serve to define the position of a point.

Core use areas: An area within a home range exhibited by a dense concentration of location points; commonly estimated at 50% of the location data points.

Covariates: A variable that is possibly predictive of the outcome under study.

Cranial: Pertaining to the cranium or to the anterior (in animals) or superior (in humans) end of the body.

Cryogenic: Very low temperatures, e.g. -80°C.

Den-obligated: Restricted to a particular condition of life, in this case restricted to a den site.

Density: A measure of the number of organisms that make up a population in a defined area.

Deployment: To organize and send out (people or things) to be used for a particular purpose.

Depredation: The act of preying upon.

Depressed respiration: A decrease in the ability to exhale and inhale; respiration that has a rate below 12 breaths per minute or that fails to provide full ventilation and perfusion of the lungs.

Diagnostic: The process of determining by examination the nature and circumstances of a diseased condition.

Disorientation: Loss of one's sense of direction, position, or relationship with one's surroundings.

Distribution: The manner in which a biological taxon is spatially arranged.

DNA: (deoxyribonucleic acid) is a type of macromolecule known as a nucleic acid. It is shaped like a twisted double helix and is composed of long strands of alternating sugars and phosphate groups, along with nitrogenous bases (adenine, thymine, guanine and cytosine).

Dorsal: Situated on or toward the upper side of the body, equivalent to the back, or posterior, in humans; situated on or toward the posterior plane in humans or toward the upper plane in quadrupeds.

Duration: A continuous period of time.

Dynamic Brownian bridge movement models: Incorporates temporal and behavioral characteristics of movement paths into estimation of home range.

Ectoparasite: a parasite that lives on the outside of its host rather than within the hosts body; e.g. fleas and lice.

Effective trap area: Calculated by buffering each trap site by half the mean maximum distance traveled, each of these boundaries are dissolved, creating a measurable area.

Efficacious: Producing or capable of producing a desired effect.

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Efficient: Accomplishment of or ability to accomplish a job with a minimum expenditure of time and effort.

Euthanize: The act of putting to death painlessly or allowing to die, as by withholding extreme medical measures, a person or animal suffering from an incurable, especially a painful, disease or condition.

Expedient: Suitable for achieving a particular end in a given circumstance.

Evaporative cooling: reduction in temperature resulting from the evaporation of a liquid, which removes latent heat from the surface from which evaporation takes place.

Facilitate: Make an action or process easy or easier.

Genotyping: Investigate the genetic constitution of (an individual organism).

Gonadal descent: The act or process of descending from a higher to a lower location; testicular descent occurs during the breeding season annually.

GPS: Global Positioning System, is a radio navigation system that allows land, sea, and airborne users to determine their exact location, velocity, and time 24 hours a day, in all weather conditions, anywhere in the world.

Home range: an area over which an animal or group of animals regularly travels in search of food or mates, and that may overlap with those of neighboring animals or groups of the same species.

Hybridization: The result of mixing, through sexual reproduction, two animals or plants of different breeds, varieties, species or genera.

Immobilization agent: An active force or substance capable of producing an effect.

Implantation: To put or fix firmly.

Inbreeding depression: The reduced biological fitness in a given population as a result of inbreeding, or breeding of related individuals.

Inception: The establishment or starting point of an institution or activity.

Interspecific: Existing or occurring between different species.

Iridium: A satellite constellation providing voice and data coverage to satellite phones, pagers and integrated transceivers over the Earth's entire surface.

Jugular vein: Any of several large veins in the neck, carrying blood from the head and face.

Lacerations: A deep cut or tear in skin or flesh.

Locational: A position or site occupied or available for occupancy or marked by some distinguishing feature.

Malfunction: Fail to operate in the normal or usual manner

Methodology: A system of methods used in a particular area of study or activity.

Midline: A median line or plane of bilateral symmetry, especially that of the body.

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Minimum convex polygon (MCP): Completely enclose all data points by connecting the outer locations in such a way as to create a convex polygon.

Molecular samples: Genetic samples that may be used for investigation of genetic constitution of an individual.

Morphometrics: The process of measuring the external shape and dimensions of landforms, living organisms, or other objects.

Mortality: The state of being subject to death.

Non-target bycatch: Animals caught by accident that are not the target species being sought.

Parameters: A numerical or other measurable factor forming one of a set that defines a system or sets the conditions of its operation.

Parentage: The origin of something; the state or relation of a parent.

Passive integrated transponder: A microchip implant is an identifying integrated circuit placed under the skin of an animal.

Pinna: The external part of the ear in humans and other mammals; the auricle.

Plateaued: A period or state of little or no growth or decline.

Population dynamics: The branch of life sciences that studies the size and age composition of populations as dynamic systems, and the biological and environmental processes driving them (such as birth and death rates, and by immigration and emigration).

Population growth: The increase in the number of individuals in a population.

Population size: A group of organisms of the same species that live in the same area.

Population status:

Population trend: Changes over time and can include changes in ranging behavior and distribution, biogeography and life-history.

Population viability: The process that determines the probability that a population will go extinct within a given number of years.

Proximity: Nearness in space, time, or relationship.

Quantified: Express or measure the quantity of.

Quantitative: Relating to, measuring, or measured by the quantity of something rather than its quality.

Radio-telemetry: The use of radio waves for transmitting information from a distant instrument to a device that indicates or records the measurements.

Recumbency: The state of leaning, resting, or reclining.

Reintegrate: Restore (elements regarded as disparate) to unity.

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Remnant: A small remaining quantity of something.

Reproductive status: Relating to or effecting reproduction.

Spatial: Relating to, occupying, or having the character of space.

Spatial capture-recapture: A method commonly used in ecology to estimate an animal population's size. A portion of the population is captured, marked, and released. Marked animals are either recaptured or are tracked, each tracking location being considered a recapture.

Species Continuum: An aggregate of species capable of interbreeding, resulting in fertile hybrid offspring whose genetic composition may represent a varying array of phenotypes and genotypes from the parental species, at which the extreme ends of the spectrum are distinct.

Standardize: Cause (something) to conform to a standard.

Statistically relevant inferences: the process of deducing properties of an underlying distribution by analysis of data. Inferential statistical analysis infers properties about a population: this includes testing hypotheses and deriving estimates.

Stochastic population models: Ecological population modeling is concerned with the changes in population size and age distribution within a population as a consequence of interactions of organisms with the physical environment, with individuals of their own species, and with organisms of other species; stochasticity possesses some inherent randomness. In stochastic population models, the same set of parameter values and initial conditions will lead to an ensemble of different out puts.

Strangulation: The condition in which circulation of blood to a part of the body is cut off by constriction.

Stratifying: Form or arrange into strata, one of a number of portions or divisions likened to layers or levels.

Surveillance: Continuous observation of a place, person, group, or ongoing activity in order to gather information.

Survival: A living or continuing longer than, or beyond the existence of, another person, thing, or event.

Sympatric: Occurring within the same geographical area; overlapping in distribution.

Tachycardia: A heart rate that exceeds the normal resting rate. In general, a resting heart rate over 100 beats per minute is accepted as tachycardia in human adults.

Telemetry: See radio-telemetry.

Temporal: Of or relating to time.

Tooth replacement: The process of development of two successive sets of teeth, initially the deciduous set and consecutively the permanent set.

Transmitter: A set of equipment used to generate and transmit electromagnetic waves carrying messages or signals, especially those of radio or television.

Transponder: A device for receiving a radio signal and automatically transmitting a different signal.

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682 Vaccinate: Treat with a vaccine to produce immunity against a disease; inoculate.

683 Venipuncture: The puncture of a vein as part of a medical procedure, typically to withdraw a blood
684 sample or for an intravenous injection.

685 VHF: Very high frequency is the ITU designation for the range of radio frequency electromagnetic waves
686 (radio waves) from 30 MHz to 300 MHz, with corresponding wavelengths of ten to one meters.

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Attachment 1: Intra-service Section 7 Biological Evaluation Form

Region 4

INTRA-SERVICE SECTION 7 BIOLOGICAL EVALUATION FORM

[Note: This form provides the outline of information needed for intra-Service consultation. If additional space is needed, attach additional sheets, or set up this form to accommodate your responses.]

Originating Person: Andrea Shipley

Telephone Number: 252.926.0266 **E-Mail:** andrea.shipley@ncwildlife.org

Date: November 8, 2016

PROJECT NAME (Grant Title/Number): NC – Division of Wildlife Management Cooperative Projects / (W-72)

I. Service Program:

_____**Ecological Services**
__X__**Federal Aid**
  _____**Clean Vessel act**
  _____**Coastal Wetlands**
  _____**Endangered Species Section 6**
  _____**Partners for Fish and Wildlife**
  _____**Sport Fish Restoration**
  __X__**Wildlife Restoration**
_____**Fisheries**
_____**Refuges/Wildlife**

II. State/Agency:

NORTH CAROLINA / NORTH CAROLINA WILDLIFE RESOURCES COMMISSION

III. Station Name:

FWS RALEIGH ECOLOGICAL SERVICES OFFICE

IV. Description of Proposed Action (attach additional pages as needed):

Conduct research project entitled "**Coyotes of the Albemarle: Spatial Ecology, Resource Selection, Demographics, and Interactions with a Sympatric Canid"**

The coyote (*Canis latrans*) is now abundant throughout the 100 counties in North Carolina (NC), where they are managed as nongame with no closed season or bag limit (NC Wildlife Resources Commission 2016). Previously restricted to the West and Midwest regions of the United States, by the early 1990s coyotes had expanded their range into the Albemarle Peninsula (AP), which is situated in the northeast coastal plains region of NC (Hinton et al. 2012, Murray et al. 2014).

Recently described as using "compensatory immigration," coyotes are able to opportunistically fill spatial resource gaps by periodic transiency (Hinton 2016). These periods of transiency can sometimes bring coyotes into conflict with humans and other canids, especially while taking advantage of anthropogenic resources. Though a rural area, human land uses predominate on the AP. The AP is comprised of approximately 30% agricultural fields, 50% forest and coastal marshes, and 20% "other" land cover types on federal, state and private lands (Dellinger 2011).

In 1968, individuals from a remnant population of red wolves were removed from Texas and Louisiana and a captive breeding program was initiated. The United States Fish and Wildlife Service (USFWS) released a non-essential, experimental population of red wolves (*Canis rufus*) on the Alligator River National Wildlife Refuge (ARNWR) in 1987 (Hinton et al. 2013). The red wolf population increased until 2008 and peaked at around 208 individuals (USFWS Red Wolf Recovery Program 2007), a few animals short of the recovery goal of 220 in the wild (USFWS Red Wolf Recovery Program 2013), with an estimated carrying capacity of 140-150 for the AP (Hinton et al. 2013, Kelly et al. 1999, USFWS Red Wolf Recovery Program 2007). Red wolves presently inhabit an approximately 6900 square kilometer recovery area within Beaufort, Dare, Hyde, Tyrrell, and Washington counties (Wildlife Management Institute 2014).
Accurate up-to-date estimates of the population are unavailable, but USFWS staff report a population size of 45-60 individuals with three mortalities in 2016 (https://www.fws.gov/redwolf/index.html July 2016). Hybridization with coyotes, inbreeding depression, and gunshot mortality have all been suspected issues that have affected the population growth and viability since the inception of the Red Wolf Recovery Program (RWRP) (Hinton et al. 2013). In 2013, NCWRC and USFWS established a committee to oversee the collaborative management and conservation of red wolves and other canids on the AP. A USFWS memorandum documented detailed action items for the joint management of canids on the AP, including specific research objectives which this proposal seeks to address (Attachment 1).

As coyotes on the AP increase in number, monitoring coyote movements, particularly in relation to red wolves, will provide important data to NCWRC and USFWS staff for science-based local and landscape-level decisions about coyote population management. Collection of finer temporal scale location data will help to manage interactions of both canid species with humans, as well as to support development of dynamic stochastic population models.

Coyote and red wolves will be live trapped by cooperating NCWRC and USFWS staff, and private trappers using double coil size 3 foothold traps, during the breeding season (Nov-Feb for coyote, Jan-Feb for red wolves) in the tri-county area of Dare, Hyde and Tyrrell. Morphological measurements, incidents of injury, occurrence of ectoparasites, age classification, and reproductive status will be determined; blood and tissue samples will be taken for genetic analysis. All captured individuals that meet the age classification and weight requirements will be collared with GPS collar units. All captured and collared individuals will be released at the capture site. The objectives listed below will be achieved by obtaining measurements, samples and information from the captured, collared, and tracked individuals over the course of three years using GPS location data.

Objective 1: Use GPS collar and proximity sensor technology to test performance under various conditions and evaluate the frequency and accuracy of the scheduled fix rates.

Objective 2: Use fine scale GPS data collection for investigating annual and seasonal spatial dynamics of sympatric canids: home range and core area sizes, amount of overlap in home range and core areas, movement pathways and daily activity patterns, and cover type selection and preference.

Objective 3: Use fine scale GPS data collection for investigating the number and age structure of offspring for family groups of collared sympatric canids.

Objective 4: Use fine scale GPS data collection for investigating sources of mortality for sympatric canids.

Objective 5: Use fine scale GPS data collection for preventing and mitigating canid conflicts with landowners.

Objective 6: Determine genetic profiles of sympatric canids through DNA identification of all captured individuals, parentage, and presence of hybridization.

V. Pertinent Species and Habitat:

A. Include species/habitat: See section VI

B. Complete the following table:

SPECIES/CRITICAL HABITAT	STATUS[1]
Canis rufus	T

[1]STATUS: E = endangered, T = threatened, PE = proposed endangered, PT =proposed threatened, CH = critical habitat, PC = proposed critical habitat, C = candidate species

VI. Location:

A. Statewide

Albemarle Peninsula (see web address www.ncwildlife.org)

B. Section, township, and range (or latitude and longitude):

Dare, Hyde, Tyrrell counties

C. Distance (miles) and direction to nearest town:

As stated above

D. Species/habitat occurrence:

Canis rufus

VII. Determination of Effects:

A. Explanation of effects of the action on species and critical habitats in item V. B. (attach additional pages as needed):

SPECIES/CRITICAL HABITAT	IMPACTS TO SPECIES/CRITICAL HABITAT
Canis rufus	Trap induced injury is possible

B. Explanation of actions to be implemented to reduce adverse effects:

SPECIES/CRITICAL HABITAT	ACTIONS TO MITIGATE/MINIMIZE IMPACTS
Canis rufus	Use of appropriate trap types, daily trap checks, treatment of minor injuries, trapping season limitations and limitations on environmental conditions for trap operation

VIII. Effect Determination and Response Requested:

Species/ Critical Habitat	Determination[1]			Response[1] Requested
	NE	NA	AA	
Canis rufus		X		Concurrence

[1] Determination/Response Requested:

NE = No Effect. This determination is appropriate when the proposed action will not directly, indirectly, or cumulatively impact, either positively or negatively, any listed, proposed, candidate species or designated/proposed critical habitat. Response Requested is optional but a "Concurrence" is recommended for a complete Administrative Record.

NA = Not Likely To Adversely Affect. The determination is appropriate when the proposed action is not likely to adversely impact any listed, proposed, candidate species or designated/proposed critical habitat or there may be beneficial effects to these resources. Response Requested is a "Concurrence".

AA = Likely To Adversely Affect. This determination is appropriate when the proposed action is likely to adversely impact any listed, proposed, candidate species or designated/proposed critical habitat. Response Requested for listed species is "Formal Consultation". Response Requested for proposed or candidate species is "Conference".

Signature (originating station) **Date**

Title

IX. Reviewing Ecological Services Office Evaluation:

A. Concurrence _____ Non-Concurrence _____

B. Formal consultation required _____

C. Conference required _____

D. Formal conference required _____

E. Remarks (attach additional pages as needed):

_____ _____
Signature **Date**

_____ _____
Title **Office**

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Attachment 2: Joint Memorandum

MEMORANDUM

November 20, 2013

TO: All Interested Parties

FROM: "for"
Cynthia K. Dohner, Director, Southeast Region, U.S. Fish and Wildlife Service
Gordon S. Myers, Executive Director, N.C. Wildlife Resources Commission

SUBJECT: Collaborative Conservation of Red Wolves and Other Canids on North Carolina's Albemarle Peninsula

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Recovery of the federally-listed red wolf has been a priority for the U.S. Fish and Wildlife Service (FWS) for more than 20 years and is focused in North Carolina on the Albemarle Peninsula (AP; i.e., Hyde, Tyrrell, Washington, Beaufort, and Dare counties). Comprehensive stakeholder involvement and collaboration with other management agencies is critical to successful recovery of any at-risk species. The North Carolina Wildlife Resources Commission (WRC) is a key collaborator in this regard, as it has jurisdiction over all state-trust wildlife resources in N.C.

Since 2009, the FWS and WRC have worked to broaden our collaboration in the conservation and management of all canid species (including red wolves) on the AP. As these efforts have solidified, specific actions have been jointly identified by our two agencies that will improve conservation outcomes. These actions are categorized into five areas; collaboration, research, outreach, regulatory, and enforcement. Specific action items are outlined and prioritized within each of these categories in Attachment A.

This memo establishes the FWS's and WRC's commitment to initiate, or to continue, the efforts outlined in Attachment A. The common goal in this effort is to establish clear expectations and accountability for collaboration regarding the action items on Attachment A, thus resulting in enhanced and seamless canid conservation and management on the AP. This approach provides the best opportunity to achieve recovery goals for red wolves, while at the same time managing other canids to balance biological variables with social expectations. The dynamics of these canid species are complex and offer unique opportunities for innovation. Appropriate staff from each agency is hereby tasked with immediately developing a timeline to implement these actions. Through this commitment, we will continue to advance our collective conservation goals.

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Attachment A

Action Items for Collaborative Conservation of Canids on North Carolina's Albemarle Peninsula (AP)
(*Note: Action Items are prioritized within category.*)

Collaboration

1. The N.C. Wildlife Resources Commission (WRC) and U.S. Fish and Wildlife Service (FWS) will formalize in writing the collaborative management of canids on the AP. This agreement should:
    a. include a clear mission statement, goals, objectives, and implementation strategies (ask and answer the "Why?");
    b. set a goal to define success regarding canid management on the AP;
    c. espouse a philosophy of canid management operating within the context of a three-legged stool (i.e., federal and state governments and stakeholders);
    d. as available, commit funding and staffing resources for field personnel to contribute to the conservation of the red wolf and management of coyotes;
    e. as available, commit funding to conduct research pertinent to canid management on the AP;
    f. establish polices and goals for developing a collaborative genetic archive for AP canids, a data sharing portal accessible by staff in both agencies, and reciprocal sharing of all historical data (including phenotypic and genotypic data and literature) of the red wolf;
    g. establish a foundation for developing and implementing an adaptive approach to canid management on private lands on the AP;
    h. initiate development of a collaborative canid research program;
    i. describe plans to conduct the next five year Red Wolf Program review;
    j. outline options for holding annual workshops with federal and state enforcement staff;
    k. outline plans to hold semi-annual coordination meetings regarding canid management on the AP; and
    l. develop milestones for future development of a management plan for all canids in the AP.

2. The FWS will initiate a review of the current Red Wolf Recovery Plan to determine if the state-of-our-knowledge or field conditions have changed such as to warrant its revision. Review and comments from the WRC will be considered in this evaluation.

3. The WRC, with support and participation of the FWS, will establish a "Canid Forum" (similar to that established for manatees in Florida) to facilitate communication and discussion regarding canid management and citizen science opportunities on the AP.

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Attachment A

Research

1. The FWS and WRC will provide funding and logistical support for research identified by the Red Wolf Recovery Implementation Team, Red Wolf Program staff, other FWS staff, or the WRC that promote the conservation and recovery of the red wolf and other canids on the AP. Studies could include:
    a. tests of the "placeholder theory" on the AP, including behavior of sympatric canids,
    b. determining carrying capacity of canids on the AP,
    c. determining genetic profiles of canid species on the AP,
    d. evaluating predator-prey dynamics,
    e. studies of canid habitat use,
    f. epidemiology of diseases impacting canids on the AP,
    g. development of stochastic simulation models of sympatric canid population dynamics and habitat use, and
    h. canid dispersal dynamics

2. The FWS and WRC will conduct jointly-supported research to determine the attitudes and opinions of N.C. private landowners and other citizens concerning canids on the AP (i.e., human dimensions studies).

Outreach

1. The FWS and WRC will collaborate with other partners to design and implement broad-based outreach and marketing programs with clear goals, objectives, strategies, and measurable outcomes, including development of consistent agency messages and educating the public about canids on the AP.

Regulatory

1. The FWS and WRC will initiate a review and, if needed, subsequent rule-making to clarify concepts or rectify conflicts in current federal or state rules (including the current 10(J) rule).

2. The WRC will review and evaluate statutory requirements for listing red wolves as state threatened in the five AP counties.

3. As data demonstrating a relationship between coyote hunting and red wolf mortality become available, the FWS and WRC will evaluate, and if appropriate implement, adaptive approaches to regulate of take of coyotes that may result in incidental take of red wolves.

4. The WRC will evaluate the status, management, and regulation of Controlled Fox Hunting Preserves.

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5. The WRC will develop BMPs (due care provisions) for coyote hunting, trapping, and live sale.

6. The WRC will compile, compare, and contrast canid hunting and trapping regulations and programs in other states, including, but not limited to, other states with other species of wolves.

Enforcement

1. The FWS and WRC will develop coordination strategies to improve enforcement of federal regulations protecting red wolves.

Attachment 3: Landowner Agreement Form

NC Wildlife Resources Commission
Wildlife Management Division
Wildlife Diversity Program
Landowner Agreement for Scientific Collection

_____ / _____ / _____
MM DD YYYY

Property Type
Private _____ Federal _____ State _____

NC Wildlife Resources Commission
Address: 1701 Mail Service Center, Raleigh, NC 27699-1701
Phone: 919-707-0010

Cooperator's Name: _____
Last First Middle

Cooperator's Address: _____
Street City, State, Zip

Where will the work be performed? _____

give address or directions if different from above _____

Business, Farm, Property Common Name _____

Owner's or Rep Name _____ _____
If different from Cooperator Telephone Number

Owner's Address: _____
If different from Cooperator Street City, State, Zip

WRC Employee & Work Location	Species
	1)
Employee Name	2)
	3)
Duty Area	4)

I, the cooperator or cooperator's representative, have been informed of the methods and the manner in which research devices will be used, and of the possible hazards associated with their use. I understand that NCWRC, (to include its officers, employees and agents) will: exercise reasonable precautions to safeguard all persons to prevent injury to target and non-target animals; guard against the mishandling of control devices and materials; and exercise due caution and proper judgment in all scientific collection operations. I understand that NCWRC may collect Global Positioning System (GPS) coordinates at the project site as part of component or activity tracking or as wildlife disease monitoring or research data. I, the undersigned cooperator, do hereby give my consent and concurrence to NCWRC, its employees, and its agents, to use, upon lands owned, leased, or otherwise controlled by me, and identified by this document, the following methods and devices (an attachment of additional devices and/or methods may be attached):

Statement of agreement: The landowner, cooperator, or representative, as listed above hereby give permission to NCWRC to perform trap and release of the species listed for scientific collection purposes. In consideration of these understandings, I, the cooperator or cooperator's representative, agree to: assume responsibility for injury to my property under my control, when said injury is not the result of negligence on the part of NCWRC (it's officers, employees, and agents); assist in maintaining such warning signs as NCWRC may place for the purpose of notifying persons entering onto such lands of the possible hazards associated with scientific measures in use thereon; and to give adequate warning of these possible hazards to persons I authorize to enter onto such lands. Further, I, the cooperator or cooperator's representative, agree not to concurrently use or allow to be used upon lands covered by this agreement, any canid depredation efforts during the scientific collection time period.

Landowner Signature/Date _____
Signature Date

WRC Employee Signature/Date _____
Signature Date

Attachment 4: Trapper Service Contract

Contract in development.

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STATE: North Carolina

GRANT TITLE: W79-Wildlife Management

PROJECT TITLE: Pilot Study – Using Fine Scale GPS Technology to Research Sympatric Canid Population Dynamics (Job 2.0?)

A. Problem and Need

The coyote (*Canis latrans*) is now abundant throughout the 100 counties in North Carolina (NC), and is managed as nongame with no closed season or bag limit (NC Wildlife Resources Commission 2016). Previously restricted to the West and Midwest regions of the United States, by the early 1990s coyotes had expanded their range into the Albemarle Peninsula (AP), which is situated in the northeast coastal plain region of NC (Hinton et al. 2012, Murray et al. 2014). In recent years as coyotes have increased their population, some have begun to make use of the Outer Banks region.

The United States Fish and Wildlife Service (USFWS) released a non-essential, experimental population of captive-bred red wolves (*Canis rufus*) on the Alligator River National Wildlife Refuge (ARNWR) in 1987 (Hinton et al. 2013). This population increased until 2008 and peaked at around 130 individuals (Group Solutions, Inc. 2016), short of the recovery goal of 220 in the wild (USFWS Red Wolf Recovery Program 2013). The AP has an estimated carrying capacity of 140-150 wolves (Hinton et al. 2013, Kelly et al. 1999, USFWS Red Wolf Recovery Program 2007). The exact number of red wolves is not known, but USFWS staff report a population estimate of 45-60 individuals with eight mortalities to date in 2016 (https://www.fws.gov/redwolf/index.html August 2016). Hybridization with coyotes and inbreeding depression are suspected factors that have affected red wolf population growth and viability since the inception of the Red Wolf Recovery Program (RWRP), while vehicular and gunshot mortality are known factors (Hinton et al. 2013). Because of hybridization between red wolves and coyotes, the AP supports a continuum of sympatric canids, hereafter referred to as "sympatric canids."

As part of a recent program review, the USFWS halted many aspects of the RWRP in 2015 and discontinued the coyote sterilization program, potentially affecting the spatial

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distribution and population dynamics of sympatric canids. Telemetry data from coyotes on the AP suggests that about 70% of coyotes are residents (i.e., those that defend set territories) while the other 30% are transients, with most being dispersing juveniles (Hinton et al. 2015). Transient coyotes do not defend set territories. Coyotes can travel long distances and become transient even as adults, especially when they lose their mate. Recently described as using "compensatory immigration," coyotes opportunistically fill spatial resource gaps by periodic transiency; when spots come open, individuals that do not yet have permanent territories and have been roaming in the area, are able to inhabit the new openings (Hinton 2016). These periods of transiency can sometimes bring coyotes into conflict with other canids and humans, especially when they are utilizing of anthropogenic resources.

Though a rural area, human land uses occupy a significant portion of space on the AP. The AP is comprised of approximately 30% agricultural fields, 50% forest and coastal marshes, and 20% "other" land cover types on federal, state and private lands (Dellinger 2011). Concerns about fear of attacks on humans and domestic pets, the effects of sympatric canids on white-tailed deer and other game populations, and homeowner property damage comprise many of the conflict calls regarding sympatric canids on the AP (Responsive Management, forthcoming data). Wildlife managers in this region frequently receive requests for information on canid management (C. Turner, personal communication, 2016).

The changes in state and federal canid management rules have resulted in confusion regarding residents' rights and options for management of property damage by sympatric canids. As a result, some citizens are unsure of the legal and most effective methods for canid conflict management. Adding to management complexity is the need to manage canids for conservation purposes, such as reducing predation on at-risk ground nesting species or reducing hybridization of sympatric canids.

In 2013, NCWRC and USFWS established a committee to oversee the collaborative management and conservation of sympatric canids on the AP. A USFWS and NCWRC joint memorandum documented detailed action items for the joint management of sympatric canids on the AP, including specific research objectives which this proposal seeks to address (Attachment 2). As sympatric canids on the AP increase in number, monitoring their

Commented [BA1]: I don't understand the assumption that dynamics would change

Commented [BA2]: Data from how many current coyotes? Doubt you could make this determination from the current or past data, only on the coyotes that happened to have been collared in specific areas due to managing the wolf population

Commented [BA3]: Is there any data showing that this even takes place?

Commented [BA4]: Coyote number may be increasing – suggests a need, if any, to focus on them, not an endangered species with so few in the population and therefore at greater risk to loss from management actions.

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movements, particularly in relation to individuals of differing ancestry, could provide important data to NCWRC and USFWS staff for science-based local and landscape-level decisions about sympatric canid populations and conflict management. Collection of finer temporal scale location data would help to manage interactions of sympatric canids with humans, as well as to support development of dynamic stochastic population models.

B. Objectives (after December 1, 2016-November 30, 2018)

Objective 1: Use GPS collar and proximity sensor technology to test performance under various conditions and evaluate the frequency and accuracy of the scheduled fix rates.

Objective 2: Use fine scale GPS data collection for investigating annual and seasonal spatial dynamics of sympatric canids: home range and core area sizes, amount of overlap in home range and core areas, movement pathways and daily activity patterns, and cover type selection and preference.

Objective 3: Use fine scale GPS data collection for investigating the number and age structure of offspring for family groups of collared sympatric canids.

Objective 4: Use fine scale GPS data collection for investigating sources of mortality for sympatric canids.

Objective 5: Use fine scale GPS data collection for preventing and mitigating canid conflicts with landowners.

Objective 6: Determine genetic profiles of sympatric canids through DNA identification of all captured individuals, parentage, and presence of hybridization.

At the end of this two-year pilot study, we will deliver an observational summary detailing the use of the GPS and sensor technology for spatial and population dynamics research on sympatric canids on the AP.

C. Expected Results and Benefits

As part of a pilot study, we will monitor the status of collared individuals by using a finer scale assessment of space and habitat use than previous studies. Earlier research focused on many of the same objectives we suggest investigating here, but during a time of intense, active

Commented [BA5]: This is a very vague statement – what decision are being sought out here, particulary that we don't have research and data on already, at least regarding red wolves.

Commented [BA6]: This objective should not be the basis for all the work suggested in this proposal on red wolves – too much potential risk. Test them on coyotes, or dogs.

Commented [BA7]: Has already been done – no need to reinvent the wheel, especially now. The time to do that was when there were significant numbers of both species on the ground. Can't get that now.

Commented [BA8]: Why? Of all things, this is not needed on red wolves for red wolf recovery.

Commented [BA9]: Done for red wolves. Focus on coyotes if anything.

Commented [BA10]:

Commented [BA11]: What conflicts?

Commented [BA12]: Again, how does this promote recovery of red wolves, and how would this be used for management

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management. Specific management techniques are no longer being carried out and dynamics between sympatric canids are expected to have changed substantially. The uncertainty regarding current dynamics presents a need for additional research in order to inform actions for the management of sympatric canids. Information gained from research may impact management rules and landowner's abilities to manage canids in some areas. Additionally, GPS technology has improved since earlier research was conducted allowing for more temporally detailed data collection and more nuanced analyses. Understanding how sympatric canids collectively use resources in areas of human-dominated landscapes will allow wildlife managers to tailor management options to local conditions. On the AP, row crop agriculture and hunting represent the primary and secondary land uses, respectively. Row crop agriculture is a significant nutrient resource on the landscape and, as opportunists, canids take advantage of such resources when they are available. Non-consumptive wildlife-driven tourism persists in all seasons and wildlife watching is a main draw for tourists in this area. For many tourists, the opportunity to see or hear large carnivores is the sole attraction for traveling to the AP. Information from this study will be provided to local constituents to establish a knowledge base regarding how sympatric canids use resources on private lands. Management and guidance could serve to prevent or minimize conflict while maximizing positive wildlife interaction opportunities for constituents. Development of a common understanding between wildlife managers and landowners based upon factual information is paramount for collaboratively achieving successful management of sympatric canids. The data collected in this pilot study is the foundation upon which this understanding and future management actions will be built.

The current level of hybridization between sympatric canids on the AP will be characterized using DNA gathered during this study. Body size exists as a continuum between coyotes and red wolves and has been documented as the most important factor for successful interspecific breeding pairs of these canids (Hinton 2014). Though both species have been found to use resources in similar manners, red wolves generally have more expansive home ranges and therefore may not use local resources as intensively as coyotes, depending on body size. Obtaining individual identification of study animals will allow managers, armed with spatial information, to infer how and why individuals in the canid species continuum exploit

Commented [BA13]:

Commented [BA14]: Lot of words here, but what type of management options would be considered for what resources?

Commented [BA15]: Take advantage of row crops?

Commented [BA16]: "large" – is that red wolves or coyotes, or both? Is there a suggestion of tourism based on coyote presence?

Commented [BA17]: Except that the numbers do not exist on the ground to do this, particulary on non-public lands where you would need to understand the "foundation". Takes out the need to do this refuges.

Commented [BA18]: So again, we already have this information – why risk on red wolves

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anthropogenic resources considering their life history traits.

In conjunction with prior research, data collected will contribute to knowledge on sympatric canid population dynamics on the AP. Estimating population size will allow managers to monitor population trends of sympatric canids and to examine the long and short-term impacts of different management strategies on their populations. While it is unknown whether sample size will allow for population estimation, obtaining population estimates for coyotes would provide wildlife managers with baseline data, when paired with annual mortality estimates, for monitoring changes in population abundance over time. Information on changes in abundance, reproductive dynamics, and habitat use could impact management strategies to influence long-term conservation outcomes. Results of this pilot study will allow managers to determine if future work will be necessary, what amount of effort will be required to achieve each objective, and whether or not population estimates will be an attainable goal.

Commented [BA19]: You can't do this in a 2-year study though – and are different management strategies being employed during this study and being incorporated.

D. Approach

The official Red Wolf Recovery Area (RWRA) covers approximately 6,900 square kilometers within Beaufort, Dare, Hyde, Tyrrell, and Washington counties (Wildlife Management Institute 2014). However, the USFWS has proposed the RWRA be constricted to the ARNWR and the Dare County Bombing Range in Dare county by the end of 2017. Due to these proposed RWRA changes, this study proposes to capture and radio-collar 25 sympatric canids within Dare, Hyde, and Tyrrell counties (hereafter referred to as "study area"); those counties being within and directly adjacent to the proposed new RWRA. The thematic subheadings below provide detailed descriptions of the approaches required for achieving the pilot study objectives.

Sampling Efforts

Trained NCWRC personnel will conduct live trapping of sympatric canids, with assistance from the USFWS RWRP biologists, and trained, experienced local trappers. NCWRC and USFWS wildlife personnel will select local trappers based on their past performance in trapping sympatric canids, but may also select trappers from the NCWRC coyote trappers list. NCWRC staff will train contracted trappers on specific trapping procedures before every trapping

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season. The project lead will supervise and coordinate all trapping activities including locations for installation and the operation of trap lines and handling of captured animals. Simultaneous personal trapping activities by contracted trappers will not be permitted while performing contracted trapping services, as specified in the draft service contract (Attachment 4).

Trapping efforts will follow a spatial capture-recapture (SCR) framework with a systematic targeted sampling design, focusing on areas that contain resources previously found to be used by sympatric canids (e.g. edge, agricultural fields, secondary roads, etc.) (Harris et al. 2013, Ivan et al. 2013), while attempting to sample a diversity of habitat types. This effort will allow us to increase the probability of detection of sympatric canids on the landscape (Tom 2012). While it is important to sample a wide range of habitats, the most important requirement for SCR is the number of collared individuals; this requirement provides flexibility in the other requirements for field sampling as needed (K. Pacifici, personal communication, 2016). We will initially focus trapping in areas of known red wolf packs, as advised by RWRP.

Trapping will take place during the breeding season when the likelihood of capturing females in the later stages of gestation or whelping females will be low. Capture efforts will be conducted from soon after 1 December 2017 – February 2018 and December 2018 – February 2019. Captured sympatric canids will be surrendered to NCWRC or the USFWS at capture sites. Trapping should occur on both public and private lands to obtain sampling coverage of the study area. Ideally, all federal and state lands would be accessible for trap and release (hereafter referred to as "capture") of sympatric canids, but it is most important to be able to trap and release on Alligator River NWR and the Dare County Bombing Range as those encompass the newly proposed RWRP recovery area and comprise the majority of land area for Dare county. Unlike Dare county, there are ample private lands that surround Pocosin Lakes NWR and Lake Mattamuskeet NWR in both Tyrrell and Hyde counties that may be utilized to effectively sample individuals who may use those federal lands, should they be excluded from capture activities. Capture on federal lands may require USFWS take permits and proposed activities may be subject to a compatibility assessment (P. Benjamin, personal communication, 2016). Scientific collection activities that take place on private lands will require agreements outlining conditions mutually decided by NCWRC and landowners (Attachment 3).

Commented [BA20]: Even if these areas were included, the numbers don't exist for this study. And I'll say it here, but if this is the last holdout for red wolves in the population, there isn't enough information to be gleaned from this study that in any way promotes recovery, especially on the refuge, and when the objectives are focused in large part on landowner conflicts and resources.

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To increase probability of detection of sympatric canids, the accessible study area will be partitioned by a grid, the cell size of which will based on the average annual home range size of resident coyotes previously reported for the AP, approximately 23 km^2 (Hinton et al. 2015). As a system of sampling, trap lines will be referred here as "traps," and the number of trap sets (i.e. the actual trapping device) and number of each trap set size may vary between traps as necessary. Sampling will be standardized within each grid cell by use of equal number of traps per cell, on average 3 per cell, each at an approximate length of 10 km (Andelt and Gipson 1979, Way et al. 2004).

Target canids will be captured by using Softcatch #3 Coyote 4x4 (Oneida Victor Inc. Ltd., P.O. Box 32398, Euclid, Ohio 44132, Hinton 2014, Schemnitz 1994), the EZ Grip #7 (Livestock Protection Company, P.O. Box 725, Alpine, Texas 79831, Frame and Meier 2007), or equivalent. Various lures and baits will be used to increase trapping efficiency (Frederick et al. 1989, Shipley 2012). Traps will be laid on the Monday of each week and will be opened at the time of deployment. Traps will be checked once daily at dawn, to reduce potential stress to trapped individuals and will not be operated on days where the temperature is expected to reach or exceed 80° F (R. Nordsven, personal communication, 2016) or during times of predicted inclement weather (e.g. snow, hail, high wind, etc., Sikes et al. 2011). To standardize effort and remain logistically realistic, traps should be open for three trap nights in a row before being removed. Trap sets that have been closed due to non-target bycatch or other circumstances may be reopened and all traps should be re-baited and lured as appropriate.

Trap set locations will be marked by NCWRC or USFWS personnel using handheld GPS units (Garmin GPSMAP 64S, 1200 E. 151st St., Olathe, KS 66062-3426) and given a sequential identification number. Traps will also be given an identification number and trap set points will be documented in ArcMap 10.4. Trappers will keep detailed records on trap set operation, non-target species trapped, and other relevant details. Non-target species will be released from traps after an in-field assessment of injuries, if any, and animals with life threatening injuries will be euthanized by the trap operator. Targeted recapture of collared canids will occur annually during the same months, to replace GPS collar batteries and drop-off collar release units in field. Trapping effort will be quantified (trap nights), the effective sample area will be

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estimated, the encounter (detection) probability will be estimated using a Gaussian detection model (Amundson et al. 2014), and an estimate of density for coyotes will be calculated using a modified Huggins closed-capture estimator in program MARK, if sample size allows (Harris et al. 2013, Ivan et al. 2013).

Animal Handling

Handling of canids will follow American Society of Mammalogists (ASM) guidelines (Sikes et al. 2011) and will be performed at the capture site. Chemical immobilization agents may be used depending on the number of field staff during processing (i.e., three or more staff required during non-chemical immobilizations, Craft 2007, M. Morse, personal communication, 2016).

Chemical Immobilization

Unless adequate numbers of personnel are available to safely employ mechanical restraint techniques, target animals will be anesthetized with the chemical immobilization agent BAM (Wildlife Pharmaceuticals, Inc., Windsor, CO 80550). BAM, a combination of Butorphanol tartrate, Azaperone tartrate and Medetomidine HCl., will be delivered by intramuscular injection by syringe pole to the hip. Dosage for canids is based on field trails performed by Wildlife Pharmaceuticals (Wildlife Pharmaceuticals, Inc. 2016) and the recommended dose for coyotes is 0.2CC and red wolves is 0.3CC, with adjunct doses of 0.1-0.2CC delivered if initial dosages do not cause induction (S. Kirschner, personal communication, 2017). Induction times for coyotes and wolves ranged from 5 to 10 minutes after initial and/or adjunct dosages (Wildlife Pharmaceuticals, Inc. 2016). After field handling is concluded the anesthesia will be reversed using two reversal agents, Atipamezole and Naltrexone, at double the CC of Atipamezole to BAM that was delivered (including adjunct doses, if given) and 0.5CC of Naltrexone. Recovery time from the reversal agents ranged from 10 to 25 minutes during field trails (Wildlife Pharmaceuticals, Inc. 2016). Field personnel will observe animals for signs of adverse effects for up to 30 minutes after reversal agents are delivered.

Mechanical Immobilization

Unlike other carnivore families, the submissive behavioral response of canids to

Commented [BA21]: Need to look at CFR on red wolves

Commented [BA22]: We've gone through testing on red wolves using various drug combination to find what works best – I'm not aware that this combination has been tested on red wolves? The field would not be the place to do this!

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perceived dominance reduces the need to use immobilization agents. Appropriate mechanical restraint techniques can reduce handling time of animals, allowing animals to reintegrate into social groups more quickly, subsequently reducing overall stress to the individual (Powell and Proulx 2003). Target canids will be mechanically restrained with a restraint pole, until two muzzles can be placed around the snout. While pinned with the restraint pole by one person, a second person will restrain the set of legs not in the trap against the ground and a third person will release the foot from the trap. This set of legs will then be restrained by the 3rd person as the restraint pole is removed. Once the restraint pole is removed the person restraining the front legs will also then restrain the head. The first person will then move forward with processing the captured animal.

Each animal will be placed on a towel or blanket to provide thermal protection from the ground, with eyes covered and lubricated with eye ointment; temperature will be monitored with a rectal thermometer. Overheating occurs at approximately 104-105°F for canids (AZA Canid TAG 2012) and the animal handling crew will monitor temperature at 5-minute intervals; if a temperature reading reaches 104°F, corrective actions will be taken and temperature will be monitored at 1-minute intervals. Should overheating occur, the individual will be removed from insulation to expedite the natural evaporative cooling process. During days that approach 80°F in temperature, measures will be taken to reduce heat stress, such as: wetting the animal with water, application of a cold pack to the groin area between the back legs, application of rubbing alcohol to foot pads, or immediate release (AZA Canid TAG 2012). If the injured individual is suspected to be a red wolf, based on morphometrics, USFWS staff will be contacted for a decision. In the event that trap caused injuries are determined to be life threatening through use of a trap injury score assessment (Frame and Meier 2007) the individual will be euthanized. In the event that NCWRC personnel cannot be present, trained USFWS personnel may collar and measure captured target animals and will provide data sheets to NCWRC staff. Target animals will not be vaccinated or otherwise treated for diseases, regardless of the presence of disease symptoms.

Commented [BA23]: Or tranponders, or previous genetic analysis – do not use morphometrics as the sole indicator of species.

Commented [BA24]: For red wolves, this should be the call of FWS – look at CFR

Non-target animals will be released on site. Captured domestic dogs will be immediately released from the trap set following an injury score assessment and only if no life-threatening

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injuries are present. If a domestic dog has sustained life threatening injuries and owner identification information is present on the dog, then the animal will be held in either a transportable kennel, or at a dog pen on a state game land that is equipped with such facilities, until the owner can retrieve the dog. The costs associated with injuries sustained to the dog will be the responsibility of the animals' owner. Law enforcement may be requested to help communicate with the animal's owner. If the animal does not have an identifiable owner and has incurred substantial life threatening injuries (i.e. compound fracture), the dog will be euthanized on site. Target animals showing signs of disease symptoms such as circling behavior, head tilt, muscle twitches, convulsions with jaw chewing movements and salivation ("chewing gum fits"), disorientation, incoordination, staggering caused by paralysis of the hind legs, seizures, and partial or complete paralysis will be euthanized and tested according to protocol set forth by the agency veterinarian, in order to determine if there may be a public health issue (M. Palamar, personal communication, 2016). USFWS will be contacted in cases of suspected red wolves. Staff involved in animal handling duties will have the pre-exposure rabies vaccination series completed prior to field work inception and will maintain rabies titer records through properly licensed medical services providers.

Commented [BA25]: Even if it is on their property?

Commented [BA26]: This is problematic on refuges.

Commented [BA27]: Not just contacted, but the decision needs to be FWS

If staff is bitten and skin is broken by an animal while performing handling duties, they will be advised to immediately visit a local hospital or clinic for evaluation by healthcare professionals. The field coordinator will immediately notify supervisory staff and an injury report and workers' compensation claim will be opened for the incident. The animal will be euthanized and the head will be sent to the state lab for rabies testing; the body may be sent to the Southeastern Cooperative Wildlife Disease Study (SCWDS) laboratory for additional disease investigation.

Capture Processing and Marking

During canid handling, NCWRC personnel will record age class, sex, weight, total body length, head width, ear length, and tail length, visually assess ectoparasite load, look for and disinfect with betadine or iodine as needed any minor trap caused injuries, and affix GPS collars (Knick 1990, Sikes et al. 2011). All captured canids will be fitted with appropriately-sized GPS collars in the field based on morphometrics previously indicated as reliable thresholds for

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species categorization: hind foot length, weight, width of head, and tail length (Hinton 2014); analysis of DNA samples collected during trapping efforts will help to assign captured canids to position along the species continuum post release. Age of individuals will be estimated based on physical characteristics, including weight and tooth replacement (Knick 1990, Hinton 2014, Gier 1968), and captured canids will be aged into one of three classes: > 2 years old as adults, < 2 but > 1 year old as juveniles, and > 6 months but < 12 months old as pups (Hinton 2014). Reproductive status will be determined based on estimated age class and presence of gonadal descent during the breeding season for males and the presence of nipple swelling or previous suckling for females (Hutson and Racey 2004, Magee 2008, Mengel 1971).

Captured individuals will be ear marked using a button tag (model 410, Ketchum Mfg. Co. [or equivalent], PO Box 10, 11 Town Shed Road, Lake Luzerne, NY 12846) placed along the middle of the ear where they are most protected from loss, with a pin-type applicator (485sa Pow-R-ceps plier, Ketchum Mfg. Co. [or equivalent]) (Silvy 2012). The puncture site will be treated with an antiseptic to deter infections. Each sympatric canid will also be marked with an individually-numbered, glass-encapsulated, passive integrated transponder (PIT model HPT12, 12.5 mm, 134.2 kHz, Biomark, Inc., 703 South Americana Blvd., Suite 150, Boise, ID; Gannon et al. 2007), using a syringe-type implanter and replaceable needle (model MK10 [implanter], model N125 [needle], Biomark, Inc.). Successful PIT placement will be verified with a mini portable reader (model GPR Plus, Biomark, Inc.). The implantation site will be prepared by swabbing with 70% alcohol (Mrozek et al. 1995) and a sterilized new needle will be used for each injection. The standard implantation site for transponders is subcutaneously on the dorsal midline of the back, cranial to the shoulder blades (Ingwersen 2000).

A skin biopsy will be taken from all captured target canids by puncturing the pinna of the ear with a biopsy punch in the same location where the ear tag will be placed (Palamar 2014). The biopsied area will be disinfected with alcohol after sampling. The skin biopsy will be placed in a labeled (ID, date, and sample type) cryogenic tube filled with 95% ethanol as buffer and then stored in a freezer until sent out to a lab for genetic analysis (Palamar 2014, Tom 2012). A selection of hairs with the root bulla attached will be pulled from the belly and placed in paper envelopes (Janecka et al. 2007). Hair samples will serve as back up to tissue samples

Commented [BA28]: Why? How does this fit into the study proposal? If not, no need to do it.

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for genetic testing. All samples will be sent to the Laboratory for Ecological, Evolutionary and Conservation Genetics, at University of Idaho (875 Perimeter Drive, MS 1136, Moscow, ID 83844) for genotyping to determine species as well as individual identification, hybridization presence, and parentage analysis following previously developed protocols (Adams et al. 2007, Hinton 2014, Miller et al. 2003). The appropriate genetic analyses that examine the coyote-hybrid-wolf species continuum will be performed.

Blood will be collected from all juvenile and adult target canids by venipuncture of the brachial or jugular veins using a 22-28-gauge needle (M. Palamar, NCWRC veterinarian, personal communication, 2016). As per NCWRC veterinarian recommendations, approximately 12 ml of blood will be collected for each animal for possible future testing for diseases of importance to sympatric canid species as well as the humans and domestic animals that they may come into contact with. A minimum of two 6 ml lavender top tube (for whole blood with EDTA) will be filled. Samples should be refrigerated at all times; a cooler with ice will suffice while in the field. Samples should be sent to the NCWRC within 48 hours or frozen for later shipping. Skin scrapes will be collected from animals presenting signs compatible with sarcoptic mange (lesions) for possible future diagnostic purposes. Lesions will be scraped until blood is drawn; the scrapings will be placed onto a slide and covered with a piece of clear tape for later visual confirmation.

Should overheating occur, processing will be performed in the following prioritization order and the first five items will need to be completed before releasing any individuals: 1) trap injury evaluation, 2) collaring, 3) DNA (skin biopsy) sample collection, 4) morphometrics, 5) aging, 6) PIT tagging, 7) weight, 8) ear tagging, 9) reproductive status, 10) ectoparasite evaluation, 11) blood collection, and 12) skin scrape collection.

Collaring

Vertex Plus GPS Collars will be attached to 25 sympatric canids captured on the study area, 10 of which will be equipped with proximity sensors (Vectronic Aerospace GmbH, Carl-Scheele-Str. 12, 12489 Berlin, Germany). Project staff will pilot test proximity sensor technology for utility in analysis of spatial and temporal community dynamics. Proximity sensors trigger increased GPS location acquisition during those time intervals when two collared individuals

Commented [BA29]: Why? What information is being collected and how would it be used to meet objectives?

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come within a set distance from each other (http://www.vectronic-aerospace.com/wildlife-monitoring/sensors/uhf-id-tags, accessed August 2016).

To avoid instances of collar induced strangulation, only adult (>2 years old) male and female individuals will receive collars (Hinton 2014). ASM guidelines recommends a collar weight of <5-10% of a canids bodyweight, we will observe these guidelines (Sikes et al. 2011). Sympatric canids not releasable at a capture site will not be collared and will not become study animals.

GPS radio-collars will have both VHF and GPS Iridium locational systems as well as store-on-board capabilities. Radio-collar units will be programmed to record GPS coordinates once every 1.75 hours producing approximately 13 locations per day while cycling through the 24-hour time cycle. These settings will allow for a GPS battery life of 300 to 552 days, averaging 431 days. The VHF beacon will be in operation from 0800 – 1600 hours daily. GPS locations will be sent via satellite once per day and each transmission with contain 12 locations. The use of an integrated drop off firing mechanism should allow the collars to drop off within a maximum of approximately 548 days after deployment. The drop off schedule once set cannot be changed. The drop off firing mechanism is wired to a battery unit independent of the collar battery, therefore should the collar battery become depleted, the drop off mechanism will not be affected (C. Akakpo, Vectronic Aerospace GmbH, personal communication, 2016). Unless a collared individual is recaptured before the collar battery dies, the drop off mechanism will fire at the scheduled time frame post collar deployment.

Observation of sympatric canid habitat use and movements will occur through GPS data obtained with combination GPS/VHF radio-collars. VHF relies on triangulation, the process of estimating the location of a transmitter by using two or more compass bearings obtained by using directional antennas at known locations remote from the transmitter's position (White and Garrott 1990), whereas GPS uses a satellite based system to obtain location coordinates. There have been many published studies where one or both of these methods were used, with mixed success for determining various aspects of carnivore ecology throughout the United States (Hinton et al. 2012, Schrecengost et al. 2009, Sparkman et al. 2012). While GPS technology has developed rapidly in recent history, the real time functional advantage of VHF

Commented [BA30]: How long is the battery life on the vhf beacon?

Commented [BA31]: This gets at the previous issues we had with managing a population of red wolves using an adaptive management plan but not having wolves collared for longer periods of time and losing contact, hence the inability to manage. You may gain data (though we already have what's being suggested here), but at the risk of the remaining few wolves in the population. In other words, I still don't see the rationale to even consider this proposal.

Commented [BA32]:

Commented [BA33]: Way to short – now no contact with wolves? Are you kidding?

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cannot be disregarded. When GPS technology falters or malfunctions, VHF can serve as replacement for data collection in addition to its use in real time monitoring of study animals. Canids will be minimally monitored for mortality approximately every 30 days by using VHF aerial telemetry techniques (Whitehouse and Steven 1977) as there may be a delay in satellite transmission of GPS location data due to weather, season, and animal behavior. Transient canids and individuals from breeding pairs that have lost a mate, have been found to use much larger areas versus paired residents, potentially increasing the opportunity for losing track of these individuals when GPS technology reaches its functional capacity or experiences malfunction. VHF data may also provide locations of canids in cover too dense for GPS units to function. Use of VHF telemetry techniques for data collection may be expanded as necessary for project needs.

Spatial Data Analyses

Both minimum convex polygon (MCP) and adaptive kernel (AK) home ranges (95%) and core use areas (50% and 25%) (Seaman and Powell 1996, Seaman et al. 1999) will be calculated from GPS data by using BIOTAS (Ecological Software Solutions LLC, 2016) and Geospatial Modelling Environment (Spatial Ecology, LLC, 2016) for ArcGIS 10.2.2 (Environmental Systems Research Institute, 2016) (Benson et al. 2006, Riley 2006, Tucker et al. 2008, Hinton 2014) for comparison to older studies. These estimations can also be calculated using VHF data, provided data minimum requirements are met. Spatial distribution in relation to habitat will also be estimated by dynamic Brownian bridge movement models as described by Hinton (2014) with R statistical software (R Core Team 2016) using the moveud package with habitat covariates important to each species (Bryne et al. 2014, Collier 2013, Kranstauber and Smolla 2013, C. Proctor, personal communication, 2016). Additionally, recent research into how canids shift their ranges will also be investigated for populations on the AP (Morin and Kelly, in review). Spatial overlap and co-occurrence will be assessed using methods described by Shipley (2012). Habitat and cover types will be estimated from digitized maps created by the SEGAP (Hinton 2014) or ortho files, as available (Shipley 2012). Percent composition of habitat and cover types within home ranges and core areas as well as edge density will be quantified (Shipley 2012). Habitat selection and cover type use effects on spatial distribution will be estimated at both the population (2nd order) and individual (3rd order) spatial scales using resource selection functions

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(Johnson et al. 2006, Manly et al. 2002, Shipley 2012). Effects of seasonality and time of day activity will also be explored. The spatial and temporal patterns of space use by sympatric canids will be studied using data generated from the interaction GPS collar sensors, particularly distance between individuals and duration of proximity.

Den Monitoring

Project staff will attempt to locate den sites for sympatric canids to get pup counts, morphometric measurements, age estimates, and skin biopsies. Project staff will also attempt to monitor pup survival during the pup rearing season by using remote cameras placed around the den site (Harrison and Gilbert 1985, Parks 1979, Way et al. 2001). Pups will be weighed, measured, and PIT tagged during May and June of each year when they become active but are still den-obligated (Gier 1968). We will investigate the use of remote camera traps for monitoring den behavior with a two-camera array around the den (H. Garbe, personal communication, 2016, Kays and Slauson 2008). This method has been successfully used to monitor kit fox pup survival (Kluever et al. 2013). Because coyotes have been found to be sensitive to den site disturbance, there is a general lack of data in the literature regarding this approach for monitoring pup survival. Approaching an experimental methodology systematically will be important for determining which methods are effective and which are not. As a starting point for testing this methodology, remote cameras will be placed two to five meters from main den entrances and set to take photos using a passive infrared sensor trigger (a beam that when broken by movement through it, triggers the camera to take a series of photos) with a time restriction between photo intervals to limit the number of photos taken and maximize the space on the memory card for the time period between camera checks (Kluever et al. 2013). Cameras will be checked six days after deployment and will be redeployed (i.e. new batteries and memory card, if required); cameras will remain at each den site until radio-collar data indicates the den site has been moved (Kluever et al. 2013). Cameras will be not be redeployed to a new coyote den site during a season if that breeding pair has already moved the den once due to the disturbance of camera presence/deployment.

Commented [BA34]: Based on past experience, will likely cause dam to move the den, or abandon pups

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Mortalities

If a collared animal dies during the project, the carcass will be sent to SCWDS for necropsy. Red wolves will be sent to the SCWDS laboratory for necropsy, unless it is determined to be a law enforcement case. In potential law enforcement cases, the NCWRC Division of Wildlife Management Chief and USFWS Ecological Services Raleigh Field Office Field Supervisor will be contacted and requested to contact the appropriate law enforcement personnel, immediately after determining the need for law enforcement involvement. The carcass and all relevant information will then be turned over to law enforcement; the GPS-collar will be removed and genetic samples will be taken from the individual prior to release to law enforcement.

Commented [BA35]: Not sure about this w/ES

Commented [BA36]: All mortalities have the potential to involve LE – this needs to be coordinated directly through FWS LE

Commented [BA37]:

Commented [BA38]: Was this not already done when handling initially? This sounds more like an attempt to collect material from canids not already involved in the study. ES material is owned by FWS – would need permit otherwise?

E. Project Personnel

Andrea Shipley has worked for the North Carolina Wildlife Resources Commission as a Canid Biologist since February 2016. Prior to that, she worked as a Wildlife Biologist for a non-profit located in northeastern Nevada as well as in several different field biologist oriented positions. Andrea has a background in carnivore and spatial ecology, having earned her MS in Biological Sciences from Eastern Kentucky University and BS in Biological Sciences from Rutgers University; Andrea will act as project lead and coordinator.

Brandon Sherrill has worked for the North Carolina Wildlife Resources Commission as a Mammalogist since December 2013. Prior to that, he worked as an educator at the North Carolina Museum of Natural Sciences and as a regional wildlife biologist for the South Carolina Department of Natural Resources. Brandon earned a BS and MS in Fisheries, Wildlife, and Conservation Biology from North Carolina State University; Brandon will act as project supervisor.

Krishna Pacifici, Research Assistant Professor at NCSU, will be the quantitative analysis collaborator on the project. Krishna's background and experience in quantitative ecology makes him well suited to consult and assist with advanced statistical analyses of spatial data.

Lisette Waits, Department Head and Distinguished Professor at the University of Idaho, will be the DNA analysis collaborator for the project, responsible for all DNA related sample processing and subsequent analyses.

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F. Schedule and Estimated Costs

The project will run from soon after December 1, 2017 through June 30, 2020. The estimated timeline for major tasks is as follows:

Year 1: Initiate field work soon after December 1, 2017 with assistance from 1-2 field technicians; 1 technician will be required for trapping and den monitoring efforts. Data collection will begin immediately after collar deployment and data will be managed by Andrea Shipley throughout the life of the project. Data analysis will be initiated after den monitoring season concludes, with guidance and assistance from Krishna Pacifici at North Carolina State University (NCSU). Report, manuscript and presentation production will be initiated concurrently with data analysis.

Year 2: Continue field work and data collection with assistance from 1-2 field technicians. Continue data analysis with guidance and assistance from Krishna Pacifici at NCSU. Continue and finalize report and manuscript production, and presentation at professional working groups and/or meetings.

GPS technology allows researchers to collect locational data at fine spatial and temporal scales through the deployment of collar units on wildlife study subjects. In this project, we propose to study a sample of sympatric canid populations with GPS radio-collars, in order to investigate the population parameters outlined in previous sections as well as species interactions. The purchase and use of this technology is critical to meeting the research objectives set forth in this document as well as in the document included in Attachment 1.

While GPS technology has evolved over the past 20 years, the cost of technology has plateaued. Upfront cost per unit remains relatively high, however project savings occurs at the back end when compared to older telemetry technology such as very high frequency (VHF)

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which require intensive labor to collect data at similar spatial and temporal scales. Pilot testing the proximity sensor enabled GPS-collars will allow investigation of the utility of this relatively new tool for community dynamics analysis by providing an increased locational data acquisition when individuals come within a set distance, or closer, from each other. Additionally, these sensors record the identities of the interacting individuals and the duration of their interactions. Using a trigger to temporarily switch GPS fix schedules will enable us to collect very fine scale data while conserving battery life, achieving project objectives in an efficient manner. Exploring the efficaciousness of this technology has the potential to positively impact future research projects requiring use of GPS-collars for data collection.

Aerial tracking will provide regular study animal surveillance useful to investigate cases of mortality, collar malfunction, or satellite data transmission delays, which can vary seasonally. In some situations, ground tracking could prove less expensive than aerial tracking. However, ground telemetry techniques require more than one biologist working in tandem to acquire accurate location estimates. This often translates to increased labor to collect data, particularly in large study areas. Aerial tracking will provide a more efficient and cost-effective method for surveilling study subjects in this large study area, requiring only one biologist and a contracted pilot. NCWRC personnel will perform aerial tracking along with the NCWRC pilot at a minimum frequency of every 30 days.

Use of local trappers to assist with sampling efforts provides several benefits. Local trappers have established, long-term relationships with private land owners, thereby providing access to private lands that might be otherwise difficult to secure. This will enable project biologists to obtain a representative sample of sympatric canids in the study area, as well as to operate more trap lines concurrently. This is particularly important when using a SCR sample design, as it will have direct implications on the resulting analyses and inferences.

As part of collaboration efforts, the project will contract the services of Krishna Pacifici, Research Assistant Professor in the Applied Ecology department at NCSU. Krishna's expertise is in quantitative ecology; consultation and assistance services provided will allow project biologists to make appropriate statistically relevant inferences from collected data.

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DNA analysis will be contracted to Lisette Wait's lab at the University of Idaho. Lisette's team at The Laboratory for Ecological, Evolutionary and Conservation Genetics has previous experience in analyzing red wolf and coyote hybrid molecular samples and has the most comprehensive DNA methodology for this sympatric canid species continuum in the nation. This expertise will facilitate expedient species identification on collared study animals besides landscape level population dynamics analysis.

	Commission	In-kind	Total
a. Personnel	$ 7,200.00	$ -	$ 7,200.00
b. Fringe Benefits	$ -	$ -	$ -
c. Travel	$ 30,000.00	$ -	$ 30,000.00
d. Equipment	$ 54,000.00	$ -	$ 54,000.00
e. Supplies	$ 61,500.00	$ -	$ 61,500.00
f. Contractual	$315,590.00	$ -	$315,590.00
g. Construction	$ -	$ -	$ -
h. Other	$ 6,000.00	$ -	$ 6,000.00
i. Total Direct Charges (sum of a – h)	$474,290.00	$ -	$474,290.00
j. Indirect Charges	$ 4,800.00	$ -	$ 4,800.00
k. Totals (sum of i and j)	$479,090.00	$ -	$479,090.00
Federal (75%)			$359,317.50
State (25%)			$119,772.50

Commented [BA39]: Really? This amount for what exactly?

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G. Geographic Location

Three counties of the Albemarle Peninsula of North Carolina (Dare, Hyde, and Tyrrell counties).

H. Related Federal Projects

NC-W-F15AF00726 (W-72) NC-Division of Wildlife Management Cooperative Projects

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I. Glossary

Abundance: Species abundance is the number of individuals per species, and relative abundance refers to the evenness of distribution of individuals among species in a community.

Adaptive kernel (AK): A probabilistic home range estimator based on the distribution and density of locations that has been collected over a period of time.

Adverse reactions: In pharmacology, any unexpected or dangerous reaction to a drug.

Aerial: Existing, happening, or operating in the air.

Annually: Once a year; every year.

Anthropogenic: Caused or influenced by humans.

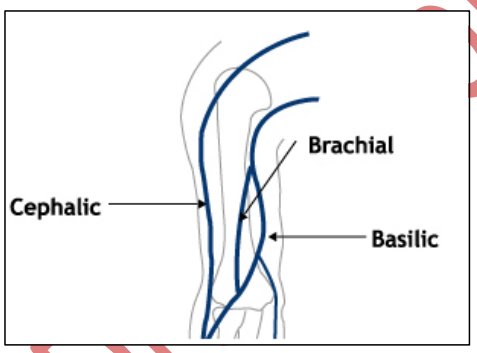
Apex: Having no natural predators in its ecosystem.

Ataxia: The loss of full control of bodily movements.

Beacon: A radio beacon whose purpose is the investigation of the propagation of radio signals.

Biopsy: The removal for diagnostic study of a piece of tissue from a living body.

Brachial vein: One of a pair of veins accompanying the brachial artery and uniting with each other and with the basilic vein to form the axillary vein.



Breeding pair: A pair of animals which cooperate over time to produce offspring with some form of a bond between the individuals.

Carrying capacity: The maximum population size of the species that the environment can sustain indefinitely, given the food, habitat, water, and other necessities available in the environment.

Compensatory immigration: Individuals emigrating from areas with lower mortality to those with higher mortality; filling a deficiency of individuals in a population experiencing higher mortality. The increase in size or activity of one part of an organism or organ that makes up for the loss or dysfunction of another.

Composition: The combining of distinct parts or elements to form a whole.

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Co-occurrence: Refers to observation of the spatial overlap between two (or more) different individuals over a period of time.

Coordinates: Any of the scales or magnitudes that serve to define the position of a point.

Core use areas: An area within a home range exhibited by a dense concentration of location points; commonly estimated at 50% of the location data points.

Covariates: A variable that is possibly predictive of the outcome under study.

Cranial: Pertaining to the cranium or to the anterior (in animals) or superior (in humans) end of the body.

Cryogenic: Very low temperatures, e.g. -80°C.

Den-obligated: Restricted to a particular condition of life, in this case restricted to a den site.

Density: A measure of the number of organisms that make up a population in a defined area.

Deployment: To organize and send out (people or things) to be used for a particular purpose.

Depredation: The act of preying upon.

Depressed respiration: A decrease in the ability to exhale and inhale; respiration that has a rate below 12 breaths per minute or that fails to provide full ventilation and perfusion of the lungs.

Diagnostic: The process of determining by examination the nature and circumstances of a diseased condition.

Disorientation: Loss of one's sense of direction, position, or relationship with one's surroundings.

Distribution: The manner in which a biological taxon is spatially arranged.

DNA: (deoxyribonucleic acid) is a type of macromolecule known as a nucleic acid. It is shaped like a twisted double helix and is composed of long strands of alternating sugars and phosphate groups, along with nitrogenous bases (adenine, thymine, guanine and cytosine).

Dorsal: Situated on or toward the upper side of the body, equivalent to the back, or posterior, in humans; situated on or toward the posterior plane in humans or toward the upper plane in quadrupeds.

Duration: A continuous period of time.

Dynamic Brownian bridge movement models: Incorporates temporal and behavioral characteristics of movement paths into estimation of home range.

Ectoparasite: a parasite that lives on the outside of its host rather than within the hosts body; e.g. fleas and lice.

Effective trap area: Calculated by buffering each trap site by half the mean maximum distance traveled, each of these boundaries are dissolved, creating a measurable area.

Efficacious: Producing or capable of producing a desired effect.

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Efficient: Accomplishment of or ability to accomplish a job with a minimum expenditure of time and effort.

Euthanize: The act of putting to death painlessly or allowing to die, as by withholding extreme medical measures, a person or animal suffering from an incurable, especially a painful, disease or condition.

Expedient: Suitable for achieving a particular end in a given circumstance.

Evaporative cooling: reduction in temperature resulting from the evaporation of a liquid, which removes latent heat from the surface from which evaporation takes place.

Facilitate: Make an action or process easy or easier.

Genotyping: Investigate the genetic constitution of (an individual organism).

Gonadal descent: The act or process of descending from a higher to a lower location; testicular descent occurs during the breeding season annually.

GPS: Global Positioning System, is a radio navigation system that allows land, sea, and airborne users to determine their exact location, velocity, and time 24 hours a day, in all weather conditions, anywhere in the world.

Home range: an area over which an animal or group of animals regularly travels in search of food or mates, and that may overlap with those of neighboring animals or groups of the same species.

Hybridization: The result of mixing, through sexual reproduction, two animals or plants of different breeds, varieties, species or genera.

Immobilization agent: An active force or substance capable of producing an effect.

Implantation: To put or fix firmly.

Inbreeding depression: The reduced biological fitness in a given population as a result of inbreeding, or breeding of related individuals.

Inception: The establishment or starting point of an institution or activity.

Interspecific: Existing or occurring between different species.

Iridium: A satellite constellation providing voice and data coverage to satellite phones, pagers and integrated transceivers over the Earth's entire surface.

Jugular vein: Any of several large veins in the neck, carrying blood from the head and face.

Lacerations: A deep cut or tear in skin or flesh.

Locational: A position or site occupied or available for occupancy or marked by some distinguishing feature.

Malfunction: Fail to operate in the normal or usual manner

Methodology: A system of methods used in a particular area of study or activity.

Midline: A median line or plane of bilateral symmetry, especially that of the body.

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Minimum convex polygon (MCP): Completely enclose all data points by connecting the outer locations in such a way as to create a convex polygon.

Molecular samples: Genetic samples that may be used for investigation of genetic constitution of an individual.

Morphometrics: The process of measuring the external shape and dimensions of landforms, living organisms, or other objects.

Mortality: The state of being subject to death.

Non-target bycatch: Animals caught by accident that are not the target species being sought.

Parameters: A numerical or other measurable factor forming one of a set that defines a system or sets the conditions of its operation.

Parentage: The origin of something; the state or relation of a parent.

Passive integrated transponder: A microchip implant is an identifying integrated circuit placed under the skin of an animal.

Pinna: The external part of the ear in humans and other mammals; the auricle.

Plateaued: A period or state of little or no growth or decline.

Population dynamics: The branch of life sciences that studies the size and age composition of populations as dynamic systems, and the biological and environmental processes driving them (such as birth and death rates, and by immigration and emigration).

Population growth: The increase in the number of individuals in a population.

Population size: A group of organisms of the same species that live in the same area.

Population status:

Population trend: Changes over time and can include changes in ranging behavior and distribution, biogeography and life-history.

Population viability: The process that determines the probability that a population will go extinct within a given number of years.

Proximity: Nearness in space, time, or relationship.

Quantified: Express or measure the quantity of.

Quantitative: Relating to, measuring, or measured by the quantity of something rather than its quality.

Radio-telemetry: The use of radio waves for transmitting information from a distant instrument to a device that indicates or records the measurements.

Recumbency: The state of leaning, resting, or reclining.

Reintegrate: Restore (elements regarded as disparate) to unity.

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Remnant: A small remaining quantity of something.

Reproductive status: Relating to or effecting reproduction.

Spatial: Relating to, occupying, or having the character of space.

Spatial capture-recapture: A method commonly used in ecology to estimate an animal population's size. A portion of the population is captured, marked, and released. Marked animals are either recaptured or are tracked, each tracking location being considered a recapture.

Species Continuum: An aggregate of species capable of interbreeding, resulting in fertile hybrid offspring whose genetic composition may represent a varying array of phenotypes and genotypes from the parental species, at which the extreme ends of the spectrum are distinct.

Standardize: Cause (something) to conform to a standard.

Statistically relevant inferences: the process of deducing properties of an underlying distribution by analysis of data. Inferential statistical analysis infers properties about a population: this includes testing hypotheses and deriving estimates.

Stochastic population models: Ecological population modeling is concerned with the changes in population size and age distribution within a population as a consequence of interactions of organisms with the physical environment, with individuals of their own species, and with organisms of other species; stochasticity possesses some inherent randomness. In stochastic population models, the same set of parameter values and initial conditions will lead to an ensemble of different out puts.

Strangulation: The condition in which circulation of blood to a part of the body is cut off by constriction.

Stratifying: Form or arrange into strata, one of a number of portions or divisions likened to layers or levels.

Surveillance: Continuous observation of a place, person, group, or ongoing activity in order to gather information.

Survival: A living or continuing longer than, or beyond the existence of, another person, thing, or event.

Sympatric: Occurring within the same geographical area; overlapping in distribution.

Tachycardia: A heart rate that exceeds the normal resting rate. In general, a resting heart rate over 100 beats per minute is accepted as tachycardia in human adults.

Telemetry: See radio-telemetry.

Temporal: Of or relating to time.

Tooth replacement: The process of development of two successive sets of teeth, initially the deciduous set and consecutively the permanent set.

Transmitter: A set of equipment used to generate and transmit electromagnetic waves carrying messages or signals, especially those of radio or television.

Transponder: A device for receiving a radio signal and automatically transmitting a different signal.

Draft - Confidential

682 Vaccinate: Treat with a vaccine to produce immunity against a disease; inoculate.

683 Venipuncture: The puncture of a vein as part of a medical procedure, typically to withdraw a blood
684 sample or for an intravenous injection.

685 VHF: Very high frequency is the ITU designation for the range of radio frequency electromagnetic waves
686 (radio waves) from 30 MHz to 300 MHz, with corresponding wavelengths of ten to one meters.

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Attachment 1: Intra-service Section 7 Biological Evaluation Form

Region 4

INTRA-SERVICE SECTION 7 BIOLOGICAL EVALUATION FORM

[Note: This form provides the outline of information needed for intra-Service consultation. If additional space is needed, attach additional sheets, or set up this form to accommodate your responses.]

Originating Person: Andrea Shipley

Telephone Number: 252.926.0266 **E-Mail:** andrea.shipley@ncwildlife.org

Date: November 8, 2016

PROJECT NAME (Grant Title/Number): NC – Division of Wildlife Management Cooperative Projects / (W-72)

I. Service Program:

_____**Ecological Services**
__X__**Federal Aid**
  _____**Clean Vessel act**
  _____**Coastal Wetlands**
  _____**Endangered Species Section 6**
  _____**Partners for Fish and Wildlife**
  _____**Sport Fish Restoration**
  __X__**Wildlife Restoration**
_____**Fisheries**
_____**Refuges/Wildlife**

II. State/Agency:

NORTH CAROLINA / NORTH CAROLINA WILDLIFE RESOURCES COMMISSION

III. Station Name:

FWS RALEIGH ECOLOGICAL SERVICES OFFICE

IV. Description of Proposed Action (attach additional pages as needed):

Conduct research project entitled "**Coyotes of the Albemarle: Spatial Ecology, Resource Selection, Demographics, and Interactions with a Sympatric Canid"**

The coyote (*Canis latrans*) is now abundant throughout the 100 counties in North Carolina (NC), where they are managed as nongame with no closed season or bag limit (NC Wildlife Resources Commission 2016). Previously restricted to the West and Midwest regions of the United States, by the early 1990s coyotes had expanded their range into the Albemarle Peninsula (AP), which is situated in the northeast coastal plains region of NC (Hinton et al. 2012, Murray et al. 2014).

Recently described as using "compensatory immigration," coyotes are able to opportunistically fill spatial resource gaps by periodic transiency (Hinton 2016). These periods of transiency can sometimes bring coyotes into conflict with humans and other canids, especially while taking advantage of anthropogenic resources. Though a rural area, human land uses predominate on the AP. The AP is comprised of approximately 30% agricultural fields, 50% forest and coastal marshes, and 20% "other" land cover types on federal, state and private lands (Dellinger 2011).

In 1968, individuals from a remnant population of red wolves were removed from Texas and Louisiana and a captive breeding program was initiated. The United States Fish and Wildlife Service (USFWS) released a non-essential, experimental population of red wolves (*Canis rufus*) on the Alligator River National Wildlife Refuge (ARNWR) in 1987 (Hinton et al. 2013). The red wolf population increased until 2008 and peaked at around 208 individuals (USFWS Red Wolf Recovery Program 2007), a few animals short of the recovery goal of 220 in the wild (USFWS Red Wolf Recovery Program 2013), with an estimated carrying capacity of 140-150 for the AP (Hinton et al. 2013, Kelly et al. 1999, USFWS Red Wolf Recovery Program 2007). Red wolves presently inhabit an approximately 6900 square kilometer recovery area within Beaufort, Dare, Hyde, Tyrrell, and Washington counties (Wildlife Management Institute 2014).
Accurate up-to-date estimates of the population are unavailable, but USFWS staff report a population size of 45-60 individuals with three mortalities in 2016 (https://www.fws.gov/redwolf/index.html July 2016). Hybridization with coyotes, inbreeding depression, and gunshot mortality have all been suspected issues that have affected the population growth and viability since the inception of the Red Wolf Recovery Program (RWRP) (Hinton et al. 2013). In 2013, NCWRC and USFWS established a committee to oversee the collaborative management and conservation of red wolves and other canids on the AP. A USFWS memorandum documented detailed action items for the joint management of canids on the AP, including specific research objectives which this proposal seeks to address (Attachment 1).

As coyotes on the AP increase in number, monitoring coyote movements, particularly in relation to red wolves, will provide important data to NCWRC and USFWS staff for science-based local and landscape-level decisions about coyote population management. Collection of finer temporal scale location data will help to manage interactions of both canid species with humans, as well as to support development of dynamic stochastic population models.

Coyote and red wolves will be live trapped by cooperating NCWRC and USFWS staff, and private trappers using double coil size 3 foothold traps, during the breeding season (Nov-Feb for coyote, Jan-Feb for red wolves) in the tri-county area of Dare, Hyde and Tyrrell. Morphological measurements, incidents of injury, occurrence of ectoparasites, age classification, and reproductive status will be determined; blood and tissue samples will be taken for genetic analysis. All captured individuals that meet the age classification and weight requirements will be collared with GPS collar units. All captured and collared individuals will be released at the capture site. The objectives listed below will be achieved by obtaining measurements, samples and information from the captured, collared, and tracked individuals over the course of three years using GPS location data.

Objective 1: Use GPS collar and proximity sensor technology to test performance under various conditions and evaluate the frequency and accuracy of the scheduled fix rates.

Objective 2: Use fine scale GPS data collection for investigating annual and seasonal spatial dynamics of sympatric canids: home range and core area sizes, amount of overlap in home range and core areas, movement pathways and daily activity patterns, and cover type selection and preference.

Objective 3: Use fine scale GPS data collection for investigating the number and age structure of offspring for family groups of collared sympatric canids.

Objective 4: Use fine scale GPS data collection for investigating sources of mortality for sympatric canids.

Objective 5: Use fine scale GPS data collection for preventing and mitigating canid conflicts with landowners.

Objective 6: Determine genetic profiles of sympatric canids through DNA identification of all captured individuals, parentage, and presence of hybridization.

V. Pertinent Species and Habitat:

A. Include species/habitat: See section VI

B. Complete the following table:

SPECIES/CRITICAL HABITAT	STATUS[1]
Canis rufus	T

[1]STATUS: E = endangered, T = threatened, PE = proposed endangered, PT =proposed threatened, CH = critical habitat, PC = proposed critical habitat, C = candidate species

VI. Location:

A. Statewide

Albemarle Peninsula (see web address www.ncwildlife.org)

B. Section, township, and range (or latitude and longitude):

Dare, Hyde, Tyrrell counties

C. Distance (miles) and direction to nearest town:

As stated above

D. Species/habitat occurrence:

Canis rufus

VII. Determination of Effects:

A. Explanation of effects of the action on species and critical habitats in item V. B. (attach additional pages as needed):

SPECIES/CRITICAL HABITAT	IMPACTS TO SPECIES/CRITICAL HABITAT
Canis rufus	Trap induced injury is possible

B. Explanation of actions to be implemented to reduce adverse effects:

SPECIES/CRITICAL HABITAT	ACTIONS TO MITIGATE/MINIMIZE IMPACTS
Canis rufus	Use of appropriate trap types, daily trap checks, treatment of minor injuries, trapping season limitations and limitations on environmental conditions for trap operation

VIII. Effect Determination and Response Requested:

Species/ Critical Habitat	Determination[1]			Response[1] Requested
	NE	NA	AA	
Canis rufus		X		Concurrence

[1] Determination/Response Requested:

NE = No Effect. This determination is appropriate when the proposed action will not directly, indirectly, or cumulatively impact, either positively or negatively, any listed, proposed, candidate species or designated/proposed critical habitat. Response Requested is optional but a "Concurrence" is recommended for a complete Administrative Record.

NA = Not Likely To Adversely Affect. The determination is appropriate when the proposed action is not likely to adversely impact any listed, proposed, candidate species or designated/proposed critical habitat or there may be beneficial effects to these resources. Response Requested is a "Concurrence".

AA = Likely To Adversely Affect. This determination is appropriate when the proposed action is likely to adversely impact any listed, proposed, candidate species or designated/proposed critical habitat. Response Requested for listed species is "Formal Consultation". Response Requested for proposed or candidate species is "Conference".

Signature (originating station) **Date**

Title

IX. Reviewing Ecological Services Office Evaluation:

A. Concurrence _____ Non-Concurrence _____

B. Formal consultation required _____

C. Conference required _____

D. Formal conference required _____

E. Remarks (attach additional pages as needed):

_____ _____
Signature **Date**

_____ _____
Title **Office**

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Attachment 2: Joint Memorandum

MEMORANDUM

November 20, 2013

TO: All Interested Parties

FROM: "for"
Cynthia K. Dohner, Director, Southeast Region, U.S. Fish and Wildlife Service
Gordon S. Myers, Executive Director, N.C. Wildlife Resources Commission

SUBJECT: Collaborative Conservation of Red Wolves and Other Canids on North Carolina's Albemarle Peninsula

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Recovery of the federally-listed red wolf has been a priority for the U.S. Fish and Wildlife Service (FWS) for more than 20 years and is focused in North Carolina on the Albemarle Peninsula (AP; i.e., Hyde, Tyrrell, Washington, Beaufort, and Dare counties). Comprehensive stakeholder involvement and collaboration with other management agencies is critical to successful recovery of any at-risk species. The North Carolina Wildlife Resources Commission (WRC) is a key collaborator in this regard, as it has jurisdiction over all state-trust wildlife resources in N.C.

Since 2009, the FWS and WRC have worked to broaden our collaboration in the conservation and management of all canid species (including red wolves) on the AP. As these efforts have solidified, specific actions have been jointly identified by our two agencies that will improve conservation outcomes. These actions are categorized into five areas; collaboration, research, outreach, regulatory, and enforcement. Specific action items are outlined and prioritized within each of these categories in Attachment A.

This memo establishes the FWS's and WRC's commitment to initiate, or to continue, the efforts outlined in Attachment A. The common goal in this effort is to establish clear expectations and accountability for collaboration regarding the action items on Attachment A, thus resulting in enhanced and seamless canid conservation and management on the AP. This approach provides the best opportunity to achieve recovery goals for red wolves, while at the same time managing other canids to balance biological variables with social expectations. The dynamics of these canid species are complex and offer unique opportunities for innovation. Appropriate staff from each agency is hereby tasked with immediately developing a timeline to implement these actions. Through this commitment, we will continue to advance our collective conservation goals.

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Attachment A

Action Items for Collaborative Conservation of Canids on North Carolina's Albemarle Peninsula (AP)
(*Note: Action Items are prioritized within category.*)

Collaboration

1. The N.C. Wildlife Resources Commission (WRC) and U.S. Fish and Wildlife Service (FWS) will formalize in writing the collaborative management of canids on the AP. This agreement should:
    a. include a clear mission statement, goals, objectives, and implementation strategies (ask and answer the "Why?");
    b. set a goal to define success regarding canid management on the AP;
    c. espouse a philosophy of canid management operating within the context of a three-legged stool (i.e., federal and state governments and stakeholders);
    d. as available, commit funding and staffing resources for field personnel to contribute to the conservation of the red wolf and management of coyotes;
    e. as available, commit funding to conduct research pertinent to canid management on the AP;
    f. establish polices and goals for developing a collaborative genetic archive for AP canids, a data sharing portal accessible by staff in both agencies, and reciprocal sharing of all historical data (including phenotypic and genotypic data and literature) of the red wolf;
    g. establish a foundation for developing and implementing an adaptive approach to canid management on private lands on the AP;
    h. initiate development of a collaborative canid research program;
    i. describe plans to conduct the next five year Red Wolf Program review;
    j. outline options for holding annual workshops with federal and state enforcement staff;
    k. outline plans to hold semi-annual coordination meetings regarding canid management on the AP; and
    l. develop milestones for future development of a management plan for all canids in the AP.

2. The FWS will initiate a review of the current Red Wolf Recovery Plan to determine if the state-of-our-knowledge or field conditions have changed such as to warrant its revision. Review and comments from the WRC will be considered in this evaluation.

3. The WRC, with support and participation of the FWS, will establish a "Canid Forum" (similar to that established for manatees in Florida) to facilitate communication and discussion regarding canid management and citizen science opportunities on the AP.

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Attachment A

Research

1. The FWS and WRC will provide funding and logistical support for research identified by the Red Wolf Recovery Implementation Team, Red Wolf Program staff, other FWS staff, or the WRC that promote the conservation and recovery of the red wolf and other canids on the AP. Studies could include:
    a. tests of the "placeholder theory" on the AP, including behavior of sympatric canids,
    b. determining carrying capacity of canids on the AP,
    c. determining genetic profiles of canid species on the AP,
    d. evaluating predator-prey dynamics,
    e. studies of canid habitat use,
    f. epidemiology of diseases impacting canids on the AP,
    g. development of stochastic simulation models of sympatric canid population dynamics and habitat use, and
    h. canid dispersal dynamics

2. The FWS and WRC will conduct jointly-supported research to determine the attitudes and opinions of N.C. private landowners and other citizens concerning canids on the AP (i.e., human dimensions studies).

Outreach

1. The FWS and WRC will collaborate with other partners to design and implement broad-based outreach and marketing programs with clear goals, objectives, strategies, and measurable outcomes, including development of consistent agency messages and educating the public about canids on the AP.

Regulatory

1. The FWS and WRC will initiate a review and, if needed, subsequent rule-making to clarify concepts or rectify conflicts in current federal or state rules (including the current 10(J) rule).

2. The WRC will review and evaluate statutory requirements for listing red wolves as state threatened in the five AP counties.

3. As data demonstrating a relationship between coyote hunting and red wolf mortality become available, the FWS and WRC will evaluate, and if appropriate implement, adaptive approaches to regulate of take of coyotes that may result in incidental take of red wolves.

4. The WRC will evaluate the status, management, and regulation of Controlled Fox Hunting Preserves.

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5. The WRC will develop BMPs (due care provisions) for coyote hunting, trapping, and live sale.

6. The WRC will compile, compare, and contrast canid hunting and trapping regulations and programs in other states, including, but not limited to, other states with other species of wolves.

Enforcement

1. The FWS and WRC will develop coordination strategies to improve enforcement of federal regulations protecting red wolves.

Attachment 3: Landowner Agreement Form

NC Wildlife Resources Commission
Wildlife Management Division
Wildlife Diversity Program
Landowner Agreement for Scientific Collection

_____ / _____ / _____
MM DD YYYY

Property Type
Private _____ Federal _____ State _____

NC Wildlife Resources Commission
Address: 1701 Mail Service Center, Raleigh, NC 27699-1701
Phone: 919-707-0010

Cooperator's Name: _____
Last First Middle

Cooperator's Address: _____
Street City, State, Zip

Where will the work be performed? _____

give address or directions if different from above _____

Business, Farm, Property Common Name _____

Owner's or Rep Name _____ _____
If different from Cooperator Telephone Number

Owner's Address: _____
If different from Cooperator Street City, State, Zip

WRC Employee & Work Location	Species
	1)
Employee Name	2)
	3)
Duty Area	4)

I, the cooperator or cooperator's representative, have been informed of the methods and the manner in which research devices will be used, and of the possible hazards associated with their use. I understand that NCWRC, (to include its officers, employees and agents) will: exercise reasonable precautions to safeguard all persons to prevent injury to target and non-target animals; guard against the mishandling of control devices and materials; and exercise due caution and proper judgment in all scientific collection operations. I understand that NCWRC may collect Global Positioning System (GPS) coordinates at the project site as part of component or activity tracking or as wildlife disease monitoring or research data. I, the undersigned cooperator, do hereby give my consent and concurrence to NCWRC, its employees, and its agents, to use, upon lands owned, leased, or otherwise controlled by me, and identified by this document, the following methods and devices (an attachment of additional devices and/or methods may be attached):

Statement of agreement: The landowner, cooperator, or representative, as listed above hereby give permission to NCWRC to perform trap and release of the species listed for scientific collection purposes. In consideration of these understandings, I, the cooperator or cooperator's representative, agree to: assume responsibility for injury to my property under my control, when said injury is not the result of negligence on the part of NCWRC (it's officers, employees, and agents); assist in maintaining such warning signs as NCWRC may place for the purpose of notifying persons entering onto such lands of the possible hazards associated with scientific measures in use thereon; and to give adequate warning of these possible hazards to persons I authorize to enter onto such lands. Further, I, the cooperator or cooperator's representative, agree not to concurrently use or allow to be used upon lands covered by this agreement, any canid depredation efforts during the scientific collection time period.

Landowner Signature/Date _____
Signature Date

WRC Employee Signature/Date _____
Signature Date

Attachment 4: Trapper Service Contract

Contract in development.

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[redacted]

I have a few dozen traps! Never had an issue! People that love Red wolves don't have a damn thing invested in Wildlife.



1 New Comment

Write a comment...

Coyote Depredation Permit

Tele: (919) 707-0061
FAX: (919) 707-0292

North Carolina Wildlife Resources Commission
Regulated Activities Permits Section
1707 Mail Service Center
Raleigh, NC 27699-1707

AUTHORITY

STATUTES
GS 113-274

RULES
15A NCAC 10B .0106

PERMITTEE/LICENSEE

Tom Harrison
[redacted]

Telephone: [redacted]

PERMIT NUMBER
N/A

EFFECTIVE	EXPIRES
04/01/2018	5/30/2018
COUNTY See Text Below	**DISTRICT** See Text Below

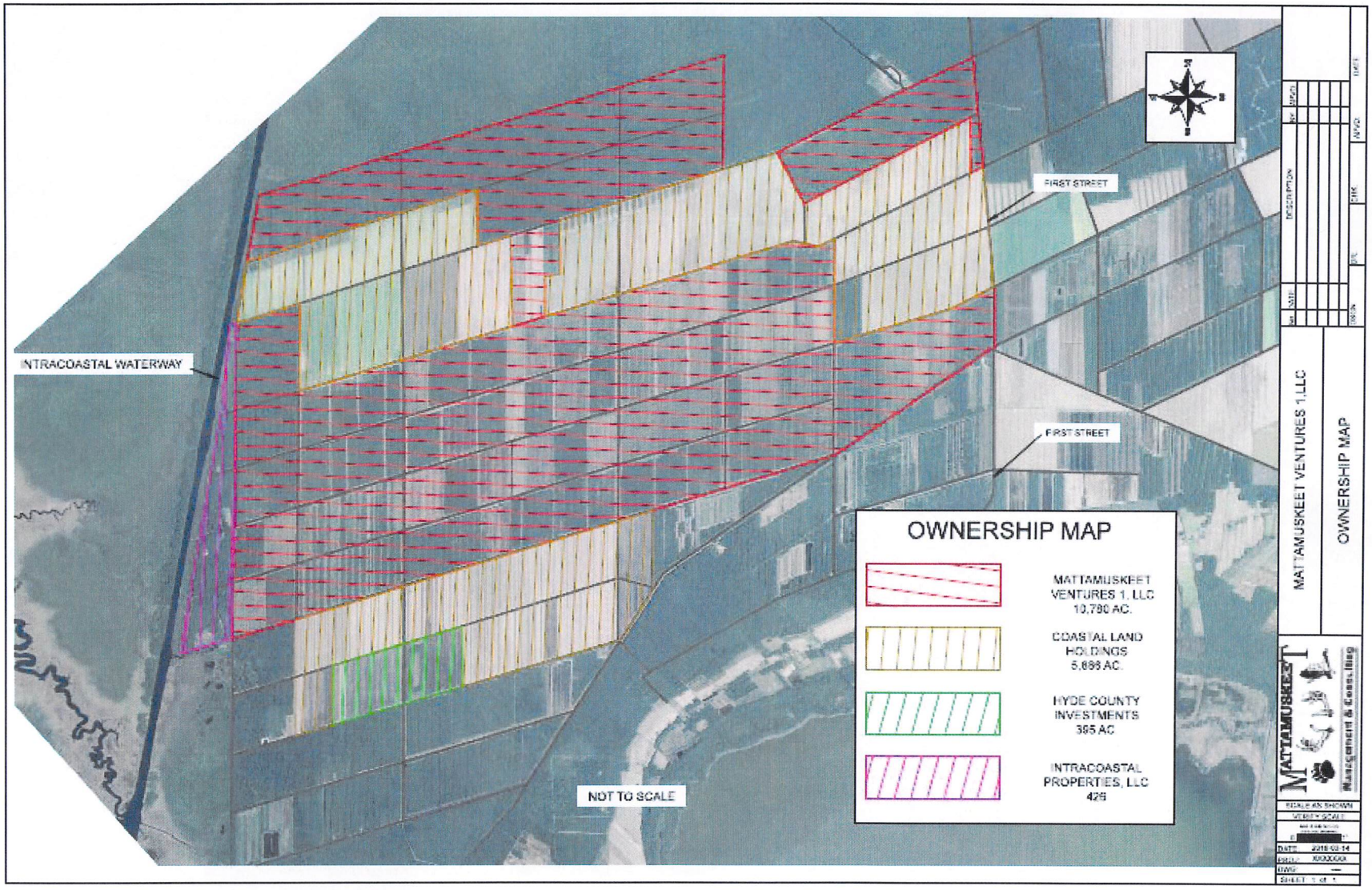
CONDITIONS AND AUTHORIZATIONS:

The above permittee and other individuals under written contract and under the supervision of the permittee are authorized to trap coyotes on the properties identified in **Attachment A** subject to the following conditions:

- Permit is valid for properties identified in **Attachment A**.
- This permit does not authorize access to any property, public or private.
- All individuals exercising the authority granted by this permit shall carry a copy of this permit and a letter of authorization from the permittee listed above while conducting trapping activities.
- Traps must be labeled as required by G.S. 113-291.6. Traps must be checked daily and any animals caught therein must be removed. All non-target wildlife must be released immediately onsite; however, any red wolf captured must be reported immediately to the Wildlife Resources Commission (WRC) at 800-662-7137 or the U.S. Fish and Wildlife Service to determine disposition of the red wolf.
- Coyotes being removed for depredation under this permit may only be trapped using legal foothold traps and the Collarum type trap as defined in G.S. 113-291.6. The reporting forms required for the use of Collarum type traps may be found at http://www.ncwildlife.org/Trapping/Laws-Safety. Collared animals must be reported immediately to the WRC at 800-662-7137 before final disposition is determined. All coyotes euthanized shall be disposed of in a sanitary manner. All collars from euthanized coyotes must be returned to the WRC.
- Permit holder must report the removal of coyotes to the WRC at 800-662-7137 or online at www.ncalvin.org/ckr/ckrmain.aspx within 24 hours of taking possession of each individual coyote. Each report must include the date; time; location; if the animal had a collar; and measurements of hind foot length and tail length taken from the carcass. Instructions for recording these measurements are enclosed and can be found at www.ncwildlife.org/Portals/0/License/Documents/Canid-Cooperator-Program-Instructions.pdf.
- A hair sample with follicle from each euthanized coyote must be submitted to WRC, Wildlife Management Division, 1722 Mail Service Center, Raleigh, NC 27699-1722.
- A report of all animals captured under this permit, date of capture, and their disposition is required within fifteen (15) days after the expiration of this permit.

This permit/license is nontransferable and expires at midnight on the above specified expiration date.

ISSUED BY:	TITLE:	DATE:
[signature]	EXECUTIVE DIRECTOR	3-23-18



ATTACHMENT A

STATE: North Carolina

GRANT TITLE: W79-Wildlife Management

PROJECT TITLE: Pilot Study – Using Fine Scale GPS Technology to Research Sympatric Canid Population Dynamics (Job 2.0?)

A. Problem and Need

The coyote (*Canis latrans*) is now abundant throughout all 100 counties in North Carolina (NC), and is managed as nongame with no closed season or bag limit (NC Wildlife Resources Commission 2016). Previously restricted to the West and Midwest regions of the United States, by the early 1990s coyotes had expanded their range into the Albemarle Peninsula (AP), which is situated in the northeast coastal plain region of NC (Hinton et al. 2012, Murray et al. 2014). Though a rural area, human land uses occupy a significant portion of space on the AP. The AP is comprised of approximately 30% agricultural fields, 50% forest and coastal marshes, and 20% "other" land cover types on federal, state and private lands (Dellinger 2011).

Telemetry data from coyotes on the AP suggests that about 70% of coyotes are residents (i.e., those that defend set territories) while the other 30% are transients, with most being dispersing juveniles (Hinton et al. 2015). Transient coyotes do not defend territories. Coyotes can travel long distances and become transient even as adults, especially when they lose their mate. Recently described as using "compensatory immigration," coyotes opportunistically fill spatial resource gaps by periodic transiency; when spots come open, individuals that do not yet have permanent territories and have been roaming in the area, are able to inhabit the new openings (Hinton 2016). These periods of transiency can sometimes bring coyotes into conflict with other canids and humans, especially when they are utilizing anthropogenic resources (e.g. crops, garbage, bird seed, etc.).

The coyote is not the only medium to large-size canid inhabiting the AP. The United States Fish and Wildlife Service (USFWS) released a non-essential, experimental population (NEP) of captive-bred red wolves (*Canis rufus*) on the Alligator River National Wildlife Refuge (ARNWR) in 1987 (Hinton et al. 2013). This population increased until 2008 and peaked at around 130 individuals (Group Solutions, Inc. 2016), short of the recovery goal of 220

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individuals dispersed amongst 3 self-sustaining mainland populations in the wild (USFWS Red Wolf Recovery Program 2013, Red Wolf Recovery Program 1984). The AP has an estimated carrying capacity of 140-150 wolves (Hinton et al. 2013, Kelly et al. 1999, USFWS Red Wolf Recovery Program 2007). The exact number of red wolves is not known, but USFWS staff report a population estimate of 25-40 individuals with six recorded mortalities in 2017 (J. Madison, personal communication, 2017).

As a result, the AP now supports these sympatric canids whose recent spatial distribution overlaps, hereafter referred to as "sympatric canids." Coyotes and red wolves on the AP have a close biological relationship which developed due to one or more similar sympatric distributions in the past at other locations; an occurrence separate from current day distribution, but explanatory of the continuum of morphology and behavior that we see in sympatric canid populations on the AP. Hybridization between red wolves and coyotes and inbreeding depression are suspected factors that have affected red wolf population growth and viability since the inception of the Red Wolf Recovery Program (RWRP), while vehicular and gunshot mortality are known factors (Hinton et al. 2013, Faust et al. 2016). As part of a recent program review, the USFWS halted use of mitigating management techniques in 2015, potentially affecting the spatial distribution and population dynamics of sympatric canids.

In 2013, North Carolina Wildlife Resources Commission (NCWRC) and USFWS established a committee to oversee the collaborative management and conservation of sympatric canids on the AP. A USFWS and NCWRC joint memorandum (Memorandum) documented detailed action items for the joint management of sympatric canids on the AP, including specific research objectives which this proposal seeks to address in part (Attachment 2). The objectives outlined in the Memorandum were identified by consensus of the various USFWS and NCWRC staff as those that may "…promote the conservation and recovery of the red wolf and other canids on the AP." As sympatric canids on the AP increase in number, monitoring their movements, particularly in relation to individuals of differing ancestry, could provide important data to NCWRC and USFWS staff for science-based local and landscape-level decisions about sympatric canid populations and conflict management. Collection of finer temporal scale location data could help managers in developing local strategies for

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collaborative education and outreach, prevention or resolution of negative interactions of sympatric canids with humans, as well as to support development of dynamic stochastic population models. One of the most important elements of management and conservation of sympatric canids on the AP is the involvement of stakeholders in the federal and state collaborative effort.

Concerns about fear of attacks on humans and domestic pets, the perceived effects of sympatric canids on white-tailed deer and other game populations, and homeowner property damage comprise many of the conflict calls regarding sympatric canids on the AP (Responsive Management, forthcoming data). In 2015 NCWRC established a Human-Wildlife Interaction (HWI) database to track and classify the different types of wildlife related calls the Wildlife Helpline receives. In the past 3 years wildlife managers working in the mainland AP region have received calls regarding observations (coyote and red wolf) and perceived or real threats to human, domestic pets, and livestock/chickens (coyote), and for information on how to deal with conflicts (C. Turner, personal communication, 2017).

The changes in state and federal canid management rules for the AP have resulted in confusion regarding residents' rights and options for management of property damage by canids (e.g. domestic pets, livestock, or chickens killed). As a result, some citizens are unsure of the legal and most effective methods for canid conflict management. Adding to management complexity is the need to manage canids for conservation purposes, such as reducing predation on at-risk ground nesting species (this may mean a need for higher or lower numbers of canids in an area) or reducing hybridization of listed canids. NCWRC has identified expanding education and outreach to constituents regarding coyote life history and management strategies as the most valuable tool to mitigating canid conflicts within the state (Committee of the Whole meeting, 6 December 2017). Recommended management strategies for dealing with coyote conflict promote landowner prevention responsibilities and recommend lethal tools as secondary to prevention, on a case-by-case basis, dependent on local management goals. Depredation permits, one tool for wildlife management, are not the norm for dealing with conflict issues. During the three-year period of 2015 through 2017, only six depredation permits

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for coyotes were issued for mainland AP (NCWRC depredation permit database, C. Turner, personal communication, 2017).

This pilot project seeks to lay the groundwork toward meeting many of the identified Memorandum research objectives, should additional research be pursued post-pilot. Data collected during this pilot could potentially be incorporated in analyses performed with collected data from additional targeted future prospective projects. Utilizing this pilot for initiating an understanding of the current state of hybridization between sympatric canid populations on the AP could aid USFWS staff with development of new approaches for managing hybridization in the red wolf NEP.

B. Objectives (after December 1, 2017-June 30, 2020)

Objective 1: Use GPS collar and proximity sensor technology to test performance under various conditions and evaluate the frequency and accuracy of the scheduled fix rates.

Objective 2: Use fine scale GPS data collection for investigating annual and seasonal spatial dynamics of sympatric canids: home range and core area sizes, amount of overlap in home range and core areas, movement pathways and daily activity patterns, and cover type selection and preference.

Objective 3: Use fine scale GPS data collection for investigating the number and age structure of offspring for family groups of collared sympatric canids.

Objective 4: Use fine scale GPS data collection for investigating sources of mortality for sympatric canids.

Objective 5: Use fine scale GPS data collection for developing local management strategies for preventing and mitigating canid conflicts with landowners.

Objective 6: Determine genetic profiles of sympatric canids through DNA identification of all captured individuals, parentage, and presence of hybridization.

At the end of this 2.5-year pilot study, we will deliver an observational summary detailing the efficacy of the GPS and sensor technology for spatial and population dynamics research on sympatric canids on the AP.

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C. Expected Results and Benefits

As part of a pilot study, we will monitor the status of collared individuals by using a finer scale assessment of space and habitat use than previous studies. Earlier research focused on many of the same objectives we suggest investigating here, but during a time of intense, active management. Some active management techniques are no longer being carried out, although they may be reinstated, and dynamics between sympatric canids (some breeding pairs) are expected to have changed substantially outside of the national wildlife refuge system. The uncertainty regarding current dynamics presents a need for additional research to inform actions for the management of sympatric canids, whether or not active management techniques by the red wolf program resume in the future, and whether or not the Non-essential Experimental Population (NEP) boundary ("NEP boundary") for red wolves is constricted. Information gained from research may impact management rules and landowner's abilities to manage canids in some areas. Additionally, GPS technology has improved since earlier research was conducted allowing for more temporally detailed data collection and more nuanced analyses.

Understanding how sympatric canids collectively use resources in areas of human-dominated landscapes will allow wildlife managers to tailor management options to local conditions. On the AP, row crop agriculture and hunting represent the primary and secondary land uses, respectively. Row crop agriculture is a significant nutrient resource on the landscape and, as opportunists, canids may take advantage of such resources when they are available. Non-consumptive wildlife-driven tourism persists in all seasons and wildlife watching is a main draw for tourists in this area. For many tourists, the opportunity to see or hear large carnivores is the sole attraction for traveling to the AP. Information from this study will be provided to local constituents to establish a knowledge base regarding how sympatric canids use resources on private lands. Management and guidance could serve to prevent or minimize conflict while maximizing positive wildlife interaction opportunities for constituents. Development of a common understanding between wildlife managers and landowners based upon factual information is paramount for collaboratively achieving successful management of sympatric

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canids. The data collected in this pilot study is the foundation upon which this understanding and future management actions will be built.

The current level of hybridization between sympatric canids on the AP will be characterized using DNA gathered during this study. Body size exists as a continuum between coyotes and red wolves and has been documented as the most important factor for successful interspecific breeding pairs of these canids (Hinton 2014). Though both species have been found to use resources in similar manners, red wolves generally have more expansive home ranges and therefore may not use local resources as intensively as coyotes, depending on body size. Obtaining individual characteristics of study animals will allow managers, armed with spatial information, to infer how and why individuals in the canid species continuum exploit anthropogenic resources considering their anatomical and life history traits.

In conjunction with prior research, data collected in this study will contribute to knowledge on sympatric canid population dynamics on the AP. Estimating population size will allow managers to monitor population trends of sympatric canids and to examine the long and short-term impacts of different management strategies on their populations. While it is unknown whether sample size will allow for population estimation, obtaining relative abundance estimates for coyotes would provide wildlife managers with baseline data for monitoring changes in population abundance over time when paired with annual mortality estimates. Information on changes in abundance, reproductive dynamics, and habitat use could impact management strategies to influence long-term conservation outcomes. Results of this pilot study will allow managers to determine if future work will be necessary, what amount of effort will be required to achieve each objective, and if population estimates will be an attainable goal. Furthermore, data gathered on survival rates by age class, breeding success, litter size, mortality rates by age class, and relative abundance of sympatric canids during this project could contribute toward a two-species population viability analysis (PVA) model in development by USFWS staff, expanding upon the PVA previously performed for red wolf populations (Faust et al. 2016).

The collaborative approach NCWRC seeks to take in the initiation, implementation, and finalization of this project is as equally important as the data collection itself for red wolf

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conservation and recovery. Though the two agencies have varying missions and stances regarding canid management, we believe this pilot will serve to also lay the groundwork for an ongoing, inclusive, working collaborative relationship. Overcoming the history of each agency's stances and actions will be paramount to the long-term success of respective missions and canid management goals. Cultivation and maintenance of a collaborative relationship will help to foster trust between the two agencies and with the human population that reside within the AP, a portion of which may have established suspicious and negative views of state and federal agency activities, as well as guide ongoing research directions. Crafting an understanding between the differences and similarities of the two agencies missions and goals should help clarify where each agency can add value, initiate changes, and increase collaboration within and between each agency's missions and goals. A dynamic process that should continue to be instituted well beyond the scope of this pilot project.

Exploiting locally residing NCWRC field staff for development of relationships with landowners during the implementation of the project is an imperative goal for NCWRC. Engendering trust with landowners by practicing forthrightness, upholding landowner agreements in a transparent manner, and actively working with landowners on canid conflict issues is also significant for the long-term success of canid management on the AP. Dovetailing field operations during the trapping and den monitoring seasons, in addition to addressing landowner canid conflicts in a collaborative manner that involve suspected or known red wolves, with RWRP field staff would hopefully open minds and doors of previously resistant landowners to the value of the work that we are performing while expanding the data collection value of this pilot project (see Decision Trees in Attachment 4).

D. Approach

The current NEP boundary covers approximately 6,900 square kilometers within Beaufort, Dare, Hyde, Tyrrell, and Washington counties (Wildlife Management Institute 2014). The USFWS has proposed the NEP boundary be constricted to the ARNWR and the Dare County Bombing Range in Dare county by the end of 2017; the associated National Environmental Policy Act (NEPA) process for this recommendation is ongoing (J. Madison, personal

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communication, 2017). This study proposes to capture and radio-collar 20 coyotes, and their sympatric hybrids, within Dare, Hyde, and Tyrrell counties ("study area"); those counties being comprised of and adjacent to the center of the red wolf recovery effort at ARNWR. The thematic subheadings below provide detailed descriptions of the approaches required for achieving the pilot study objectives.

Sampling Efforts

Trained NCWRC personnel will conduct live trapping of sympatric canids, with assistance from the USFWS RWRP biologists, and trained, experienced local trappers. NCWRC and USFWS wildlife personnel will select local trappers. NCWRC staff will train contracted trappers on desired trapping methods before every trapping season. The project lead will supervise and coordinate all trapping activities including locations for installation and the operation of trap lines and handling of captured animals. Simultaneous personal trapping activities by contracted trappers will not be permitted while performing contracted trapping services, as specified in the draft service contract (Attachment 4).

Trapping efforts will follow a spatial capture-recapture (SCR) framework, where subsequent location "fixes" are considered "recaptures," with a systematic targeted sampling design. We will be focusing on areas that contain resources previously found to be used by sympatric canids (e.g. edge, agricultural fields, secondary roads, etc.) (Harris et al. 2013, Ivan et al. 2013), while attempting to sample a diversity of habitat types. Due to low population numbers, we will be avoiding areas with known red wolf breeding pairs and will be coordinating with RWRP staff during the trapping season regarding dovetailing our respective programs' trapping efforts. This effort will allow us to increase the probability of detection of sympatric canids on the landscape in a balanced approach that is sensitive to issues of the NEP (Tom 2012). While it is important to sample a wide range of habitats, the most important requirement for SCR is the number of collared individuals; this requirement provides flexibility in the other requirements for field sampling as needed (K. Pacifici, personal communication, 2016). We will initially focus trapping on non-federal properties where we have been granted access.

Trapping will take place during the breeding season when the likelihood of capturing

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females in the later stages of gestation or whelping females will be low. Capture efforts will be conducted from soon after 1 December 2017 – February 2018 and December 2018 – February 2019. Captured sympatric canids will be surrendered to NCWRC or the USFWS at capture sites (please refer to the decision tree in Attachment 4). Trapping should occur on both public and private lands to obtain sampling coverage of the study area. We will focus trapping efforts on private and state game lands that are accessible for trap and release ("capture") of sympatric canids. Unlike Dare County, there are ample non-federal lands that surround Pocosin Lakes NWR and Lake Mattamuskeet NWR in both Tyrrell and Hyde counties that may be utilized upon agreement from landowners to effectively sample individuals who may use those federal lands. Management activities on federal lands by non-federal wildlife professionals are subject to compatibility assessment and some level of NEPA (P. Benjamin, personal communication, 2017). Due to the timeline for achieving approval for such activities on federal lands with respect to the timeline of this project, we will not be pursuing federal land access. Scientific collection activities that take place on non-federal lands will require agreements outlining conditions mutually decided by NCWRC and landowners/managers (Attachment 3).

Hinton and Chamberlain (2014) tested the use of morphometric measurements to differentiate between coyotes, red wolves, and their hybrids in field, prior to genetic confirmation, with an 86% success rate in differentiation, consolidating 3 age classes [pups (>6 but <12 months old), juveniles (<2 but >1 years old), and adults (>2 years old)]. While coyotes and red wolves were correctly classified 98% and 99% of the time, hybrids were only classified correctly 13% of the time and were more likely to be misclassified as coyotes (61% of the time) (Hinton 2014). Four morphological measurements which helped establish reliable thresholds for coyote and red wolf classification in field were determined by regression analysis: hind foot length, weight, width of head, and tail length. The minimum measurements for red wolves represent the small end of adult female red wolves, while adult male red wolves would have significantly greater measurement values than the minimum thresholds. Due to the overlap in body size of hybrids, Hinton and Chamberlain (2014) found that their measurement values fall between the minimum measurement values for red wolves (i.e. small female red wolves) and the maximum measurements for coyotes (e.g. large adult male coyotes). Using the

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morphological thresholds discerned in Hinton's research, we define red wolves as those individuals that inclusively meet the minimum values for the following morphological measurements: 1) hind foot length (measured from the hock to the tip of the digital pads) greater than 21.5cm, 2) weight greater than 21.5kg (47.4lb), 3) width of head greater than 10.5cm, and 4) tail length greater than 35cm, or those individuals that have been previously tagged and whom RWRP staff are able to verify their genetic testing determination. Using those same morphological measurements, we define coyotes as those individuals that fall below the maximum values as set forth by Hinton and Chamberlain (2014): 1) hind foot length less than 19.5cm, 2) weight less than 19.5kg (43lb), 3) width of head less than 10.5cm, and 4) tail length less than 35cm. Due to the range of overlap in morphological measurements of hybrids with both red wolves and coyotes, we cannot easily define what a hybrid is by method of morphological measurements. Based on Hinton's findings, it may be likely that hybrids could be classified as coyotes more often than red wolves in field. Genetic determination post processing could help reclassify red wolves and coyotes as hybrids in some cases. However, in relation to in field practices, individuals that do not inclusively fall within either the red wolf or coyote morphometric thresholds and are not tagged will be treated as of unknown canid identity. Unknown individuals will await classification based on post processing genetic analysis, but will be collared and released post process following this projects' protocol.

Target canids will be captured by using Softcatch #3 Coyote 4x4 (Oneida Victor Inc. Ltd., P.O. Box 32398, Euclid, Ohio 44132, Hinton 2014, Schemnitz 1994), the EZ Grip #7 (Livestock Protection Company, P.O. Box 725, Alpine, Texas 79831, Frame and Meier 2007), or equivalent. Stakes or drags may be implemented depending on the field conditions, the advantages and disadvantages of which will be discussed at the time of installation. Because we will be selectively trapping for adult individuals, pan tension on traps will be set to approximately 6lbs as recommended by RWRP trapping Standard Operating Procedure (SOP) 6.1 (Red Wolf Recovery Program 2017a). Various lures and baits will be used to increase trapping efficiency (Frederick et al. 1989, Shipley 2012). Traps will be laid on the Monday of each week and will be opened at the time of deployment. Traps will be checked once daily at dawn, to reduce potential stress to trapped individuals and will not be operated on days where the temperature

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is expected to reach or exceed 80° F (R. Nordsven, personal communication, 2016) or during times of predicted inclement weather or hard freeze (e.g. snow, hail, high wind, etc., Sikes et al. 2011). To standardize effort and remain logistically realistic, traps should be open for three trap nights in a row before being removed or as determined necessary based on field conditions. Trap sets that have been closed due to non-target bycatch or other circumstances may be reopened and all traps should be re-baited and lured as appropriate, given the field conditions.

Trap set locations will be marked by NCWRC or USFWS personnel using handheld GPS units (Garmin GPSMAP 64S, 1200 E. 151st St., Olathe, KS 66062-3426) and given a sequential identification number. Traps will also be given an identification number and trap set points will be documented in ArcMap 10.4. Trappers will keep detailed records on trap set operation, non-target species trapped, and other relevant details. Non-target species will be released from traps after an in-field assessment of injuries, if any, and wildlife with life threatening injuries will be euthanized by the trap operator. Trapping effort will be quantified (trap nights), the effective sample area will be estimated, the encounter (detection) probability will be estimated using a Gaussian detection model (Amundson et al. 2014), and an estimate of density for coyotes will be calculated using a modified Huggins closed-capture estimator in program MARK, if sample size allows (Harris et al. 2013, Ivan et al. 2013).

Animal Handling

Handling of canids will follow American Society of Mammalogists (ASM) guidelines (Sikes et al. 2011) and will be performed at the capture site. Chemical immobilization agents may be used depending on the number of field staff during processing (i.e., three or more staff required during non-chemical immobilizations, Craft 2007, M. Morse, personal communication, 2016). For all red wolves of known or questionable identity, RWRP staff will be involved in processing activities as determined using the decision tree (Attachment 4) on a case-by-case basis. The decision trees were developed with respect to RWRP's need for decision making in what happens to red wolves and possible red wolves as well as to address issues that may affect landowners property rights, especially in relation to the treatment of domestic canids.

Chemical Immobilization

Unless adequate numbers of personnel are available to safely employ mechanical

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restraint techniques, target animals will be anesthetized with the chemical immobilization agent BAM (Wildlife Pharmaceuticals, Inc., Windsor, CO 80550). BAM, a combination of Butorphanol tartrate, Azaperone tartrate and Medetomidine HCl., will be delivered by intramuscular injection by syringe pole or hand injection (after being restrained by a catch pole) to the muscular masses of the hind quarters. Dosage for canids is based on field trails performed by Wildlife Pharmaceuticals (Wildlife Pharmaceuticals, Inc. 2016) and the recommended dose for coyotes is 0.2CC and red wolves is 0.3CC, with adjunct doses of 0.1-0.2CC delivered if initial dosages do not cause induction (S. Kirschner, personal communication, 2017). We may also follow the RWRP SOP 1.2 for live canid immobilization for captured red wolves of known or questionable identity (Red Wolf Recovery Program 2017b). Induction times for coyotes and wolves ranged from 5 to 10 minutes after initial and/or adjunct dosages (Wildlife Pharmaceuticals, Inc. 2016). The animals will be kept with minimal disturbance until the head is down and the animal is not responding to stimuli. The animals will be placed with the neck extended to ensure proper oxygenation and with the nose at a lower level than the rest of the head to minimize the risk of aspiration. After field handling is concluded, the anesthesia will be reversed using two reversal agents, Atipamezole and Naltrexone, at double the CC of Atipamezole to BAM that was delivered (including adjunct doses, if given) and 0.5CC of Naltrexone. Recovery time from the reversal agents ranged from 10 to 25 minutes during field trails (Wildlife Pharmaceuticals, Inc. 2016). Field personnel will observe animals from an appropriate distance for signs of adverse effects after reversal agents are delivered and to ensure the safety of the recovering animal.

Mechanical Immobilization

Unlike other carnivore families, the submissive behavioral response of canids to perceived dominance reduces the need to use immobilization agents. Appropriate mechanical restraint techniques can reduce handling time of animals, allowing animals to reintegrate into social groups more quickly, subsequently reducing overall stress to the individual (Powell and Proulx 2003). Target canids will be mechanically restrained with a restraint pole, until two muzzles can be placed around the snout. While pinned with the restraint pole by one person, a second person will restrain the set of legs not in the trap against the ground and a third person

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will release the foot from the trap. This set of legs will then be restrained by the 3rd person as the restraint pole is removed. Once the restraint pole is removed the person restraining the front legs will also then restrain the head. The first person will then move forward with processing the captured animal.

Each animal will be placed on a tarp (or similar) to provide thermal protection from the ground and reduce the risk of hypothermia, with eyes covered and lubricated with eye ointment as appropriate. Respiration and heart rate will be monitored to assess stress and pain in the animal. Temperature will be monitored with a rectal thermometer. Overheating occurs at approximately 104-105°F for canids (AZA Canid TAG 2012) and the animal handling crew will monitor temperature at 5-minute intervals; if a temperature reading reaches 104°F, corrective actions will be taken and temperature will be monitored at 1-minute intervals. Should overheating occur, the individual will be removed from insulation to expedite the natural evaporative cooling process and may be released or reversed (for those under chemical immobilization) if necessary. During days that approach 80°F in temperature, measures will be taken to reduce heat stress, such as: wetting the animal with water, application of a cold pack to the groin area between the back legs, application of rubbing alcohol to foot pads, or immediate release (AZA Canid TAG 2012). If the injured individual is suspected to be a red wolf, based on morphometrics, USFWS staff will be contacted for involvement. In the event that trap caused injuries are determined to be life threatening through use of a trap injury score assessment (Frame and Meier 2007) the individual will be euthanized by an AVMA approved method; if the injured individual is suspected or known to be a red wolf, USFWS staff will be contacted for involvement. Target animals will not be vaccinated or otherwise treated for infectious disease, regardless of the presence of disease signs.

Non-target animals will be released on site. Captured domestic animals will be immediately released from the trap set, followed by an injury score assessment to determine the presence of life-threatening injuries. Captured domestic animals will be handled in an agreed upon fashion as per pre-arranged agreement with landowners or organization, or as determined by landowner consultation. If a domestic animal has sustained life threatening injuries and owner identification information is present on the animal, then the animal will be

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transported to a local veterinary facility until the owner is able to retrieve it. If a domestic animal does not have a life-threatening injury and has identifiable owner information, field personnel will treat the minor injuries and attempt to contact the owners. Field personnel may transport the animal to the owners or to a holding facility as appropriate. The costs associated with injuries sustained to the animal will be the responsibility of the animals' owner. Law enforcement may be requested to help communicate with the animal's owner. If the animal does not have an identifiable owner and has incurred substantial life threatening injuries (i.e. compound fracture), the animal will be euthanized on site by an AVMA approved method. Domestic animals that do not have identification nor life threatening injuries may be released on site as per pre-arranged agreement or landowner consultation, or may be transported to a local animal shelter as appropriate. Trapped animals showing signs of rabies (e.g. circling behavior, head tilt, muscle twitches, convulsions with jaw chewing movements and salivation ("chewing gum fits"), disorientation, incoordination, staggering caused by paralysis of the hind legs, seizures, and partial or complete paralysis) will be euthanized and tested according to protocol set forth by the agency veterinarian, to determine if there may be a public health issue (M. Palamar, personal communication, 2016). USFWS will be contacted in cases of suspected red wolves, as USFWS retains decision making authority regarding euthanasia for red wolves (see Attachment 4). Staff involved in animal handling duties will have the pre-exposure rabies vaccination series completed prior to field work inception and will maintain rabies titer records through properly licensed medical services providers.

If staff is bitten and skin is broken by an animal while performing handling duties, they will wash the wound with soap and water and will be advised to immediately visit a local hospital or clinic for evaluation by healthcare professionals and for a rabies booster and titer. The field coordinator will immediately notify supervisory staff and an injury report and workers' compensation claim will be opened for the incident and the local public health department will be notified. The animal will be euthanized and the head will be sent to the state lab for rabies testing; the body may be sent to the Southeastern Cooperative Wildlife Disease Study (SCWDS) laboratory for additional disease investigation. If the animal is suspected or known to be a red wolf, it will be returned to USFWS staff to be held for observation for an appropriate amount of

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time according to medical recommendations by the health department.

Capture Processing and Marking

During canid handling, NCWRC personnel will record age class, sex, weight, total body length, head width, ear length, and tail length, visually assess ectoparasite load, look for and disinfect as needed any minor trap caused injuries, and affix GPS collars (Knick 1990, Sikes et al. 2011). All captured canids will be fitted with appropriately-sized GPS collars in the field based on morphometrics previously indicated as reliable thresholds for species categorization: hind foot length, weight, width of head, and tail length (Hinton 2014); analysis of DNA samples collected during trapping efforts will help to assign captured canids to a position along the species continuum post release. Age of individuals will be estimated based on physical characteristics, including weight and tooth replacement (Knick 1990, Hinton 2014, Gier 1968), and captured canids will be aged into one of three classes: > 2 years old as adults, < 2 but > 1 year old as juveniles, and > 6 months but < 12 months old as pups (Hinton 2014). Reproductive status will be determined based on estimated age class and presence of gonadal descent during the breeding season for males and the presence of nipple swelling or previous suckling for females (Hutson and Racey 2004, Magee 2008, Mengel 1971).

Captured individuals will be marked with an individually-numbered, glass-encapsulated, passive integrated transponder (PIT model HPT12, 12.5 mm, 134.2 kHz, Biomark, Inc., 703 South Americana Blvd., Suite 150, Boise, ID; Gannon et al. 2007), using a syringe-type implanter and replaceable needle (model MK10 [implanter], model N125 [needle], Biomark, Inc.). Successful PIT placement will be verified with a mini portable reader (model GPR Plus, Biomark, Inc.). The implantation site will be prepared by swabbing with 70% alcohol (Mrozek et al. 1995) and a sterilized new needle will be used for each injection. The standard implantation site for transponders is subcutaneously on the dorsal midline of the back, cranial to the shoulder blades (Ingwersen 2000).

A selection of hairs with the root bulla attached will be pulled from the belly and placed in paper envelopes (Janecka et al. 2007). Hair samples will serve as back up to blood samples for genetic testing. Genetic samples will be sent to the Laboratory for Ecological, Evolutionary and Conservation Genetics, at University of Idaho (875 Perimeter Drive, MS 1136, Moscow, ID

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83844) for genotyping to determine species as well as individual identification, hybridization presence, and parentage analysis following previously developed protocols (Adams et al. 2007, Hinton 2014, Miller et al. 2003). The appropriate genetic analyses that examine the coyote-hybrid-wolf species continuum will be performed.

Blood will be collected from all juvenile and adult target canids by venipuncture of the brachial or jugular veins using a 22-28-gauge needle (M. Palamar, NCWRC veterinarian, personal communication, 2016). As per NCWRC veterinarian recommendations, approximately 12 ml of blood will be collected for each animal for possible future testing for diseases of importance to sympatric canid species as well as the humans and domestic animals that they may come into contact with. An additional 1-2 ml of blood will be collected for genetic analysis. When possible, a minimum of 6 ml of whole blood with EDTA (lavender top tube) and 6 ml of blood for serum will be filled. Samples should be refrigerated at all times; a cooler with ice will suffice while in the field. Samples should be sent to the NCWRC within 48 hours; serum samples (from whole blood) can be centrifuged and the separated serum can be frozen. Skin scrapes will be collected from animals presenting signs compatible with sarcoptic mange (lesions) for diagnostic purposes. Lesions will be scraped until blood is drawn; the scrapings will be placed onto a slide and covered with a piece of clear tape for later visual confirmation. A set of sampling guidelines will be developed for reference while performing these activities in field.

Should overheating occur, processing will be performed in the following prioritization order and the first three items will need to be completed before releasing any individuals: 1) trap injury evaluation/cooling, 2) collaring, 3) DNA (blood) sample collection, 4) PIT tagging, 5) aging, 6) morphometrics, 7) weight, 8) reproductive status, 9) ectoparasite evaluation, 10) disease (blood) collection, and 11) skin scrape collection.

Collaring

Vertex Plus GPS Collars will be attached to 20 sympatric canids captured on the study area, 10 of which will be equipped with proximity sensors (Vectronic Aerospace GmbH, Carl-Scheele-Str. 12, 12489 Berlin, Germany). Project staff will pilot test proximity sensor technology for utility in analysis of spatial and temporal community dynamics. Proximity sensors trigger increased GPS location acquisition during those time intervals when two collared individuals

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462 come within a set distance from each other (http://www.vectronic-aerospace.com/wildlife-
463 monitoring/sensors/uhf-id-tags, accessed August 2016).
464 To avoid instances of collar induced strangulation, only adult (>2 years old) male and
465 female individuals will receive collars (Hinton 2014). ASM guidelines recommends a collar
466 weight of <5-10% of a canids bodyweight, we will observe these guidelines (Sikes et al. 2011).
467 Collaring of any red wolves, known or suspected individuals, will be determined by the USFWS
468 on a case-by-case basis using the collaborative process outlined in the decision tree
469 (Attachment 4).
470 GPS radio-collars will have both VHF and GPS Iridium locational systems as well as store-
471 on-board capabilities. Radio-collar units will be programmed to record GPS coordinates once
472 every 1.75 hours producing approximately 13 locations per day while cycling through the 24-
473 hour time cycle. These settings will allow for a GPS battery life of 300 to 552 days, averaging
474 431 days. The VHF beacon will be in operation from 0800 – 1600 hours daily. GPS locations will
475 be sent via satellite once per day and each transmission with contain 12 locations. The use of an
476 integrated drop off firing mechanism should allow the collars to drop off within a maximum of
477 approximately 548 days after deployment. The drop off schedule once set cannot be changed.
478 The drop off firing mechanism is wired to a battery unit independent of the collar battery,
479 therefore should the collar battery become depleted, the drop off mechanism will not be
480 affected (C. Akakpo, Vectronic Aerospace GmbH, personal communication, 2016). Unless a
481 collared individual is recaptured before the collar battery dies, the drop off mechanism will fire
482 at the scheduled time frame post collar deployment.
483 Observation of sympatric canid habitat use and movements will occur through GPS data
484 obtained with combination GPS/VHF radio-collars. VHF relies on triangulation, the process of
485 estimating the location of a transmitter by using two or more compass bearings obtained by
486 using directional antennas at known locations remote from the transmitter's position (White
487 and Garrott 1990), whereas GPS uses a satellite based system to obtain location coordinates.
488 There have been many published studies where one or both of these methods were used, with
489 mixed success for determining various aspects of carnivore ecology throughout the United
490 States (Hinton et al. 2012, Schrecengost et al. 2009, Sparkman et al. 2012). While GPS

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technology has developed rapidly in recent history, the real time functional advantage of VHF cannot be disregarded. When GPS technology falters or malfunctions, VHF can serve as replacement for data collection in addition to its use in real time monitoring of study animals. Canids will be minimally monitored for mortality approximately every 30 days by using VHF aerial telemetry techniques (Whitehouse and Steven 1977) as there may be a delay in satellite transmission of GPS location data due to weather, season, and animal behavior. Transient canids and individuals from breeding pairs that have lost a mate, have been found to use much larger areas versus paired residents, potentially increasing the opportunity for losing track of these individuals when GPS technology reaches its functional capacity or experiences malfunction. VHF data may also provide locations of canids in cover too dense for GPS units to function. Use of VHF telemetry techniques for data collection may be expanded as necessary for project needs.

Spatial Data Analyses

Both minimum convex polygon (MCP) and adaptive kernel (AK) home ranges (95%) and core use areas (50% and 25%) (Seaman and Powell 1996, Seaman et al. 1999) will be calculated from GPS data by using BIOTAS (Ecological Software Solutions LLC, 2016) and Geospatial Modelling Environment (Spatial Ecology, LLC, 2016) for ArcGIS 10.2.2 (Environmental Systems Research Institute, 2016) (Benson et al. 2006, Riley 2006, Tucker et al. 2008, Hinton 2014) for comparison to older studies. These estimations can also be calculated using VHF data, provided data minimum requirements are met. Spatial distribution in relation to habitat will also be estimated by dynamic Brownian bridge movement models as described by Hinton (2014) with R statistical software (R Core Team 2016) using the moveud package with habitat covariates important to each species (Bryne et al. 2014, Collier 2013, Kranstauber and Smolla 2013, C. Proctor, personal communication, 2016). Additionally, recent research into how canids shift their ranges will also be investigated for populations on the AP (Morin and Kelly, in review). Spatial overlap and co-occurrence will be assessed using methods described by Shipley (2012). Habitat and cover types will be estimated from digitized maps created by the SEGAP (Hinton 2014) or ortho files, as available (Shipley 2012). Percent composition of habitat and cover types within home ranges and core areas as well as edge density will be quantified (Shipley 2012). Habitat selection and cover type use effects on spatial distribution will be estimated at both the

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population (2nd order) and individual (3rd order) spatial scales using resource selection functions (Johnson et al. 2006, Manly et al. 2002, Shipley 2012). Effects of seasonality and time of day activity will also be explored. The spatial and temporal patterns of space use by sympatric canids will be studied using data generated from the interaction GPS collar sensors, particularly distance between individuals and duration of proximity.

Den Monitoring

Project staff will attempt to locate den sites for sympatric canids to get pup counts, morphometric measurements, age estimates, and blood samples. Pups will be weighed, measured, and PIT tagged during May and June of each year when they become active but are still den-obligated (Gier 1968). USFWS will be contacted in cases of known and suspected red wolf dens following the outlined decision tree process (Attachment 4).

Project staff will also attempt to monitor coyote and hybrid canid pup survival during the pup rearing season by using remote cameras placed around the den site (Harrison and Gilbert 1985, Parks 1979, Way et al. 2001). We will investigate the use of remote camera traps for monitoring den behavior with a two-camera array around the den (H. Garbe, personal communication, 2016, Kays and Slauson 2008). This method has been successfully used to monitor kit fox pup survival (Kluever et al. 2013). Because coyotes have been found to be sensitive to den site disturbance, there is a general lack of data in the literature regarding this approach for monitoring pup survival. Approaching an experimental methodology systematically will be important for determining which methods are effective and which are not. As a starting point for testing this methodology, remote cameras will be placed two to five meters from main den entrances and set to take photos using a passive infrared sensor trigger (a beam that when broken by movement through it, triggers the camera to take a series of photos) with a time restriction between photo intervals to limit the number of photos taken and maximize the space on the memory card for the time period between camera checks (Kluever et al. 2013). Cameras will be checked six days after deployment and will be redeployed (i.e. new batteries and memory card, if required); cameras will remain at each den site until radio-collar data indicates the den site has been moved (Kluever et al. 2013). Cameras will be not be redeployed to a new coyote den site during a season if that breeding pair has already

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moved the den once due to the disturbance of camera presence/deployment. This experiment may be abandoned if success rate is low and is found to interfere with other project objectives.

Mortalities

If a collared animal dies during the project, the carcass will be sent to SCWDS for necropsy. Red wolves will be turned over to USFWS staff to be sent to the FWS Lab in Madison, WI for necropsy, unless it is determined to be a law enforcement case. In potential red wolf law enforcement cases, the NCWRC Division of Wildlife Management Chief, USFWS Ecological Services Raleigh Field Office Field Supervisor, and the RWRP office in Manteo, NC will be contacted and requested to contact the appropriate law enforcement personnel, immediately after determining the need for law enforcement involvement. The carcass and all relevant information will then be turned over to USFWS law enforcement and the carcass will be sent to the FWS Lab in Ashland, OR; the GPS-collar will be removed from the individual prior to release to law enforcement.

Data Sharing

A compilation of spatial, capture, and den monitoring data will be provided to the collaborative USFWS partners at the end of the project. Spatial, capture, and den monitoring data may be shared with RWRP staff as part of the working collaborative field work process during the implementation of the project. State agency records are subject to the Freedom Of Information Act (FOIA) and requests for information related to this project, including project data, may be shared with requestees.

E. Project Personnel

Andrea Shipley has worked for the North Carolina Wildlife Resources Commission as a Canid Biologist since February 2016. Prior to that, she worked as a Wildlife Biologist for a non-profit located in northeastern Nevada as well as in several different field biologist oriented positions. Andrea has a background in carnivore and spatial ecology, having earned her MS in Biological Sciences from Eastern Kentucky University by studying bobcat spatial dynamics and BS in Biological Sciences from Rutgers University. Her previous experience trapping mesocarnivores in the southeast make Andrea well suited to serving as project lead and coordinator.

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Krishna Pacifici, Assistant Professor at NCSU, will be the quantitative analysis collaborator on the project. Krishna's background and experience in quantitative ecology makes him well suited to consult and assist with advanced statistical analyses of spatial data.

Lisette Waits, Department Head and Distinguished Professor at the University of Idaho, will be the DNA analysis collaborator for the project, responsible for all DNA related sample processing and subsequent analyses.

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F. Schedule and Estimated Costs

The project will run from soon after December 1, 2017 through June 30, 2020. The estimated timeline for major tasks is as follows:

Year 1: Initiate field work soon after December 1, 2017 with assistance from 1-2 field technicians; 1 technician will be required for trapping and den monitoring efforts. Data collection will begin immediately after collar deployment and data will be managed by Andrea Shipley throughout the life of the project. Data analysis will be initiated after den monitoring season concludes, with guidance and assistance from Krishna Pacifici at North Carolina State University (NCSU). Report, manuscript and presentation production will be initiated concurrently with data analysis.

Year 2: Continue field work and data collection with assistance from 1-2 field technicians. Continue data analysis with guidance and assistance from Krishna Pacifici at NCSU. Continue and finalize report and manuscript production, and presentation at professional working groups and/or meetings.

Year 3 (half year): Continue data analysis with guidance and assistance from Krishna Pacifici at NCSU. Continue and finalize report and manuscript production, and presentation at professional working groups and/or meetings.

GPS technology allows researchers to collect locational data at fine spatial and temporal scales through the deployment of collar units on wildlife study subjects. In this project, we propose to study a sample of sympatric canid populations with GPS radio-collars, in order to investigate the population parameters outlined in previous sections as well as species interactions. The purchase and use of this technology is critical to meeting the research

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objectives set forth in this document as well as in the document included in Attachment 1.

While GPS technology has evolved over the past 20 years, the cost of technology has plateaued. Upfront cost per unit remains relatively high, however project savings occurs at the back end when compared to older telemetry technology such as very high frequency (VHF) which require intensive labor to collect data at similar spatial and temporal scales. Pilot testing the proximity sensor enabled GPS-collars will allow investigation of the utility of this relatively new tool for community dynamics analysis by providing an increased locational data acquisition when individuals come within a set distance, or closer, from each other. Additionally, these sensors record the identities of the interacting individuals and the duration of their interactions. Using a trigger to temporarily switch GPS fix schedules will enable us to collect very fine scale data while conserving battery life, achieving project objectives in an efficient manner. Exploring the efficaciousness of this technology has the potential to positively impact future research projects requiring use of GPS-collars for data collection.

Aerial tracking will provide regular study animal surveillance useful to investigate cases of mortality, collar malfunction, or satellite data transmission delays, which can vary seasonally. In some situations, ground tracking could prove less expensive than aerial tracking. However, ground telemetry techniques require more than one biologist working in tandem to acquire accurate location estimates. This often translates to increased labor to collect data, particularly in large study areas. Aerial tracking will provide a more efficient and cost-effective method for surveilling study subjects in this large study area, requiring only one biologist and a contracted pilot. NCWRC personnel will perform aerial tracking along with the NCWRC pilot at a minimum frequency of every 30 days.

Use of local trappers to assist with sampling efforts provides several benefits. Local trappers have established, long-term relationships with private land owners, thereby providing access to private lands that might be otherwise difficult to secure. This will enable project biologists to obtain a representative sample of sympatric canids in the study area, as well as to operate more trap lines concurrently. This is particularly important when using a SCR sample design, as it will have direct implications on the resulting analyses and inferences.

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As part of collaboration efforts, the project will contract the services of Krishna Pacifici, Assistant Professor in the Forestry and Environmental Resources department at NCSU. Krishna's expertise is in quantitative ecology; consultation and assistance services provided will allow project biologists to make appropriate statistically relevant inferences from collected data.

DNA analysis will be contracted to Lisette Wait's lab at the University of Idaho. Lisette's team at The Laboratory for Ecological, Evolutionary and Conservation Genetics has previous experience in analyzing red wolf and coyote hybrid molecular samples and has the most comprehensive DNA methodology for this sympatric canid species continuum in the nation. This expertise will facilitate expedient species identification on collared study animals besides landscape level population dynamics analysis.

	Commission	In-kind	Total
a. Personnel	$ 9,360.00	$ -	$ 9,360.00
b. Fringe Benefits	$ -	$ -	$ -
c. Travel	$ 22,590.00	$ -	$ 22,590.00
d. Equipment	$ 53,655.00	$ -	$ 53,655.00
e. Supplies	$ 33,451.00	$ -	$ 33,451.00
f. Contractual	$ 329,031.00	$ -	$ 329,031.00
g. Construction	$ -	$ -	$ -
h. Other	$ 1,500.00	$ -	$ 1,500.00
i. Total Direct Charges (sum of a – h)	$ 449,587.00	$ -	$ 449,587.00
j. Indirect Charges	$ 6,444.00	$ -	$ 6,444.00
k. Totals (sum of i and j)	$ 456,031.00	$ -	$ 456,031.00
Federal (75%)			$ 342,023
State (25%)			$ 114,008

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G. Geographic Location

Three counties of the Albemarle Peninsula of North Carolina (Dare, Hyde, and Tyrrell counties).

H. Related Federal Projects

NC-W-F15AF00726 (W-72) NC-Division of Wildlife Management Cooperative Projects

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I. Glossary

Abundance: Species abundance is the number of individuals per species, and relative abundance refers to the evenness of distribution of individuals among species in a community.

Adaptive kernel (AK): A probabilistic home range estimator based on the distribution and density of locations that has been collected over a period of time.

Adverse reactions: In pharmacology, any unexpected or dangerous reaction to a drug.

Aerial: Existing, happening, or operating in the air.

Annually: Once a year; every year.

Anthropogenic: Caused or influenced by humans.

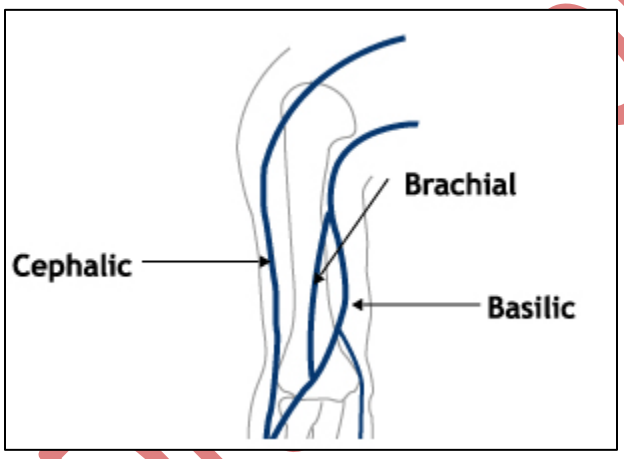
Apex: Having no natural predators in its ecosystem.

Ataxia: The loss of full control of bodily movements.

Beacon: A radio beacon whose purpose is the investigation of the propagation of radio signals.

Biopsy: The removal for diagnostic study of a piece of tissue from a living body.

Brachial vein: One of a pair of veins accompanying the brachial artery and uniting with each other and with the basilic vein to form the axillary vein.



Breeding pair: A pair of animals which cooperate over time to produce offspring with some form of a bond between the individuals.

Carrying capacity: The maximum population size of the species that the environment can sustain indefinitely, given the food, habitat, water, and other necessities available in the environment.

Compensatory immigration: Individuals emigrating from areas with lower mortality to those with higher mortality; filling a deficiency of individuals in a population experiencing higher mortality. The increase in size or activity of one part of an organism or organ that makes up for the loss or dysfunction of another.

Composition: The combining of distinct parts or elements to form a whole.

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Co-occurrence: Refers to observation of the spatial overlap between two (or more) different individuals over a period of time.

Coordinates: Any of the scales or magnitudes that serve to define the position of a point.

Core use areas: An area within a home range exhibited by a dense concentration of location points; commonly estimated at 50% of the location data points.

Covariates: A variable that is possibly predictive of the outcome under study.

Cranial: Pertaining to the cranium or to the anterior (in animals) or superior (in humans) end of the body.

Cryogenic: Very low temperatures, e.g. -80^{o}C.

Den-obligated: Restricted to a particular condition of life, in this case restricted to a den site.

Density: A measure of the number of organisms that make up a population in a defined area.

Deployment: To organize and send out (people or things) to be used for a particular purpose.

Depredation: The act of preying upon.

Depressed respiration: A decrease in the ability to exhale and inhale; respiration that has a rate below 12 breaths per minute or that fails to provide full ventilation and perfusion of the lungs.

Diagnostic: The process of determining by examination the nature and circumstances of a diseased condition.

Disorientation: Loss of one's sense of direction, position, or relationship with one's surroundings.

Distribution: The manner in which a biological taxon is spatially arranged.

DNA: (deoxyribonucleic acid) is a type of macromolecule known as a nucleic acid. It is shaped like a twisted double helix and is composed of long strands of alternating sugars and phosphate groups, along with nitrogenous bases (adenine, thymine, guanine and cytosine).

Dorsal: Situated on or toward the upper side of the body, equivalent to the back, or posterior, in humans; situated on or toward the posterior plane in humans or toward the upper plane in quadrupeds.

Duration: A continuous period of time.

Dynamic Brownian bridge movement models: Incorporates temporal and behavioral characteristics of movement paths into estimation of home range.

Ectoparasite: a parasite that lives on the outside of its host rather than within the hosts body; e.g. fleas and lice.

Effective trap area: Calculated by buffering each trap site by half the mean maximum distance traveled, each of these boundaries are dissolved, creating a measurable area.

Efficacious: Producing or capable of producing a desired effect.

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Efficient: Accomplishment of or ability to accomplish a job with a minimum expenditure of time and effort.

Euthanize: The act of putting to death painlessly or allowing to die, as by withholding extreme medical measures, a person or animal suffering from an incurable, especially a painful, disease or condition.

Expedient: Suitable for achieving a particular end in a given circumstance.

Evaporative cooling: reduction in temperature resulting from the evaporation of a liquid, which removes latent heat from the surface from which evaporation takes place.

Facilitate: Make an action or process easy or easier.

Genotyping: Investigate the genetic constitution of (an individual organism).

Gonadal descent: The act or process of descending from a higher to a lower location; testicular descent occurs during the breeding season annually.

GPS: Global Positioning System, is a radio navigation system that allows land, sea, and airborne users to determine their exact location, velocity, and time 24 hours a day, in all weather conditions, anywhere in the world.

Home range: an area over which an animal or group of animals regularly travels in search of food or mates, and that may overlap with those of neighboring animals or groups of the same species.

Hybridization: The result of mixing, through sexual reproduction, two animals or plants of different breeds, varieties, species or genera.

Immobilization agent: An active force or substance capable of producing an effect.

Implantation: To put or fix firmly.

Inbreeding depression: The reduced biological fitness in a given population as a result of inbreeding, or breeding of related individuals.

Inception: The establishment or starting point of an institution or activity.

Interspecific: Existing or occurring between different species.

Iridium: A satellite constellation providing voice and data coverage to satellite phones, pagers and integrated transceivers over the Earth's entire surface.

Jugular vein: Any of several large veins in the neck, carrying blood from the head and face.

Lacerations: A deep cut or tear in skin or flesh.

Locational: A position or site occupied or available for occupancy or marked by some distinguishing feature.

Malfunction: Fail to operate in the normal or usual manner

Methodology: A system of methods used in a particular area of study or activity.

Midline: A median line or plane of bilateral symmetry, especially that of the body.

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Minimum convex polygon (MCP): Completely enclose all data points by connecting the outer locations in such a way as to create a convex polygon.

Molecular samples: Genetic samples that may be used for investigation of genetic constitution of an individual.

Morphometrics: The process of measuring the external shape and dimensions of landforms, living organisms, or other objects.

Mortality: The state of being subject to death.

Non-target bycatch: Animals caught by accident that are not the target species being sought.

Parameters: A numerical or other measurable factor forming one of a set that defines a system or sets the conditions of its operation.

Parentage: The origin of something; the state or relation of a parent.

Passive integrated transponder: A microchip implant is an identifying integrated circuit placed under the skin of an animal.

Pinna: The external part of the ear in humans and other mammals; the auricle.

Plateaued: A period or state of little or no growth or decline.

Population dynamics: The branch of life sciences that studies the size and age composition of populations as dynamic systems, and the biological and environmental processes driving them (such as birth and death rates, and by immigration and emigration).

Population growth: The increase in the number of individuals in a population.

Population size: A group of organisms of the same species that live in the same area.

Population status:

Population trend: Changes over time and can include changes in ranging behavior and distribution, biogeography and life-history.

Population viability: The process that determines the probability that a population will go extinct within a given number of years.

Proximity: Nearness in space, time, or relationship.

Quantified: Express or measure the quantity of.

Quantitative: Relating to, measuring, or measured by the quantity of something rather than its quality.

Radio-telemetry: The use of radio waves for transmitting information from a distant instrument to a device that indicates or records the measurements.

Recumbency: The state of leaning, resting, or reclining.

Reintegrate: Restore (elements regarded as disparate) to unity.

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Remnant: A small remaining quantity of something.

Reproductive status: Relating to or effecting reproduction.

Spatial: Relating to, occupying, or having the character of space.

Spatial capture-recapture: A method commonly used in ecology to estimate an animal population's size. A portion of the population is captured, marked, and released. Marked animals are either recaptured or are tracked, each tracking location being considered a recapture.

Species Continuum: An aggregate of species capable of interbreeding, resulting in fertile hybrid offspring whose genetic composition may represent a varying array of phenotypes and genotypes from the parental species, at which the extreme ends of the spectrum are distinct.

Standardize: Cause (something) to conform to a standard.

Statistically relevant inferences: the process of deducing properties of an underlying distribution by analysis of data. Inferential statistical analysis infers properties about a population: this includes testing hypotheses and deriving estimates.

Stochastic population models: Ecological population modeling is concerned with the changes in population size and age distribution within a population as a consequence of interactions of organisms with the physical environment, with individuals of their own species, and with organisms of other species; stochasticity possesses some inherent randomness. In stochastic population models, the same set of parameter values and initial conditions will lead to an ensemble of different out puts.

Strangulation: The condition in which circulation of blood to a part of the body is cut off by constriction.

Stratifying: Form or arrange into strata, one of a number of portions or divisions likened to layers or levels.

Surveillance: Continuous observation of a place, person, group, or ongoing activity in order to gather information.

Survival: A living or continuing longer than, or beyond the existence of, another person, thing, or event.

Sympatric: Occurring within the same geographical area; overlapping in distribution.

Tachycardia: A heart rate that exceeds the normal resting rate. In general, a resting heart rate over 100 beats per minute is accepted as tachycardia in human adults.

Telemetry: See radio-telemetry.

Temporal: Of or relating to time.

Tooth replacement: The process of development of two successive sets of teeth, initially the deciduous set and consecutively the permanent set.

Transmitter: A set of equipment used to generate and transmit electromagnetic waves carrying messages or signals, especially those of radio or television.

Transponder: A device for receiving a radio signal and automatically transmitting a different signal.

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Vaccinate: Treat with a vaccine to produce immunity against a disease; inoculate.

Venipuncture: The puncture of a vein as part of a medical procedure, typically to withdraw a blood sample or for an intravenous injection.

VHF: Very high frequency is the ITU designation for the range of radio frequency electromagnetic waves (radio waves) from 30 MHz to 300 MHz, with corresponding wavelengths of ten to one meters.

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J. Literature Cited

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Attachment 1: Intra-service Section 7 Biological Evaluation Form

Region 4

INTRA-SERVICE SECTION 7 BIOLOGICAL EVALUATION FORM

[Note: This form provides the outline of information needed for intra-Service consultation. If additional space is needed, attach additional sheets, or set up this form to accommodate your responses.]

Originating Person: Allen Boynton

Telephone Number: 919-707-0069 **E-Mail:** allen.boynton@ncwildlife.org

Date: December 14, 2017

PROJECT NAME (Grant Title/Number): NC – Division of Wildlife Management Cooperative Projects / (W-79)

I. Service Program:

_____**Ecological Services**
__X__**Federal Aid**
_____**Clean Vessel Act**
_____**Coastal Wetlands**
_____**Endangered Species Section 6**
_____**Partners for Fish and Wildlife**
_____**Sport Fish Restoration**
__X__**Wildlife Restoration**
_____**Fisheries**
_____**Refuges/Wildlife**

II. State/Agency:

NORTH CAROLINA / NORTH CAROLINA WILDLIFE RESOURCES COMMISSION

III. Station Name:

FWS RALEIGH FIELD OFFICE, ASHEVILLE FIELD OFFICE

IV. Description of Proposed Action (attach additional pages as needed):

Conduct research project entitled "**Pilot Study – Using Fine Scale GPS Technology to Research Sympatric Canid Population Dynamics**"

This is a 2.5-year pilot research project on the efficacy of fine-scale GPS data collection and use of proximity sensors within the AP of North Carolina to improve North Carolina Wildlife Resource Commission's management of this species.

Objective 1: Use GPS collar and proximity sensor technology to test performance under various conditions and evaluate the frequency and accuracy of the scheduled fix rates.. *These data will be used to determine the efficacy of GPS and proximity sensor technology for collecting fine scale locational data throughout the study area.*

Objective 2: Use fine scale GPS data collection for investigating annual and seasonal spatial dynamics of sympatric canids: home range and core area sizes, amount of overlap in home range and core areas, movement pathways and daily activity patterns, and cover type selection and preference. *These data will be used to determine 1) the distribution of sympatric canids within the AP, and 2) determine habitat preferences to guide in habitat management and conflict management.*

Objective 3: Use fine scale GPS data collection for investigating the number and age structure of offspring for family groups of collared sympatric canids. *These data will be used to determine fecundity of sympatric canids.*

Objective 4: Use fine scale GPS data collection for investigating sources of mortality for sympatric canids. *These data will be used to assess sympatric canid survival.*

Objective 5: Use fine scale GPS data collection for preventing and mitigating canid conflicts with landowners. *These data will be used to develop strategies for improved conflict management.*

Objective 6: Determine genetic profiles of sympatric canids through DNA identification of all captured individuals, determine parentage of individuals, and assess the level of hybridization in each individual. *These data will determine the status of the sympatric canid species on the AP. Understanding gene flow between populations and potential hybridization between sympatric canids will be important in determining management objectives for coyotes.*

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V. Pertinent Species and Habitat:

A. Include species/habitat: This project

B. Complete the following table:

SPECIES/CRITICAL HABITAT	STATUS[1]
Red Wolf (*Canis rufus*)	T (on federal properties in study area)
Red Wolf (*Canis rufus*)	PT (on non-federal properties in study area)

[1]STATUS: E = endangered, T = threatened, PE = proposed endangered, PT =proposed threatened, CH = critical habitat, PC = proposed critical habitat, C = candidate species

VI. Location:

A. Statewide

Only on three counties in the Albemarle Peninsula of NC

B. Section, township, and range (or latitude and longitude):

Dare, Hyde, and Tyrrell Counties

C. Distance (miles) and direction to nearest town:

As stated above

D. Species/habitat occurrence:

The United States Fish and Wildlife Service (USFWS) released a non-essential, experimental population of captive-bred red wolves (*Canis rufus*) on the Alligator River National Wildlife Refuge (ARNWR) in 1987 (Hinton et al. 2013). This population increased until 2008 and peaked at around 130 individuals (Group Solutions, Inc. 2016), short of the recovery goal of 220 in the wild (USFWS Red Wolf Recovery Program 2013). The AP has an estimated carrying capacity of 140-150 wolves (Hinton et al. 2013, Kelly et al. 1999, USFWS Red Wolf Recovery Program 2007). The exact number of red wolves is not known, but USFWS staff report a population estimate of 25-40 individuals with six recorded mortalities in 2017 (J. Madison, personal communication, 2017). Though a rural area, human land uses occupy a significant portion of space on the AP. The AP is comprised of approximately 30% agricultural fields, 50% forest and coastal marshes, and 20% "other" land cover types on federal, state and private lands (Dellinger 2011). Dellinger et al. (2013) found that red wolves preferentially select for agricultural fields and early successional fields versus other land cover types they have been previously found to utilize when human density is low, e.g. pocosin, wetlands, pine plantations, and

lowland forests. However, this relationship inversed as human density increased (Dellinger et al. 2013).

VII. Determination of Effects:

A. Explanation of effects of the action on species and critical habitats in item V. B. (attach additional pages as needed):

SPECIES/CRITICAL HABITAT	IMPACTS TO SPECIES/CRITICAL HABITAT
Red Wolf	Trap induced injury is possible, e.g. foot trauma, thermal regulation issues, potential predation, and capture myopathy.

B. Explanation of actions to be implemented to reduce adverse effects:

SPECIES/CRITICAL HABITAT	ACTIONS TO MITIGATE/MINIMIZE IMPACTS
Red Wolf	Use of appropriate trap types, daily trap checks in the early morning, treatment of minor injuries, trapping season timing limitations and protocols for trapping which delineate when environmental conditions become inappropriate for continued trap operation, to minimize the potential for injury/stress to canids and/or target species. USFWS employees may be involved in trapping efforts to lend expertise and veterinary services are available in Manteo, NC for treatment of any injuries or other urgent medical conditions. No trapping of red wolves during February.

VIII. Effect Determination and Response Requested:

SPECIES/	DETERMINATION[1]			RESPONSE[1]
CRITICAL HABITAT	NE	NA	AA	REQUESTED
Red Wolf		X		Concurrence

[1] DETERMINATION/RESPONSE REQUESTED:

NE = No Effect. This determination is appropriate when the proposed action will not directly, indirectly, or cumulatively impact, either positively or negatively, any listed, proposed, candidate species or designated/proposed critical habitat. Response Requested is optional but a "Concurrence" is recommended for a complete Administrative Record.

NA = Not Likely To Adversely Affect. The determination is appropriate when the proposed action is not likely to adversely impact any listed, proposed, candidate species or designated/proposed critical habitat or there may be beneficial effects to these resources. Response Requested is a "Concurrence".

AA = Likely To Adversely Affect. This determination is appropriate when the proposed action is likely to adversely impact any listed, proposed, candidate species or designated/proposed critical habitat. Response Requested for listed species is "Formal Consultation". Response Requested for proposed or candidate species is "Conference".

_____ _____

Signature (originating station) **Date**

_____

Title

IX. Reviewing Ecological Services Office Evaluation:

A. Concurrence _____ Non-Concurrence _____

B. Formal consultation required _____

C. Conference required _____

D. Formal conference required _____

E. Remarks (attach additional pages as needed):

_____ _____

Signature **Date**

_____ _____

Title **Office**

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Attachment 2: Joint Memorandum

MEMORANDUM

November 20, 2013

TO: All Interested Parties

FROM: "for" Cynthia K. Dohner, Director, Southeast Region, U.S. Fish and Wildlife Service
Gordon S. Myers, Executive Director, N.C. Wildlife Resources Commission

SUBJECT: Collaborative Conservation of Red Wolves and Other Canids on North Carolina's Albemarle Peninsula

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Recovery of the federally-listed red wolf has been a priority for the U.S. Fish and Wildlife Service (FWS) for more than 20 years and is focused in North Carolina on the Albemarle Peninsula (AP; i.e., Hyde, Tyrrell, Washington, Beaufort, and Dare counties). Comprehensive stakeholder involvement and collaboration with other management agencies is critical to successful recovery of any at-risk species. The North Carolina Wildlife Resources Commission (WRC) is a key collaborator in this regard, as it has jurisdiction over all state-trust wildlife resources in N.C.

Since 2009, the FWS and WRC have worked to broaden our collaboration in the conservation and management of all canid species (including red wolves) on the AP. As these efforts have solidified, specific actions have been jointly identified by our two agencies that will improve conservation outcomes. These actions are categorized into five areas; collaboration, research, outreach, regulatory, and enforcement. Specific action items are outlined and prioritized within each of these categories in Attachment A.

This memo establishes the FWS's and WRC's commitment to initiate, or to continue, the efforts outlined in Attachment A. The common goal in this effort is to establish clear expectations and accountability for collaboration regarding the action items on Attachment A, thus resulting in enhanced and seamless canid conservation and management on the AP. This approach provides the best opportunity to achieve recovery goals for red wolves, while at the same time managing other canids to balance biological variables with social expectations. The dynamics of these canid species are complex and offer unique opportunities for innovation. Appropriate staff from each agency is hereby tasked with immediately developing a timeline to implement these actions. Through this commitment, we will continue to advance our collective conservation goals.

Attachment A

Action Items for Collaborative Conservation of Canids on North Carolina's Albemarle Peninsula (AP)
(*Note: Action Items are prioritized within category.*)

Collaboration

1. The N.C. Wildlife Resources Commission (WRC) and U.S. Fish and Wildlife Service (FWS) will formalize in writing the collaborative management of canids on the AP. This agreement should:
    a. include a clear mission statement, goals, objectives, and implementation strategies (ask and answer the "Why?");
    b. set a goal to define success regarding canid management on the AP;
    c. espouse a philosophy of canid management operating within the context of a three-legged stool (i.e., federal and state governments and stakeholders);
    d. as available, commit funding and staffing resources for field personnel to contribute to the conservation of the red wolf and management of coyotes;
    e. as available, commit funding to conduct research pertinent to canid management on the AP;
    f. establish polices and goals for developing a collaborative genetic archive for AP canids, a data sharing portal accessible by staff in both agencies, and reciprocal sharing of all historical data (including phenotypic and genotypic data and literature) of the red wolf;
    g. establish a foundation for developing and implementing an adaptive approach to canid management on private lands on the AP;
    h. initiate development of a collaborative canid research program;
    i. describe plans to conduct the next five year Red Wolf Program review;
    j. outline options for holding annual workshops with federal and state enforcement staff;
    k. outline plans to hold semi-annual coordination meetings regarding canid management on the AP; and
    l. develop milestones for future development of a management plan for all canids in the AP.

2. The FWS will initiate a review of the current Red Wolf Recovery Plan to determine if the state-of-our-knowledge or field conditions have changed such as to warrant its revision. Review and comments from the WRC will be considered in this evaluation.

3. The WRC, with support and participation of the FWS, will establish a "Canid Forum" (similar to that established for manatees in Florida) to facilitate communication and discussion regarding canid management and citizen science opportunities on the AP.

Attachment A

Research

1. The FWS and WRC will provide funding and logistical support for research identified by the Red Wolf Recovery Implementation Team, Red Wolf Program staff, other FWS staff, or the WRC that promote the conservation and recovery of the red wolf and other canids on the AP. Studies could include:
    a. tests of the "placeholder theory" on the AP, including behavior of sympatric canids,
    b. determining carrying capacity of canids on the AP,
    c. determining genetic profiles of canid species on the AP,
    d. evaluating predator-prey dynamics,
    e. studies of canid habitat use,
    f. epidemiology of diseases impacting canids on the AP,
    g. development of stochastic simulation models of sympatric canid population dynamics and habitat use, and
    h. canid dispersal dynamics

2. The FWS and WRC will conduct jointly-supported research to determine the attitudes and opinions of N.C. private landowners and other citizens concerning canids on the AP (i.e., human dimensions studies).

Outreach

1. The FWS and WRC will collaborate with other partners to design and implement broad-based outreach and marketing programs with clear goals, objectives, strategies, and measurable outcomes, including development of consistent agency messages and educating the public about canids on the AP.

Regulatory

1. The FWS and WRC will initiate a review and, if needed, subsequent rule-making to clarify concepts or rectify conflicts in current federal or state rules (including the current 10(J) rule).

2. The WRC will review and evaluate statutory requirements for listing red wolves as state threatened in the five AP counties.

3. As data demonstrating a relationship between coyote hunting and red wolf mortality become available, the FWS and WRC will evaluate, and if appropriate implement, adaptive approaches to regulate of take of coyotes that may result in incidental take of red wolves.

4. The WRC will evaluate the status, management, and regulation of Controlled Fox Hunting Preserves.

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Attachment A

5. The WRC will develop BMPs (due care provisions) for coyote hunting, trapping, and live sale.

6. The WRC will compile, compare, and contrast canid hunting and trapping regulations and programs in other states, including, but not limited to, other states with other species of wolves.

Enforcement

1. The FWS and WRC will develop coordination strategies to improve enforcement of federal regulations protecting red wolves.

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Attachment 3: Landowner Agreement Form

NC Wildlife Resources Commission
Wildlife Management Division
Wildlife Diversity Program
Landowner Agreement for Scientific Collection

_____ / _____ / _____
MM DD YYYY

Property Type
Private _____ Federal _____ State _____

NC Wildlife Resources Commission
Address: 1701 Mail Service Center, Raleigh, NC 27699-1701
Phone: 919-707-0010

Cooperator's Name: _____
Last First Middle

Cooperator's Address: _____
Street City, State, Zip

Where will the work be performed? _____

give address or directions if different from above _____

Business, Farm, Property Common Name _____

Owner's or Rep Name _____ _____
If different from Cooperator Telephone Number

Owner's Address: _____
If different from Cooperator Street City, State, Zip

WRC Employee & Work Location	Species
Employee Name	1)
	2)
Duty Area	3)
	4)

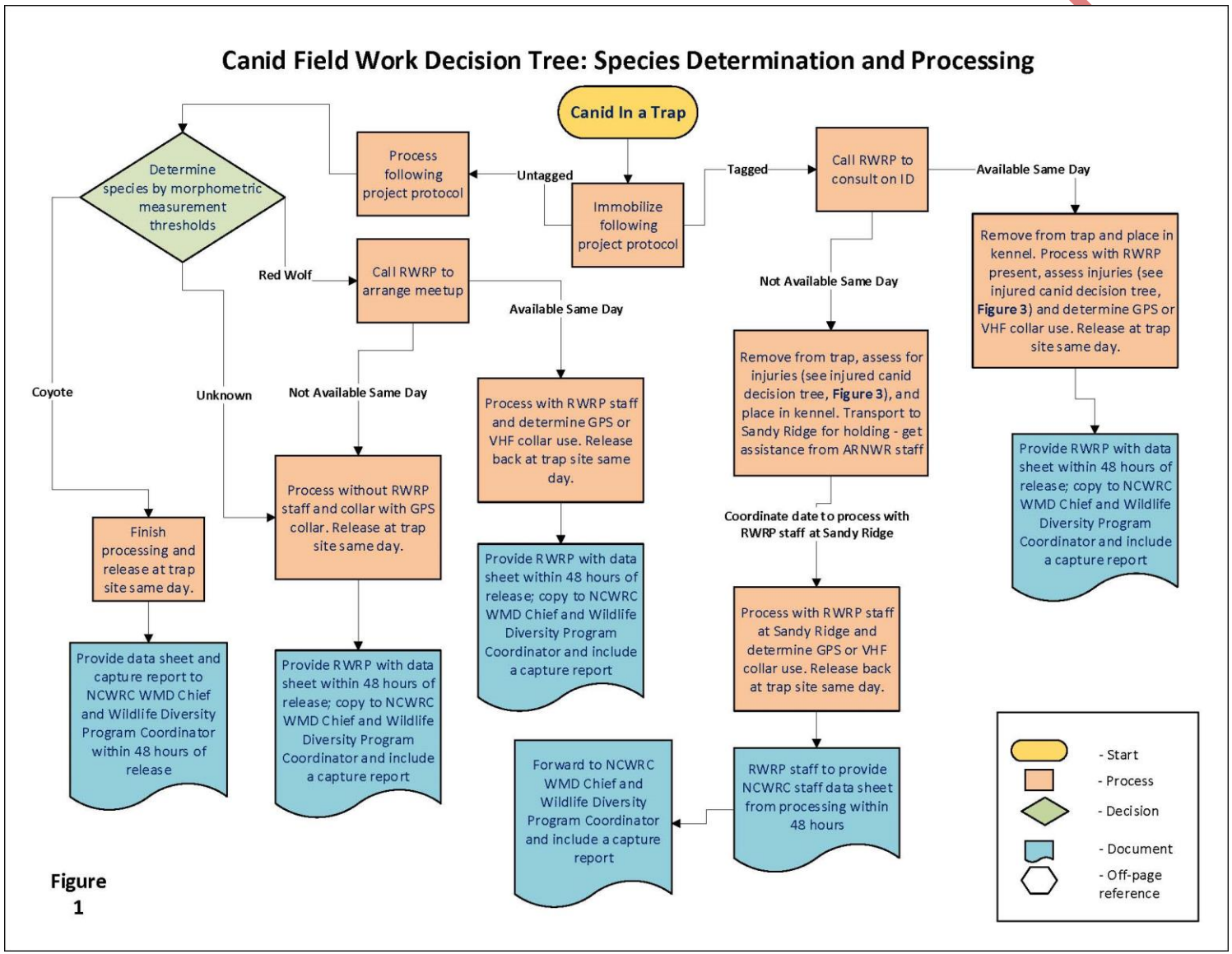
I, the cooperator or cooperator's representative, have been informed of the methods and the manner in which research devices will be used, and of the possible hazards associated with their use. I understand that NCWRC, (to include its officers, employees and agents) will: exercise reasonable precautions to safeguard all persons to prevent injury to target and non-target animals; guard against the mishandling of control devices and materials; and exercise due caution and proper judgment in all scientific collection operations. I understand that NCWRC may collect Global Positioning System (GPS) coordinates at the project site as part of component or activity tracking or as wildlife disease monitoring or research data. I, the undersigned cooperator, do hereby give my consent and concurrence to NCWRC, its employees, and its agents, to use, upon lands owned, leased, or otherwise controlled by me, and identified by this document, the following methods and devices (an attachment of additional devices and/or methods may be attached):

Statement of agreement: The landowner, cooperator, or representative, as listed above hereby give permission to NCWRC to perform trap and release of the species listed for scientific collection purposes. In consideration of these understandings, I, the cooperator or cooperator's representative, agree to: assume responsibility for injury to my property under my control, when said injury is not the result of negligence on the part of NCWRC (it's officers, employees, and agents); assist in maintaining such warning signs as NCWRC may place for the purpose of notifying persons entering onto such lands of the possible hazards associated with scientific measures in use thereon; and to give adequate warning of these possible hazards to persons I authorize to enter onto such lands. Further, I, the cooperator or cooperator's representative, agree not to concurrently use or allow to be used upon lands covered by this agreement, any canid depredation efforts during the scientific collection time period.

Landowner Signature/Date _____
Signature Date

WRC Employee Signature/Date _____
Signature Date

Attachment 4: Working Draft of Canid Field Work Decision Trees



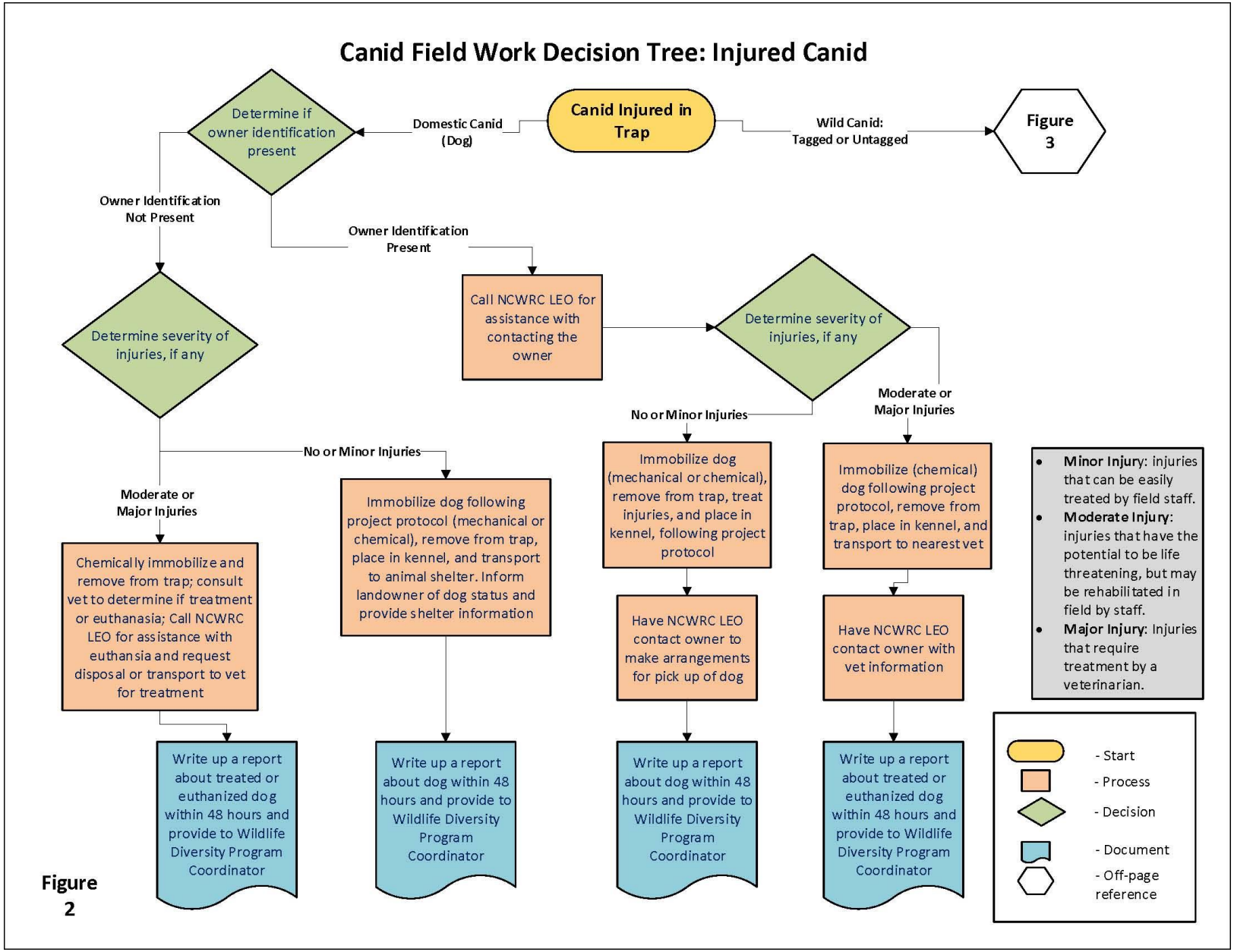


Figure 2

1019

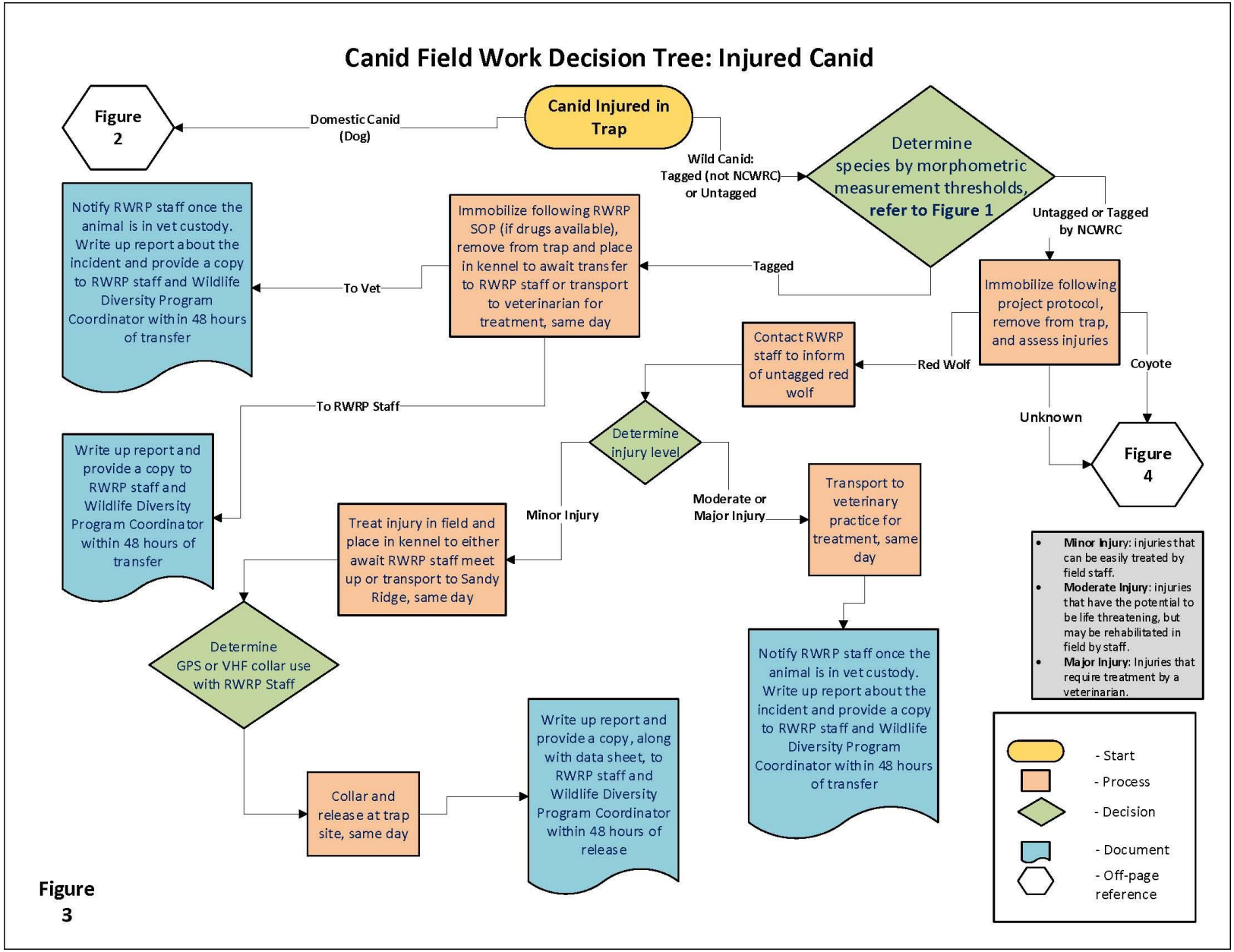


Figure 3

1020

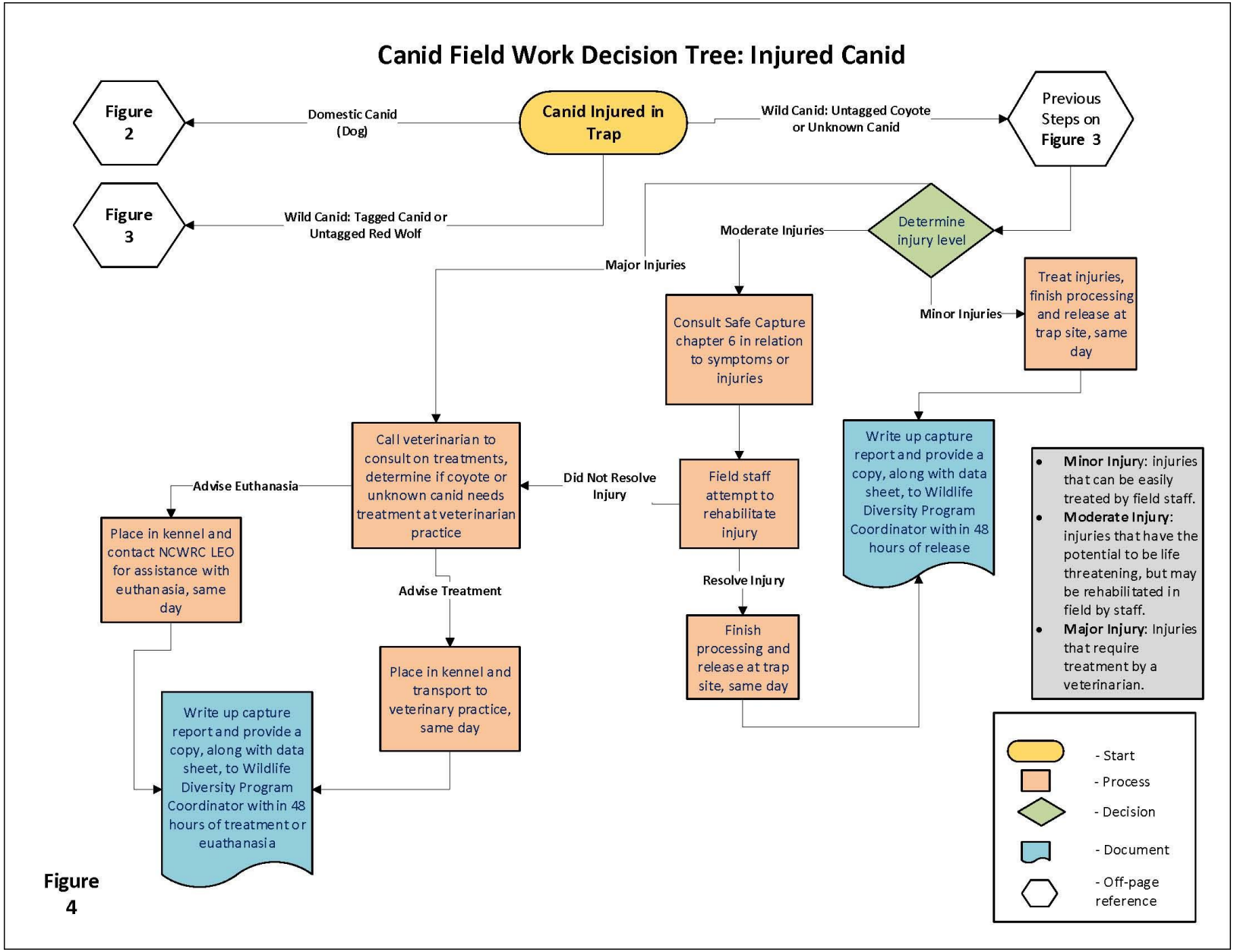


Figure 4

1021

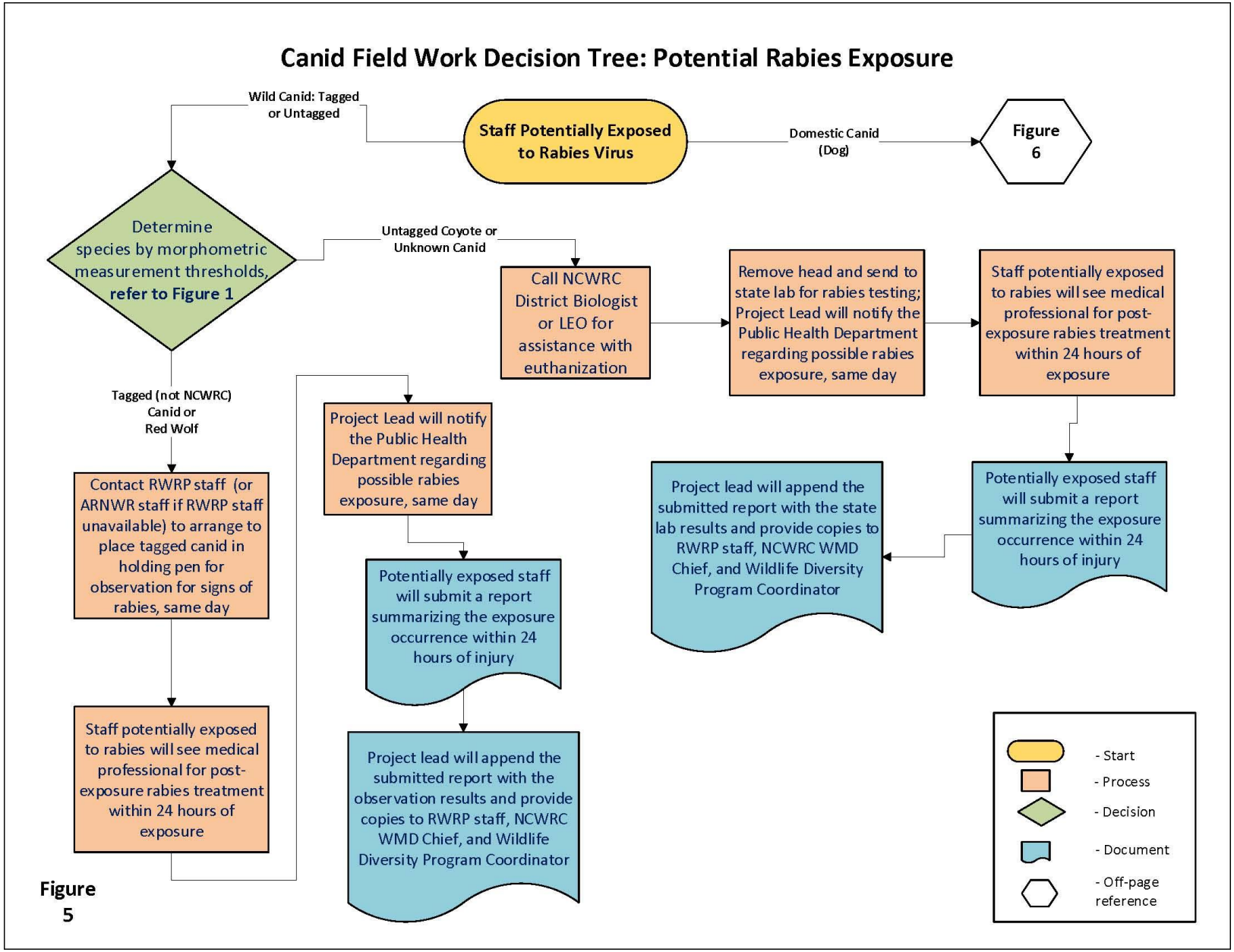


Figure 5

1022

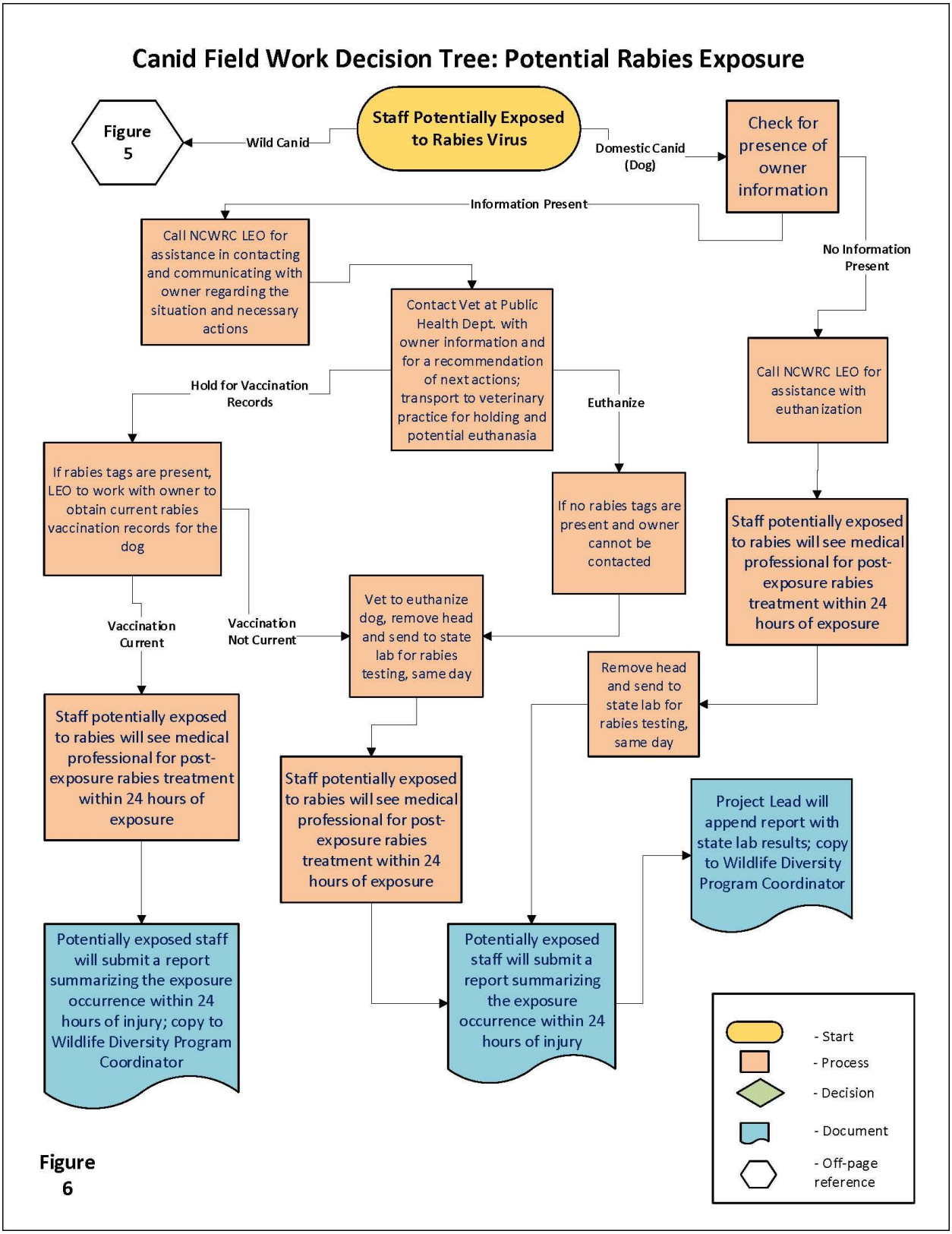

Canid Field Work Decision Tree: Potential Rabies Exposure
Figure 5
Staff Potentially Exposed to Rabies Virus
Wild Canid
Domestic Canid (Dog)
Check for presence of owner information
Information Present
No Information Present
Call NCWRC LEO for assistance in contacting and communicating with owner regarding the situation and necessary actions
Contact Vet at Public Health Dept. with owner information and for a recommendation of next actions; transport to veterinary practice for holding and potential euthanasia
Hold for Vaccination Records
Euthanize
Call NCWRC LEO for assistance with euthanization
If rabies tags are present, LEO to work with owner to obtain current rabies vaccination records for the dog
If no rabies tags are present and owner cannot be contacted
Staff potentially exposed to rabies will see medical professional for post-exposure rabies treatment within 24 hours of exposure
Vaccination Current
Vaccination Not Current
Vet to euthanize dog, remove head and send to state lab for rabies testing, same day
Remove head and send to state lab for rabies testing, same day
Staff potentially exposed to rabies will see medical professional for post-exposure rabies treatment within 24 hours of exposure
Staff potentially exposed to rabies will see medical professional for post-exposure rabies treatment within 24 hours of exposure
Project Lead will append report with state lab results; copy to Wildlife Diversity Program Coordinator
Potentially exposed staff will submit a report summarizing the exposure occurrence within 24 hours of injury; copy to Wildlife Diversity Program Coordinator
Potentially exposed staff will submit a report summarizing the exposure occurrence within 24 hours of injury
- Start
- Process
- Decision
- Document
- Off-page reference

Figure 6

-53-

agenda

Discussion of Collaborative Field Work Efforts

28 Nov 2017
10:00AM EST at Pocosin Lakes NWR Offices in Columbia, NC

Meeting called by: David Cobb

Attendees:

WRC - David Cobb, Kyle Briggs, Allen Boynton, Brandon Sherrill, Andrea Shipley

USFWS – Howard Phillips, Joe Madison, Art Beyer, Rebekah Martin, Michael Morse, Ryan Nordsven, Becky Harrison, Scott Lanier, Kelley Van Druten, Shaun Olson

Please read: Draft Sympatric Canid Project Proposal

Potential Topics for Discussion

Trapping coordination with FWS – dovetailing our efforts and areas to avoid

Trapping on private lands – landowner buy-in/relationship building

Trapping in the Texas Plantation area – existing landowner relationships?

Trapping on public lands: the Refuge Administration Act process

Section 7 b.e. – discuss effects of targeting RW vs. RW as bycatch

Draft sympatric canid project proposal – discuss any areas of concern

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Project Summary:

In 2013, NCWRC and USFWS established a committee to oversee the collaborative management and conservation of sympatric canids on the AP. A USFWS and NCWRC joint memorandum documented detailed action items for the joint management of sympatric canids on the AP, including specific research objectives which this proposal seeks to address. As sympatric canids on the AP increase in number, monitoring their movements, particularly in relation to individuals of differing ancestry, could provide important data to NCWRC and USFWS staff for science-based local and landscape-level decisions about sympatric canid populations and conflict management. Collection of finer temporal scale location data would help to manage interactions of sympatric canids with humans, as well as to support development of dynamic stochastic population models. At the end of this two-year pilot study, we will deliver an observational summary detailing the use of the GPS and sensor technology for spatial and population dynamics research on sympatric canids on the AP.

Job Opportunity

Position: W/F Conservation Technician I/II

Department: North Carolina Wildlife Resources Commission (NCWRC)

Division: Wildlife Management

Salary: Commensurate with experience

Appointment Type: Temporary (3 months) – December 2018 – February 2019

Office Location: Swanquarter, NC

Area of Work: Dare, Hyde, and Tyrrell counties

Housing: Field housing provided

Description of Work:

This position is responsible for assisting with NCWRC research efforts on coyote, red wolf, and other canids on the Albemarle Peninsula of North Carolina which includes Dare, Hyde, and Tyrrell counties. This position will work closely with NCWRC staff to effectively carry-out job responsibilities. Duties will include, but are not limited to, assisting with the capture of canids, collecting morphometric data, deploying GPS and/or VHF radio-collars, and conducting radio telemetry. Field work may require use of immobilization/euthanasia drugs or other techniques to restrain, capture, and/or handle live animals. Work may include wildlife disease/mortality investigations (including field necropsies) and collection of a variety of biological samples. Office work will include submission of administrative paperwork and data entry. Field work will be conducted in a variety of relatively remote habitats, including dense forests and rural agricultural areas. This position will require work in harsh weather conditions (e.g., rain, heat, humidity, cold, etc.) and frequent exposure to a variety of potentially irritating environmental factors (e.g., ticks, biting flies, chiggers, snakes, etc.).

Knowledge, Skills, and Abilities/Competencies:

- Ability to work as part of a team, but also work independently, and effectively coordinate and prioritize work assignments
- Ability to provide clear, timely, and effective updates to supervisor
- Knowledge of the principles and techniques of wildlife management, including knowledge of wildlife habitats and species requirements
- Ability to safely capture and handle wildlife
- Ability to accurately collect and log field data

- Skilled use of computers for word processing and information management
- Knowledge and ability to use basic wildlife research tools and equipment, including GPS, telemetry gear, and capture equipment
- Ability to operate and maintain equipment and vehicles (e.g., ATV, 4WD truck, boat, etc.) used in wildlife research
- Physical stamina to work outdoors for prolonged periods of time in adverse conditions
- Ability to work a flexible schedule, with potential night and/or weekend work

Minimum Education and Experience:

Associate's or Bachelor's degree in wildlife or fisheries management, zoology or biology from an appropriately accredited institution and one year of experience in wildlife or fisheries management; or an equivalent combination of education and experience.

Preferred Qualifications: Experience trapping and handling large carnivores.

From: maureen_foster@ios.doi.gov
To: charisa_morris@fws.gov; jim_kurth@fws.gov; russell_roddy@ios.doi.gov; james_cason@ios.doi.gov; gary_frazer@fws.gov; tasha_robbins@ios.doi.gov; virginia_johnson@ios.doi.gov
Cc: jean_parrish@ios.doi.gov; thomas_irwin@fws.gov; roslyn_sellars@fws.gov
Subject: Updated Invitation: NOTE: New title and agenda added -- Briefing on Pending E... @ Thu Feb 9, 2017 4pm - 5pm (tasha_robbins@ios.doi.gov)
Attachments: invite.ics

This event has been changed.
more details » <https://www.google.com/calendar/event?action=VIEW&eid=dGMxYWo2Zms5cmVsMjI3aG5ydnRycXVlMmcgdGFzaGFfcm9iYmluc0Bpb3MuZG9pLmdvdg&tok=MjYjbWF1cmVlbl9mb3N0ZXJAaW9zLmRvaS5nb3YzNDM2MjA0MzkwMDIzMjExZmQ2MjU0ZmZhYjlkODY5OTAyNjc0YmMx&ctz=America/New_York&hl=en>

Changed: NOTE: New title and agenda added -- Briefing on Pending ESA-Related Actions
Changed: Agenda:
-Notice of application for ESA sec 10 permit -- Hoopeston wind farm draft HCP
-ANPR and scoping notice -- revision to red wolf experimental population rule
-Comments on draft GAO report on ESA deadline lawsuits
-Invitation to speak at National Mitigation Banking Association meeting in March
-Heads up on separate upcoming briefings on litigation RE: Our recent habitat rules and an overview of the ESA
When Thu Feb 9, 2017 4pm – 5pm Eastern Time
Where 5112 (map <https://maps.google.com/maps?q=5112&hl=en>)
Video call https://plus.google.com/hangouts/_/doi.gov/maureen-foster <https://plus.google.com/hangouts/_/doi.gov/maureen-foster?hceid=bWF1cmVlbl9mb3N0ZXJAaW9zLmRvaS5nb3Y.tc1aj6fk9rel227hnrvtrque2g>
Calendar tasha_robbins@ios.doi.gov
Who • maureen_foster@ios.doi.gov - organizer
• tasha_robbins@fws.gov - creator
• charisa_morris@fws.gov
• jim_kurth@fws.gov
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• tasha_robbins@ios.doi.gov
• virginia_johnson@ios.doi.gov
• jean_parrish@ios.doi.gov - optional
• thomas_irwin@fws.gov - optional
• roslyn_sellars@fws.gov - optional

Going? Yes <https://www.google.com/calendar/event?action=RESPOND&eid=dGMxYWo2Zms5cmVsMjI3aG5ydnRycXVlMmcgdGFzaGFfcm9iYmluc0Bpb3MuZG9pLmdvdg&rst=1&tok=MjYjbWF1cmVlbl9mb3N0ZXJAaW9zLmRvaS5nb3YzNDM2MjA0MzkwMDIzMjExZmQ2MjU0ZmZhYjlkODY5OTAyNjc0YmMx&ctz=America/New_York&hl=en>
- Maybe <https://www.google.com/calendar/event?action=RESPOND&eid=dGMxYWo2Zms5cmVsMjI3aG5ydnRycXVlMmcgdGFzaGFfcm9iYmluc0Bpb3MuZG9pLmdvdg&rst=3&tok=MjYjbWF1cmVlbl9mb3N0ZXJAaW9zLmRvaS5nb3YzNDM2MjA0MzkwMDIzMjExZmQ2MjU0ZmZhYjlkODY5OTAyNjc0YmMx&ctz=America/New_York&hl=en>
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more options » <https://www.google.com/calendar/event?action=VIEW&eid=dGMxYWo2Zms5cmVsMjI3aG5ydnRycXVlMmcgdGFzaGFfcm9iYmluc0Bpb3MuZG9pLmdvdg&tok=MjYjbWF1cmVlbl9mb3N0ZXJAaW9zLmRvaS5nb3YzNDM2MjA0MzkwMDIzMjExZmQ2MjU0ZmZhYjlkODY5OTAyNjc0YmMx&ctz=America/New_York&hl=en>
Invitation from Google Calendar <https://www.google.com/calendar/>
You are receiving this email at the account tasha_robbins@ios.doi.gov because you are subscribed for updated invitations on calendar tasha_robbins@ios.doi.gov.
To stop receiving these emails, please log in to https://www.google.com/calendar/ and change your notification settings for this calendar.
Forwarding this invitation could allow any recipient to modify your RSVP response. Learn More <https://support.google.com/calendar/answer/37135#forwarding> .

United States Fish and Wildlife Service

RED WOLF RECOVERY PROGRAM
Post Office Box 1969
Manteo, North Carolina 27954

STANDARD OPERATING PROCEDURE (SOP)

Title: Processing and immobilizing a live canid
SOP Number: 1.2
Date: 31 October 2012

Exceptions: The only permissible exceptions to the procedure described herein are those specified under an approved separate study (e.g., via NC State College of Veterinary Medicine). Otherwise, deviations from this SOP will only be permissible by having a new version approved.

Background: Wolves and other canids are routinely captured and handled in order to collect biological samples and to facilitate the monitoring of free-ranging animals. It is imperative to ensure the safety of the animals while they are immobilized and processed. It is equally as important to ensure the safety of personnel during this process.

Purpose: This SOP describes the standard protocol by which personnel of the Red Wolf Recovery Program (Program) will handle, immobilize, and process a live red wolf or other canid. Two scenarios are discussed in regard to the use of Butorphanol and Dexmedetomidine.

Important Note: ***Remember that the safety of field personnel, followed by the safety of the animal, is paramount. If attempts to stabilize an animal under sedation are not successful, sedation and processing should be abbreviated or abandoned and the sedation reversed. Be prepared to physically restrain the animal.***

Procedure: It is important that all of your capture and processing equipment be with you and in working order, and that you have a working knowledge of what you are using ***before*** you set out to capture or handle a canid. While processing the animal, record all biological information, drugs administered, and other pertinent information on a processing sheet (Appendix A). However, do not risk the health or safety of a canid or yourself by taking time to write something down.

The following steps should be followed in the order given anytime a canid is captured or handled:

SUBDUE ANIMAL

Once you arrive on site, subdue the animal as quickly as possible. Rapidly subduing the animal will minimize potential injuries, hyperthermia, and other stress-related conditions as the animal attempts to escape. If chemical immobilization will be required, draw up the immobilizing drugs and reversal drugs prior to subduing the animal (see # 2 under Chemical Immobilization - Scenario 1 below).

1. Snatch- or catch-poles are effective in subduing an animal that is restricted in movement. They provide a fair amount of safety to the handler but can be dangerous to the animal if used improperly:

    a. If they are not maintained or are worn, the cable may not release properly after it has been tightened around the animal's neck. Test the catch pole each time before it is used. Keep a good pair of wire cutters on hand in case the cable does not release.

    b. Once tightened around the animal's neck, the cable may restrict the animal's ability to breathe. If there is ***any*** reason (e.g., a panicked, open-mouth response; pawing at the mouth; gasping; lack of breathing; pale or bluish gums and tongue; or unconsciousness) to suspect that the animal's breathing is impaired **IMMEDIATELY** relax the cable. Try to place the "ball" of the snatch pole, rather than bare cable, at the level of the trachea.

    c. Damage to the neck muscles and/or vertebrae may occur if the animal is thrashing, if the pole is used to drag the animal, or if the pole is used to subdue an animal that has a wide range of movement. If these scenarios occur, use other methods described below to subdue the animal.

2. Large salmon nets are effective in subduing an animal that has a wide range of movement or when there is a high probability that the animal may escape before it can be subdued and immobilized. A netted animal often maintains control of its head and mouth, so take care when removing animals from the net, particularly if no immobilization drugs have been used.

3. A pin-stick (Y-bar) or other device to control the head or pin the animal down may be used. Pin the animal down from the back of the neck.

4. An animal should be darted only if physical restraint is impossible (refer to SOP 1.3 Darting).

IMMOBILIZATION OF ANIMAL

Once subdued, the animal should be immobilized immediately. Both ***Chemical Immobilization*** and ***Physical Restraint*** are addressed below. Individual judgment should be exercised in

determining whether physical or chemical immobilization is appropriate. Chemical immobilization should not be used (or used with extreme care) in the following situations:

1. Avoid using drugs to immobilize pregnant or lactating females.

2. Avoid using drugs on animals that you suspect for any reason to be sick. Sedation will make it more difficult for a veterinarian to diagnose any problems and could complicate medical issues. Sedation **should** be used if animals are injured but not sick. In such cases, immobilization will decrease the likelihood that the animal's injury will become worse with handling.

3. Avoid using drugs on animals that you suspect to be hypothermic (< 99º F), especially if the animal appears to be in shock. Drugs alone may lead to hypothermia and they may compound the problem if the animal is already cold.

Chemical Immobilization

Chemical immobilization is a very effective means of restraining an animal for extended periods of time, allowing a greater degree of safety for the handler and a lower level of stress for the canid during processing. ***DO NOT LEAVE A SEDATED ANIMAL UNATTENDED AT ANY TIME***. It is also very important when using chemical immobilization that you understand what the particular drugs are used for, how they work, and the dosage used. You **must** have the necessary drugs on hand for reversing immobilization and for addressing emergencies. All drugs (including emergency drugs) must be within their expiration date. ***See protocol on using drugs or vaccinations on pregnant or lactating females and pups*** (Appendix C).

Scenario 1: To provide enough sedation to immobilize an animal so that it may be removed from a trap and released or kenneled for transport to another location.

1. Estimate the animal's body weight to determine dosages for immobilization drugs. Your estimate should be within 5 lbs. on most animals. Once the animal is adequately immobilized, it should be weighed for accurate dosing of other drugs.

2. Draw up doses of immobilization drugs and reversal drug(s) and label the syringes. Immobilization drugs should be drawn into a syringe and combined before the animal is restrained or subdued. Administer Butorphanol at a dose of 0.4 mg/kg (0.18 mg/lb.) body weight and Dexmedetomidine at a dose of 0.04 mg/kg (0.018 mg/lb.) body weight, delivered intramuscular (IM) in the same syringe (see Appendix B for dosing amounts). Atipamezole, the reversal agent for Dexmedetomidine, should be drawn up at 0.2 mg/kg (0.09 mg/lb.) body weight (see Appendix B for dosing amounts). This reversal agent should be drawn up before immobilization drugs are administered. If this procedure is followed, reversal agents will be always be ready in case any complications develop.

a. Administer the initial doses of immobilization drugs as soon as possible after the animal is subdued. Note the time of administration.

b. Allow 15-20 minutes for full sedation. If the animal is extremely agitated, onset of sedation may be prolonged and extent of sedation may be lessened. It is important that all external stimuli, including noise, be minimized. Cover the animal's eyes if possible. **Do not leave the animal unattended at any time.**

c. If additional sedation is required following the 15-20 minute induction period, administer **only** Butorphanol IM at ½ the original Butorphanol dose. Note the time of this supplemental administration.

3. Once the animal is under sedation, pull the tongue out to help insure an open airway. If the airway cannot be secured this way, intubate. Use the largest endotracheal tube possible, gently inflate the cuff and secure to the top of the muzzle using gauze or similar material. Be prepared to deflate the cuff and remove the tube when you administer the reversal drugs or the animal recovers.

4. Monitor vital signs of the animal during sedation **every 5 minutes**. When assessing vital signs, it is important to look for trends in measurements, not just pinpoint values. The following vital signs should be checked and addressed if abnormal:

a. Maintain an open airway and check the respiratory rate. Normal rate is 10-30 breaths/min. Animals will likely pant if they are hyperthermic and should be allowed to do so, especially if body temperature is > 104º F. If the respiratory rate is below 8 breaths per minute, or if breathing is very shallow, the wolf should be manually stimulated. If this is ineffective in increasing respiratory rate or depth, the animal should be reversed with the calculated dose of Atipamezole as well as Naloxone at 0.02 mg/kg (0.009 mg/lb.) (see Appendix B for dosing amounts). If the animal STOPS breathing, see *Medical Emergencies* section at the end of this document.

i. Determine that the heart is beating by feeling between the ribs. Continue to monitor heart rate by feeling between the ribs or by palpating the femoral pulse. Femoral pulses should be strong. Capillary refill time (CRT) should be less than two seconds and the gums should be pink. If the animal appears to be in shock, see *Medical Emergencies* section at the end of this document. This drug combination may cause the heart rate to slow considerably. If the heart rate slows to 40 beats per minute or less, administer reversal agents (Atipamezole and Naloxone) and reassess heart

rate. Be prepared to physically restrain the animal. If the animal's heart STOPS beating, see *Medical Emergencies* section at the end of this document.

ii. Monitor body temperature. If body temperature falls below 99º F or above 104º F, implement procedures to warm or cool the animal as appropriate (See *Medical Emergencies* section at the end of this document). Consider drug reversal if attempts to stabilize the temperature are unsuccessful (particularly if the animal is cold and does not warm up). Be prepared to physically restrain the animal.

5. Once it is determined that the animal is stable, apply Paralube or similar eye lubricant to both eyes. Covering the eyes with a towel or cloth will not only protect the eyes but often keeps the animal calmer during sedation and recovery.

6. Before placing the animal into a kennel for transport, administer Atipamezole IM in order to reverse the Dexmedetomidine. **Do not transport an animal that is fully sedated**. Wait until the animal is no longer ataxic and can hold its head up before transporting. If the animal is still not alert enough for transport 10-15 minutes after Atipamezole administration, Naloxone may be administered IM in order to reverse the Butorphanol.

Scenario 2: To provide enough sedation to process an animal in the field and release the animal when completed.

Follow step 1-6 above for administering an initial dose of Butorphanol and Dexmedetomidine (see Appendix A) and additional Butorphanol if needed. ***Do not leave the animal unattended****.*

1. If additional down-time is needed or the animal is responsive to painful stimuli, administer Ketamine at a dose of 1 mg/kg (0.5 mg/lb.) IM or intravenously (IV) (see Appendix B for dosing amounts). It is best that Ketamine be administered 30-40 minutes after the initial injection of Butorphanol/Dexmedetomidine, but it may be administered earlier.

2. Monitor vital signs of the animal **every 5 minutes** (refer to # 4 under Scenario 1).

3. Prior to releasing the animal, administer Naloxone IM and Atipamezole (see Appendix B). If Ketamine was administered, wait at least 30 minutes after the **last** injection of Ketamine before reversing Butorphanol and Medetomidine. If more than two additional injections of Ketamine were given, wait at least 45 minutes after the **last** injection before reversing Butorphanol andDexmedetomidine.

4. Wait a minimum of five minutes after injection of Naloxone and Atipamezole before releasing. Many animals are fully reversed in five minutes and almost all should reverse within 10-15 minutes. The animal should show increased alertness. **Do not release the animal if it still appears sedated or uncoordinated**.

NOTE: The amount of each drug administered should be recorded on the processing sheet, along with the time of each administration, date, and animal ID number. Be sure this information is passed along to the individual responsible for tracking scheduled drugs.

Physical Restraint

Physical restraint can be effectively applied by using a muzzle and restraining all four legs with rope. **DO NOT LEAVE AN ANIMAL UNATTENDED**. An apparently subdued animal could suddenly break free and run off, possibly with a muzzle, snatch-pole, or injury.

1. Make sure the animal can breathe adequately. Continue to monitor this during the entire handling event.

2. Check for shock. Though we rarely come across it, shock is potentially life threatening to the animal. If an animal appears to be in shock, see *Medical Emergencies* section of this document. Signs of shock include:

    a. CRT > 2 seconds.

    b. Mucous membranes are pale, cold and dry.

    c. Cool extremities.

    d. Unresponsiveness or sluggish behavior.

3. Obtain a body temperature. If it is within normal range (99º F - 104º F), recheck in 5 minutes to determine if it has decreased or increased to hyper- or hypothermia. Watch for a trend and continue monitoring throughout the handling process. If body temperature is not within normal range, treat accordingly before proceeding (see Medical Emergencies below).

PROCESSING - For each point below, note the appropriate information on the processing sheet (Appendix A) as soon as possible.

1. Check the animal thoroughly for any leg fractures, dislocations, or any other medical condition requiring veterinarian care. If so, kennel it IMMEDIATELY and transport it to the veterinarian to receive treatment.

2. Note the general condition of the animal including coat quality, body fat, and tooth wear.

3. Obtain a body weight. Make sure that the rope is secure and that the animal's head will not hit the ground if the rope slips.

4. Note the ID number of the animal. This number may be found by scanning for a transponder chip, checking a radio collar, and/or looking for an old tattoo. Transponder chips may migrate under the skin, so scan the entire body. Once identification is established, one can determine which procedures need to be performed and if the animal needs to be processed.

5. If the animal has no identification or has not been processed in the past 24 months, it should be placed into a dog kennel and transported for processing.

6. Look inside the mouth for any lodged sticks or similar items. If there is anything lodged or stuck, it will need to be removed on site or by a veterinarian.

7. Administer vaccinations IM:

    a. Administer rabies vaccination if > 90 days have elapsed since the last administration.

    b. If the animal has received three 8-way vaccinations or less, repeat 8-way vaccination ONLY if it has been ≥14 days since the last administration. If the animal has received at least four vaccinations total, administer vaccine only if >90 days have elapsed.

8. Draw blood from a cephalic (foreleg) vein or saphenous (hind leg) vein. Fill one purple top EDTA tube (collect at least 2ml) and one 10 ml red/grey top serum separator tube. Label each tube with the animal's ID, if known, and the date. Store both tubes in a cooler and keep cool until the blood is processed (see SOP 1.4 Blood Handling). A heartworm test, using blood from the EDTA tube, should be performed as soon as possible to determine whether to administer Ivermectin.

9. Ivermectin may be administered for heartworm prevention **only** if the canid is heartworm negative and **only** if >30 days have elapsed since the last Ivermectin administration. Administer Ivermectin at a dose of 0.09 mg/lb. SQ.

10. Place a radio collar on the wolf at this time if applicable.

    a. Remove the magnet and test the collar to be sure it is working.

b. Record the frequency and serial number of the collar on the processing sheet.

c. If the animal is ≥ 45 lbs. place a mod-500 collar on it. If it is < 45 lbs. and ≥ 35 lbs. place a mod-400 collar on it. If it is <35 lbs. and ≥25 lbs. place a mod-315 on it.

d. Ensure the collar is secure enough that it cannot be pulled over the canid's head but loose enough so that it does not restrict breathing. With younger animals, a judgment call will need to be made in order to allow for some growth or a winter coat.

e. Tighten the collar nuts securely but DO NOT over tighten since you could break the bolts.

f. Cut off the extra belt but DO NOT cut through the antenna. Leave enough of the belt to include the last set of holes in case the collar can be adjusted later.

11. If no transponder chip was detected, inject one SQ between the shoulder blades. Palpate to make sure the chip is underneath the skin, and test it with the reader. Record the number on the processing sheet and save the label to be attached to the sheet.

12. Obtain body measurements.

13. Check the entire body for ectoparasites. Spend one minute on the body and one minute on the head. Record the type and number found on the processing sheet.

14.

15. Before releasing an animal, check the processing sheet for anything that may have been missed.

DOCUMENTATION

1. Fill out the processing sheet (Appendix A) as soon as possible.

2. Within 24 hours (ideally the same day), route the original sheet to the individual(s) responsible for entering data, or enter all data into the temporary files on the computer for proofing.

MEDICAL EMERGENCIES

Shock

Treatment for shock:

1. Administer 500-1000 ml lactated ringers IV through a catheter, and run fluids full open. If you cannot hit a vein, administer SQ. Avoid over-hydration as it could lead to fluid in the lungs. You can determine this by checking the gums or tongue for CRT and moisture. CRT will have returned to normal and the mucous membranes will be moist. Also, listen to the lungs with a stethoscope if possible. Fluid in the lungs may produce a crackling noise.

2. Administer dexamethasone sodium phosphate IV (see Appendix B for dosing amount). This can be administered through the IV line if one is established.

3. Ensure a clear airway. If the animal is unresponsive, intubate and use an Ambu bag if available, or pull the tongue out and continue to monitor breathing. If intubating, use the largest endotracheal tube possible, inflate the cuff gently and secure to the top of the muzzle with gauze or similar material.

4. Seek veterinary care for the animal ASAP. Any canid recovering from shock should be held at least overnight.

Body temperature complications

If **hyperthermic** (>104º F) or you notice a rapid increase in temperature leading to hyperthermia, cool the canid in one or more of the following ways:

1. Submersing in water is a quick way to reduce body temperature.

2. Apply water to ventral surface, especially under the legs and groin. Fan vigorously to aid in evaporation.

3. Administer lactated ringers solution IV through a catheter. This will rapidly cool temperature and is helpful in treatment or prevention of shock.

4. Apply alcohol to the foot pads and inside of the ears. If the animal is sedated, applying alcohol inside the ears could stimulate the animal.

5. Administer a cold water enema. Although effective this makes it difficult to monitor rectal temperature.

6. Administer dexamethasone IV (see Appendix B for dosing amount & Appendix C for contraindications).

If **hypothermic** (< 99º F) or you notice a rapid decrease in temperature leading to hypothermia, warm the animal using one or more of the methods below. Finish the handling event as soon as possible. Reversing an animal from sedation will allow it to produce more heat. Be sure to check for shock. If the animal is in shock, avoid warming the extremities and focus on warming the animal's core, and address the situations described for shock above. Within reason, treatment of shock supersedes treatment of low body temperature - shock needs to be treated promptly.

1. Apply heat packs under the legs against the body. Avoid warming the extremities quickly, especially when the animal is in shock.

2. Wrap the canid in a blanket/coat/etc. to conserve body heat. Rub vigorously.

3. Keep the animal inside a truck with the heater if it is immobilized. DO NOT chemically immobilize an animal in order to hold the animal in the truck.

4. If the animal is under sedation, administer reversal agents.

Respiratory Distress or Arrest

1. Check for anything obvious that may be blocking the airway, including the tongue or foreign material in the throat. Look around the mouth and nose as well as within the mouth.

2. If Medetomidine and Butorphanol were administered, administer the reversal drugs Atipamezole IV and Naloxone IV (rather than usual IM route) (see Appendix B for dosing amounts).

3. Intubate and use an Ambu bag to provide artificial respirations. If unavailable or unable to intubate, lay the canid on its side and compress the chest.

4. Administer Doxapram IV (see Appendix B for dosing amount).

Cardiac Arrest or Distress

1. If Medetomidine and Butorphanol were administered, administer Atipamezole IV and Naloxone IV (rather than usual IM route; see

Appendix B for dosing amounts).

2. Administer atropine IV or IM, only after Dexmedetomidine has been reversed (see Appendix B for dosing amount).

3. If the heart has stopped, administer Epinephrine into the heart (see Appendix B for dosing amount). If unable to hit the heart, administer IV.

Approved:

_____ _____

Coordinator Date

WOLF PROCESSING

ID # _____ Date _____ Time _____ Obs. _____

Recent Recapture ___ Dead ___

Freq._____ Serial # _____ 315___ 400___ 500___ Freq checked ___

Capture Location _____ Capture UTMs _____

Capture Method _____ Foot Caught: LF LR RF RR Damage Score _____

Drug	Amt.(ml)	Adm.	Time	Temp.	Comments
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

8-way ___y ___n
Rabies ___y ___n
Fecal Sample ___y ___n
Blood Sample ___y ___n
Ectoparasites _____

Ivermectin _____ml
Transponder # _____ New ____
Fecal Results _____
Heartworm results ____Neg ____Pos

Body Measurements (**cm**) Initials _____

Tail _____ Body _____ Hind foot _____ Shoulder _____ Ear _____

				L	W
Weight _____kg _____lb			Front Foot Pad	_____	_____
Upper canine width	_____		Hind Foot Pad	_____	_____
Lower canine width	_____		Skull	_____	_____
Body Condition Score	_____		Genitalia	_____	_____

Dentition wear: ___none ___slight ___moderate ___heavy Est. age: _____

Comments: _____

_____

_____

_____

_____

Trap damage score:
1 = none **2** = swelling @/below trap jaw **3** = <2.5cm cut **4** = >2.5cm cut **5** = swollen above trap jaw **6** = simple fracture above toes **7** = compound fracture above toes

DRUG DOSAGE CHART

The dose for each drug is:
Butorphanol @ 0.4 mg/kg or 0.18 mg/lb ..... Naloxone @ 0.02 mg/kg or 0.009 mg/lb
Medetomidine @ 0.04 mg/kg or 0.018 mg/lb ..... Atipamizole @ 0.2 mg/kg or 0.09 mg/lb

The dose for each antagonist is:

		Body Weight (lbs)/ml adm. IM											
Drug	**Conc. mg/ml**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**	**75**	**80**
Butorphanol (*Torbugesic*)	10	.45ml	.55ml	.65ml	.7ml	.8ml	.9ml	1.0ml	1.1ml	1.15ml	1.25ml	1.35ml	1.45ml
Naloxone (*Narcan*)	0.4	.55ml	.7ml	.8ml	0.9ml	1ml	1.15ml	1.25ml	1.35ml	1.45ml	1.6ml	1.7ml	1.8ml
Medetomidine (*Domitor*)	1	.45ml	.55ml	.65ml	.7ml	.8ml	.9ml	1.0ml	1.1ml	1.15ml	1.25ml	1.35ml	1.45ml
Atipamezole (*Antisedan*)	5	.45ml	.55ml	.65ml	.7ml	.8ml	.9ml	1.0ml	1.1ml	1.15ml	1.25ml	1.35ml	1.45ml
Ketamine	100	.13ml	.15ml	.18ml	.2ml	.23ml	.25ml	.28ml	.3ml	.33ml	.35ml	.38ml	.4ml

Following an induction time of 15-20 minutes, if additional sedation is required administer Butorphanol @ ½ the original dose.
If additional time is needed or the animal is responsive to painful stimulus, administer Ketamine IM or IV @ 1 mg/kg or .5mg/lb.
This dose of Ketamine may be repeated 2-3 times.

Telazol: 5mg/lb body weight - dosage depends on concentration

Body Weight(lbs)	(.33ml/lb) ***Dexamethasone** Shock	(.037ml/lb) #**Atropine** Bradycardia	(.05ml/lb) **Dopram** Resp.Arrest	(1mg/ml) **Epinephrine** Cardiac Arrest
20	6.6ml IV	0.7ml IV	1.0ml IV	**0.1-0.2ml**
25	8.9ml IV	0.9ml IV	1.3ml IV	into heart
30	10.7ml IV	1.1ml IV	1.5ml IV	(1:1,000)
35	12.4ml IV	1.3ml IV	1.8ml IV	or
40	14.2ml IV	1.5ml IV	2.0ml IV	**1.0-2.0ml**
				into heart
				(1:10,000)

***** this dose is for shock; use 1/4 dose for stress
# can also be used for excess salivation

Drug	Concentration (mg/ml)	Dosage (mg/lb)	Method of Administration
Ketamine	100	2	IM
Telazol	100-500	5	IM
Yohimbine	2	.05	IM(IV)
Atropine	0.54	0.02	IM(IV)
Dopram	20	1	IV
Dexamethasone	3	1	IV
Epinephrine	1		IC

DRUG PROTOCOL FOR FEMALES & PUPS

	Ivermectin.	Corticosteroids (dexamethasone)	Telazol & But/Med	8way	Rabies
Pregnant Females	OK	**NO**	**NO**	**NO**	OK
Lactating Females	OK	OK	**NO***	**NO**	OK
Pups under normal age for vacc.	**NO****	na	**NO**	ok @ approp. age: 6 weeks for 8-way 16 weeks for Rabies	

***** best if it can be avoided, though we used Telazol once on female w/3 day old pups and came out ok; best if canid given time to metabolize drugs before returning to pups

****** wait until 5-6 weeks of age before administering Ivermectin

Justification:

Corticosteroids (dexamethasone) administered to pregnant females may cause an abortion

Any immobilizing drugs administered, particularly to pregnant females, could kill the pups so certainly avoid if possible; with lactating females, if you have to administer drugs, try to give the canid time to metabolize the drugs before returning to the pups

Page 2; 51: Maybe a short discussion on specifically what types of property damage is being referred to here? There are very few livestock operations on the AP, so depredation rates on livestock is relatively low. Wolves have been involved in very few depredation incidents over the years, and I'm not sure what other types of property damage sympatric canids would potentially cause? Most of the complaints we receive tend to be simple presence of canids on private property or a perceived reduction in observed game populations, which of course are not property.

Page 2; 54-55: Has there been any research done to analyze direct predation of canids on at risk ground nesting species as compared to potential benefits of canids through the control of other known nest predators?

Page 2; 57-59: In addition to collaborative research, the joint memorandum also instructs NCWRC to "review and evaluate statutory requirements for listing red wolves as state threatened in the five AP counties", to "evaluate, and if appropriate implement, adaptive approaches to regulate the take of coyotes that may result in incidental take of red wolves", and to "evaluate the status, management, and regulation of Controlled Fox Hunting Preserves". Just out of curiosity, what is the current status of these regulatory directives?

Page 3; 86-89: As part of the justification for this research the proposal states "Earlier research focused on many of the same objectives we suggest investigating here, but during a time of intense, active management. Specific management techniques are no longer being carried out and dynamics between sympatric canids are expected to have changed substantially."

Should specify what dynamics are expected to have changed. I would contend that management and the resulting dynamics on ARNWR, and Milltail particularly, have not changed significantly at all. This pack recently had similar GPS-collar based data gathered by DOT a few years ago, and I don't feel much if anything would be gained by replicating this research. We should continue to use our own VHF radio collars on the Milltail pack as the battery life lasts much longer and we can continue to monitor them as we always have, and not have to subject them to the frequent trapping for recapture and subsequent handling and processing outlined by this proposal. The joint memorandum from 2013 states that any research conducted should "promote the conservation and recovery of the red wolf and other canids on the AP." In the case of the Milltail pack especially, I think the potential risks far outweigh any potential benefits gained.

Page 4; 102-103: What information will be passed to whom specifically? I'm not sure it would be in the best interest of red wolf recovery if location information were to fall into the wrong hands.

Page 5; 132-136: This may be based on a false assumption as it is my understanding that the "federal lands only" alternative was not supposed to be our proposed alternative without first going through the NEPA process, which we are doing now. We don't yet know what the proposed alternative is going to be.

Page 6; 157: If "the most important requirement for SCR is the number of collared individuals" as stated, there is no need to initially focus trapping efforts in areas of known red wolf packs. Coyotes tend to utilize smaller home ranges than do wolves, and therefore would likely populate a particular area in higher numbers than wolves. In that sense, a greater number of collared animals may well be achieved outside of areas of known red wolf packs as long as trapping was conducted in productive habitat. Also, the premise of this proposed research is to target sympatric canids and not specifically target either species. It therefore seems contradictory and biased to initially target known red wolf packs through trapping efforts. I would suggest instead focusing on areas that known wolf packs have occupied in the past but now, due to mortality and lack of management over the last few years, the pack no longer

exists, leaving an area of unknown species composition (Mattamuskeet Ventures and Texas Plantation Gamelands are good examples). This would assist not only with the proposed research, but would provide an additional programmatic benefit of learning the species composition in current zones of ignorance. Targeting areas with known red wolf packs does not provide the additional benefit of learning species composition of an area (it is already known), and replicates data collection that has already been done. As stated above, I have concerns about targeting areas of known wolf packs, and feel the risks outweigh the potential benefits, especially since there are so few (only 3 known breeding pairs) left on the A.P. We don't need to further jeopardize them.

Page 6; 159-161: We typically wait until January to trap areas with potential red wolf puppies present in order to allow them to grow, minimizing risk of trap injury. Also, February is breeding season for wolves, and it is not a good idea to disrupt known red wolf pairs at this time, especially with the ever-present risk of injury that trapping inherently presents.

Page 6; 162-173: Releases should occur as close as possible to where the animal is trapped to avoid altering behavior and to avoid unnecessary risk to the animal attempting to get back home. This has been a recurring issue the last two or three years as the WRC has insisted that captured animals be released on ARNWR regardless of where they were captured. These releases need to happen at or near the capture site, even if that land is state owned or private property (with landowner permission), in addition to federal lands. Refuge compatibility could obviously be another issue. Also, the statement "it is most important to be able to trap and release on Alligator River NWR and the Dare County Bombing Range as those encompass the newly proposed RWRP recovery area" is based on an inaccurate premise as we have not selected a preferred alternative yet so we have no official proposed recovery area.

Page 7; 182: Are traps staked or are drags used? Both can work but appropriate equipment must be used to avoid stakes being pulled out of the ground, which often leads to the death of the captured animal. Make sure appropriate shock springs and swivels are used as well to minimize injury potential. An additional thought – make sure all trappers have secure kennels to place animals in while waiting for processing to occur. It is best to remove a captured animal from a trap as soon as possible to minimize potential injury, overheating, and escape, so have the trappers place the animals in a secure kennel right away. You'd be surprised at some of the flimsy wire cages some of them carry for this purpose. Others have used duct tape on the legs and muzzle – obviously not a good idea. Have a protocol in place for this.

Page 7; 187-190: Traps should also be covered or rendered inoperable during a hard freeze. A leg-hold trap cuts off blood circulation to the foot and can lead to frozen tissue during a hard freeze. This can lead to amputated toes and even feet.

Page 8; 215-219: We already have a protocol in place for chemical immobilization of red wolves developed by NCSU Vet school. We have used it for decades now on wolves and coyotes and there is no need to change it. Also, a syringe pole is not necessary. Simply restrain the head with a noose pole and inject with a regular syringe.

Page 9; 250-254: USFWS needs to be notified any time a red wolf is captured, injured or not, and should make the decision as to whether injuries are sufficient to euthanize the animal.

Page 9; 256-257: Red wolves absolutely should be vaccinated upon capture and treated for any diseases or illnesses present. I would recommend vaccinating coyotes before release as well. Remember the stipulation for collaborative research in the 2013 joint memorandum, that research identified should "promote the conservation and recovery of the red wolf and other canids on the AP." The wild red wolf population is far too small to be taking any unnecessary risks.

Page 10; 276-282: These animals do not automatically need to be euthanized, especially red wolves. The proposed research protocol already requires that any potential handler be vaccinated for rabies. Also, any previously captured wolf or coyote on the A.P. has already been vaccinated for rabies and other canid diseases. Animals can be quarantined for a period of time but euthanasia is not necessary.

Page 11; 298-310: Why are ear tags necessary? I would think a GPS collar that emits a VHF signal plus a PIT tag would be sufficient for identification. Also, we should use Trovan PIT tags to remain consistent with the ones already deployed on the A.P. Speaking of which, it would make more sense to use a radio-collar frequency range consistent with what is already deployed on the A.P. Not having the right set of gear when needed, or having to constantly switch between two separate sets of gear will prove to be problematic .

Page 11; 311-315: Skin biopsies are also not necessary. Genetic information can be collected from blood samples and sent to Lisette as proposed, and as we have always done. There is a protocol already in place for this.

Page 12; 332-335: Animals showing signs of mange should be held and treated for mange before release to avoid spreading it to surrounding canid population, particularly red wolves. Again, conservation of the species needs to be priority number one.

Page 12; 336-340: In the event of overheating, priority must be cooling/ensuring survival of the animal. After that assess any injuries, radio-collar, draw blood. Then weights, measurements, etc.

Page 13; 354-355: In regards to the VHF signal, we really need to continue using the 164-165 mHz frequency range already being used for canids on the A.P. While regular GPS locations may be sufficient for research purposes, there is often a need for RWRP personnel to be able to track canids in real time (depredations and other complaints, reports of injuries, den locations, telemetry flights, etc.) It is not practical to carry two separate sets of telemetry gear at all times (especially when thick vegetation or when walking long distances), or to gear aircraft with two sets of antennas, or to constantly have to switch between two sets of gear when time is a factor. There are many field-based scenarios where utilizing two sets of gear would be problematic at best. Previous researchers (including the ones cited in this proposal) utilizing VHF or GPS collars on canids for data collection within the red wolf recovery area have always used frequencies consistent with ours to help alleviate these problems.

Page 13; 358: I would set the VHF beacon to operate beyond 1600 hours daily. You occasionally run into situations (depredations or complaints for example) that require the need to track animals in real time beyond 1600 hours. Ours are set on 12 hour rotations – 0700 to 1900 (0800 to 2000 during daylight savings).

Page 14; 378: A flight every 30 days is not going to be enough to determine cause of mortality should the GPS function fail. We already fly between 50 and 100 times a year to monitor red wolves, I'm not sure an additional 12 is going to benefit anything.

Page 15; 411-412: We already do den work on red wolves. The dens should not be disturbed more than once so any data collected must be in conjunction with USFWS. With fewer than 25 red wolves currently known to exist in the wild, the survival of each and every pup is vital, so no unnecessary risks will be taken. Time spent at the den must be minimal to minimize the disturbance. Skin biopsies are not necessary. We collect a blood sample for genetics and that should suffice. I'm not sure if morphometric measurements are necessary but if done it must be completed quickly. PIT tags are implanted for future identification. We use Trovan and would prefer to keep this consistent with the canids already on the A.P.

Page 15; 413-432: Cameras at a red wolf den site are a bad idea. We have attempted the use of them a couple of times in the past. One time it caused a visible disturbance when the adults returned, and the other time it resulted in puppy deaths when the female would not re-enter the den. Again, each and every red wolf pup is vital. If attempts want to be made to experiment with cameras at den sites, use them at coyote dens but not wolf dens, at least until more is known about potential disturbance (2 to 5 meters is likely too close). Another issue with these cameras is that wolves, and likely coyotes as well, will typically move the pups to a new den site very soon after a disturbance. In the type of habitat found on the A.P., den sites are usually located in vegetation so thick cameras may be ineffective, and any human visit to the site is going to cause an unavoidable disturbance.

Page 16; 435: Red wolf carcasses go to the lab in Madison, WI as they always have. LE cases go to Asheland, OR. Coyotes can go to SCWDS.

Page 16; 436-442: We notify LE after every red wolf mortality. They decide if it will become an LE case and if they need to take possession of the animal. LE also probably won't allow genetic samples to be taken from animals they need to take possession of for evidence.

Aside from the specific concerns addressed above, I am also concerned by the overall scope of this proposal. I would prefer to see a research proposal more limited in scope with a clearer objective (for example, an analysis or quantification of predator/prey relationships on the A.P. would be beneficial), and to use equipment and protocols consistent with equipment and protocols already in place on the A.P. Sympatric canids should be targeted in current zones of ignorance (which is now the majority of the A.P.) instead of targeting known wolf packs.

If this proposal were carried out as written, it would effectively hand control and management of the red wolf program at the field level to the WRC. WRC plans to collar 25 "sympatric canids", and initially target known red wolf packs with their trapping efforts. There are only 23 known red wolves currently on the A.P. If they were to successfully radio-collar the majority of those wolves with collars emitting their own frequency range, it would severely limit our ability to monitor and manage this population. They also propose doing their own den work, using their own labs for necropsies, using separate protocols for data collection, etc. All this is concerning on two fronts. First, it is our (USFWS) legal mandate to manage and recover this federally listed species on the landscape. We do not turn over management to a state agency until the species is recovered to the point where federal protections are no longer needed. Second, the WRC has made it clear that their objective is to eradicate this species from the state of North Carolina. Turning monitoring and field management over to the WRC likely would not bode well for the recovery of this species.

While I think it is preferable in theory for the two agencies to collaboratively conserve and manage red wolves and other canids on the A.P., it is problematic when their respective objectives are polar opposites of one another. It is quite clear now, after exhaustive and repetitive reviews on the taxonomy and historical range of the red wolf, that the best available science indicates that this is indeed a valid listable species native to northeast NC. If the two agencies are to realistically work towards the conservation and management of canids on the A.P., the WRC needs to, at minimum, rescind their resolution requesting that red wolves be removed from the state of NC and declared extinct in the wild, and move towards listing the red wolf as a state listed threatened species. Then, in addition to collaborative research, we can explore joint regulatory efforts to reduce anthropogenic causes of red wolf mortality, take steps to minimize hybridization and control the coyote population as necessary, and collaboratively manage and recover red wolves on the A.P. Until then I am not comfortable handing over this level of monitoring and management of red wolves on the A.P. to WRC.

Canid Handling and Chemical Immobilization Workshop

customized for

U.S. Fish and Wildlife Service – Red Wolf Recovery Program

and

North Carolina Wildlife Resources Commission – Sympatric Canid Project

March 26-28, 2019

Instructor

Dr. Mark R. Johnson, DVM

Global Wildlife Resources

Day One

Date:	Tuesday, March 26
Location:	Coastal North Carolina National Wildlife Refuges Gateway Visitor Center, Manteo, NC – Conference Room
Time:	8:00 a.m. – 5:00 p.m.

Day Two

Date:	Wednesday, March 27
Location:	Coastal North Carolina National Wildlife Refuges Gateway Visitor Center, Manteo, NC – Conference Room
Time:	8:00 a.m. – 5:00 p.m.

Day Three

Date:	Thursday, March 28
Location:	Alligator River National Wildlife Refuge – Sandy Ridge Captive Red Wolf Facility
Time:	8:00 a.m. – 5:00 p.m.

Canid Handling and Chemical Immobilization Workshop
Customized for Red Wolf Recovery Program
March 26-28, 2019
Manteo, NC.
DRAFT OUTLINE

INTRODUCTION

A. INSTRUCTOR:

Mark R. Johnson DVM
Global Wildlife Resources
PO Box 1025, Freeland, WA 98249
E-mail: *mjohnson@wildliferesources.com*
Website: www.wildliferesources.com
Mobile: 406.570.3915

B. PARTICIPANTS

Introductions

C. WORKSHOP OBJECTIVES

- Develop confidence, skills, and knowledge for working with trapped and captive red wolves and coyotes using either physical restraint and/or chemical immobilization.
- Address the well-being of the animal as our highest priority which includes handling each canid with care, compassion, and respect. This is not just about getting our work done.
- Explore how to create a calm conscious manner to minimize the energy of conflict and reduce stress, struggles, and injuries associated with animal captures.
- Discuss the use of facilities, tools, strategies, and mannerisms for successful, safe, and humane canid capture in pen situations.
- Learn basic handling tools and techniques for physical restraint of canids including: scruff, lateral restraint, and hobbles without adding energy to any struggle.
- Become familiar with the Y pole: what it is, how it works, & how to properly use it.
- Acquire knowledge, confidence, and skills with the most current chemical immobilization drugs, drug delivery systems, and principles.
- Develop skill and understanding with animal care and monitoring vital signs of anesthetized wolves.
- Generate opportunity among workshop participants to discuss and practice canid handling and chemical immobilization with captive red wolves.

CAPTURE METHODS

A. HANDLING TRAPPED WOLVES

1. Y Pole – a humane tool for use with the syringe pole or a lead to physical restraint.
It is a safe extension of your hand. The quietest way to effectively handle canids.
Note: Use Y pole then syringe pole. Back away for the drugs to work.

a. Construction

Commercial Y poles or make your own.
Global Wildlife Resources, *GWR Products* for a lightweight, 2-piece aluminum Y pole. Recommended: buy one and have a local welder make copies.
Heart of the Earth Animal Equipment; *www.animal-traps.com* for a heavier one

b. Proper Technique for first contact – see GWR YouTube videos with dogs

Move in slowly with non-threatening manner and with good posture and confidence.
Only move in ways that build trust. Move slow and in small steps. Move in waves (stop & settle)
Utilize submissive "trance" when present.

2. Syringe Poles (avoid the term "jabsticks")

a. Tomahawk syringe pole with needle guard for 1cc or 3cc syringes.
Model PSP32. *www.livetrap.com*

b. Zoolu pole syringe – great for use with box traps
Heart of the Earth Animal Equipment, *www.animal-traps.com*

c. Campbell 1cc re-usable syringe pole
Small syringe pole for small volumes of BAM
Campbell Pet Company *https://www.campbellpet.com*

d. Safe T Flex Pole Syringe S100 (Neogen) re-usable syringe pole
Sold by livestock suppliers

B. HANDLING CAPTIVE WOLVES

1. Working in large pens

Note: It is important how we enter the pens. Earn comfort and trust to increase success.

- Facility design - large pen should have attached sub-enclosure and a shape to easily move animals. Use remote guillotine gates whenever possible.
- Holding pens ("sub-enclosures")
  - Attached to the pen where wolves can be funneled.
  - Remote guillotine gates – improves capture success and lowers energy
  - Creates confined location to effectively use Y pole or net.
  - May even have a security box for wolves to hide in – which captures them.

2. Security boxes

- Most canids like "den boxes"
- Canids can be urged to enter (with soft pressure) when boxes are in smaller sub-enclosures. Move them with Y poles.
- Should have door to close to keep them in and roof to lift to use Y pole and syringe pole.
- Ideally, wall would also drop to easily enter the box and process or remove the animal.

3. Walking a line - People can be assembled in a long line.

- Everyone must stay calm and relaxed. Minimize arm or body movement. No talking.
- Be small. No big tools in your hand. Bite sticks for safety. Or nets and Y poles.
- Keep *your* energy low and calm to keep the capture energy as low as you can.
- Follow one person's lead. Move a few steps at a time. Do not pressure the wolf. Give him time to see options.
- Move at the canid's pace. Give them time to think about their options.
- Move in waves. Soft pressure than stop and settle yourself. Look for canid to settle.
- If nets are used, position people with nets and shadow person with a Y pole at both ends of line along a wall.
- Move wolf toward Y poling corner or crate(s) or smaller enclosure.

4. Canvas Barrier - for guiding wolves to a Y poling corner or sub-enclosure

- The best material is a re-usable dark brown (?) cordura fabric 25 feet long by 5 feet high. Grommets are set along both ends and along the top edge.
- Plan, plan, plan. Long planning leads to more efficient & successful captures.
- Use caribiners to hook to fences, or make a chain of them to wrap around trees.
- At times weigh down the lower edge with the fold on the ground toward the wolf.
- Add calm people (with low energy) and Y poles.

5. Proper Y Pole Technique w captive wolves – see GWR video capturing Mexican wolf
Y pole will not work if canid wants to run. If/when it settles, slowly move a line of people to corner the animal. Calm and quiet to use and keep the submissive "trance"
If canid only runs in pen, then use barriers to move wolf into den box or nets for capture

B. NETS AND NETTING

1. Construction - Brands: Beckman, Ranger, and Frabill salmon nets

- 30" hoop diameter with 5-6 foot depth so net that can be twisted; 4-5 foot handle
- Hook-proof netting, thick cord to prevent cutting, mesh large enough to see and work through
- Basic principle is catch, twist, Y pole, and cover with towel.
- Important accessories: Y pole and towel

2. Technique and Strategy

- Good posture and relaxed attitude – stand up tall and straight
- Along a fence line: stand so your reach with the net is a few inches away from the fence
- Net should be held parallel to fence or a bit farther away; your body can hide it.
- Hide the net behind you and do not crouch. Good posture.

- Energetically invite the wolf to pass - *then quickly changer your mind*.
- Y pole person (with towel) should always shadow the net to act quickly.
- Place netters at each end of the line along a fence when walking a line

3. Accessories

a. Y Pole - a Y pole person should shadow the net person. When the wolf is caught quickly place the Y pole over the twist in the net to reduce the wolf's struggle.

b. Towel - after the Y pole place a towel over the wolf. This will reduce the wolf's struggle, reduce their stress, increase your safety to handle the net, and it looks far more professional and respectful.

c. Teach wolves to choose the Y pole
Learn good Y poling techniques and more wolves will accept it. Always add a towel.
Do not reach out with a Y pole to stop a wolf from running past
Over time, more wolves will tend to accept the Y pole over the net.

PHYSICAL RESTRAINT

A. Scruff - physical restraint of the head. (see video on YouTube channel GWRFeralDogs)
Three steps:
1. Ear in notch of thumb (this prevents squeezing the ears)
2. Fingers to corner of mouth (we will gather the cheeks)
3. Curl fingers. Thumbs stay parallel between ears. Do not scruff skin of neck to avoid choking animal

B. Lateral Restraint - animal on it's side (see video on YouTube channel GWRFeralDogs)
- Elbow at the base of the head. Hold lower front leg <u>above</u> the elbow.
- Elbow touches your knee. Do not put pressure on soft part of throat;

C. Headcover
- <u>All</u> animals benefit from a headcover at <u>all</u> times.
- Make sure it puts the animal in the dark. Can be as effective as a sedative.
- Wolf Quickmuzzle*: Four Flags Over Aspen, St. Clair MN, 800.222.9263*
- Towel when carrying wolf; Cover nets, traps, and crates as well.

D. Cloth Carrier
- MegaMover Portable Transport Unit - strong and light, maybe less durable.
- from Graham Professional *www.grahammedical.com*

E. Hobbles (see video on YouTube channel GWRFeralDogs)
- Not commonly used. Consider for safety when processing and for transport
- <u>*Always*</u> use a headcover first.
- Use short soft boat strap. NRS company – 3 foot straps, *www.nrsweb.com*
- Cross lower front leg and upper hind leg.
- Once around the top leg, once around the bottom leg, once around both legs
- Always wrap towards the body and above the carpal and tarsal joints.
- This is only intended for brief transport such as in a disaster rescue.

F. Crating A Wolf

1. Technique

Tip crate at 45 degree angle. Assign person to door.
Tail in first. Scruff is last person to let go.

2. Safety measures

Assign roles: Holding crate, controlling gate, tucking in legs, hips, scruff
Scruff is the last person to let go.

G. The Catch Pole

The catch pole may be one of the most commonly used tools for catching and controlling animals, yet they should be considered the last tool of choice.

1. Proper construction

- A rigid metal pole with a plastic coated adjustable cable loop.
- A swivel head and an instant release mechanism are most important.

2. Proper techniques

- See "Control Issues", Animal Sheltering Magazine. Jan/Feb 2013
- Those who have acquired the skill working with a Y pole recommend using the catch pole as if it is a Y pole.
- The crazier the animal gets the calmer we should be.

3. Things *not* to do

- No lifting. No pulling.
- Do not hang catch poles by their loops.

CHEMICAL IMMOBILIZATION

A. TERMINOLOGY

1. Anesthesia – lack of consciousness, an unresponsiveness. An anesthetic produces anesthesia. Examples: Ketamine and tiletamine; M-99 and carfentanil

2. Tranquilizer – induces a calming effect without affecting the central nervous system (CNS). Increasing from the recommended dose does not have increased action. Examples: zolazepam and acepromazine

3. Sedative – reduces an animal's response and *depresses CNS*. Stronger immobilization than tranquilizers, more side effects. Increasing from the recommended dose has increased action. Examples: xylazine and medetomidine

4. Antagonist - antidote; a drug which specifically counteracts another drug. Examples: yohimbine, tolazoline, and atipamizole

LAB 1: Needle and Syringes Lab

Learn safe and controlled use of needles and syringes
Safe recapping of needles; Handling syringe poles

IMMOBILIZING DRUGS

A. Dissociative anesthetics (Cyclohexamines) - ketamine and tiletamine

1. Ketamine - anesthetic; Schedule III; Used with a sedative

- Possibly the most versatile drug for chemical capture; wide safety margin
- Produces anesthesia w/ muscle tension
- Swallowing and ear-twitching reflexes generally remain intact
- Produces strong heart rate and breathing
- Can produce excessive salivation and seizures
- Recovering animals are <u>hypersensitive</u> to stimulus. Minimize stimulus during recovery.

2. Tiletamine – anesthetic; Schedule III ; Telazol® (500 mg in vial)

- Sold as TWO drugs: tiletamine (an anesthetic) and zolazepam (a tranquilizer)
- Sold as powder in 5 ml vial - add sterile water, vary concentration to meet your needs
- 2.5 times more potent than ketamine, but also with wide safety margin
- Can produce excessive salivation
- Muscle relaxation varies with species: tense in dogs, relaxed in wolves and bears.
- Limited shelf life when mixed with water LABEL DATE WHEN MIXED.

B. Sedatives (Alpha-2 agonists) - xylazine, medetomidine

1. Xylazine – sedative; Usually used with ketamine to produce a relaxed anesthesia

- Produces sedation, muscle relaxation, analgesia, slow heart, slow breathing
- Can promote bloat, vomiting, hypotension, loss of thermoregulation
- Used alone, animals will wake with sound or touch stimulus then return to "sleeping"
- Animals recover with a wobbly drunk-like state
- Can be antagonized with yohimbine, tolazoline, or Atipamezole

2. Medetomidine - sedative (Wildlife Pharmaceuticals [10 ml vial, 20mg/ml])

- 10-20 times more potent than xylazine, reduces volume of ketamine needed
- Same negative side effects as xylazine. Antagonize with atipamezole only.

C. Butorphanol - mild opioid; add butorphanol when using ketamine/xylazine combinations.

- Sold as TWO drugs: tiletamine (an anesthetic) and zolazepam (a tranquilizer)
- Ketamine/xylazine combinations can be inconsistent in their effects, tense, result in sudden wake-ups, and have tense and disoriented recoveries.
- Butorphanol will enhance xylazine effects and improve the quality of the immobilizations.
- Butorphanol is also a very strong analgesic.
- Ungulates: Add 0.05 - 0.1 mg/kg. Carnivores: 0.2 mg/kg.

D. Alpha-adrenergic <u>Antagonists</u> - yohimbine, tolazoline, or atipamezole

1. <u>Yohimbine</u> - Yobine (20 ml vial, 2mg/ml); Antagonil (20 ml vial, 5mg/ml)
   Give 0.15mg/kg IV, IM, or SQ. For antagonizing xylazine. DOES NOT antagonize ketamine. Less reliable in bovids.

2. <u>Tolazoline</u> - (Tolazine, Wildlife Pharmaceuticals [100 ml vial, 100mg/ml])
   More consistent and effective than yohimbine in sheep and other ruminants.
   For antagonizing xylazine.

3. Atipamezole - (Wildlife Pharmaceuticals)
   Made for antagonizing medetomidine. Also antagonizes xylazine.
   Generally give equal volume of medetomidine, but follow label
   Generally give 1 mg for every 10 mg xylazine. Administer IM.
   Acts much more specifically on xylazine than yohimbine and tolazoline

E. BAM (See Handout K) - BAM is a Butorphanol, Azaperone, & Medetomidine mix from Wildlife Pharmaceuticals. Many wildlife agencies have adopted this drug combo though it is still currently classified as experimental. Effective in a wide variety of species. Quick knockdown. Produces a smoother and more rapid recovery than ketamine or Telazol combos. For more information visit: *http://www.zoopharm.net/drugs/pdf/BAM-V2.pdf*

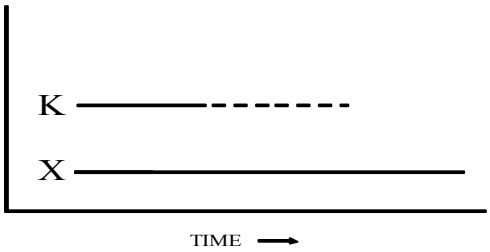
F. Accessory Drugs

1. Atropine sulfate - (small animal [0.5mg/ml] and large animal [2 mg/ml])
   Imitates fight or flight responses: i.e. stops salivation, increases heart rate
   Most commonly used to reduce excessive salivation or strengthen heart function
   Dilates pupils so protect eyes from sunlight
   Increases metabolism of the drug

2. Doxapram hydrochloride - (Dopram-V® in 20mg/ml concentrations)
   Stimulates breathing – short term so may require additional CPR
   Occasionally used to increase metabolism of ketamine or Telazol®

PRINCIPLES OF IMMOBILIZATION

B. KETAMINE/XYLAZINE EFFECTS

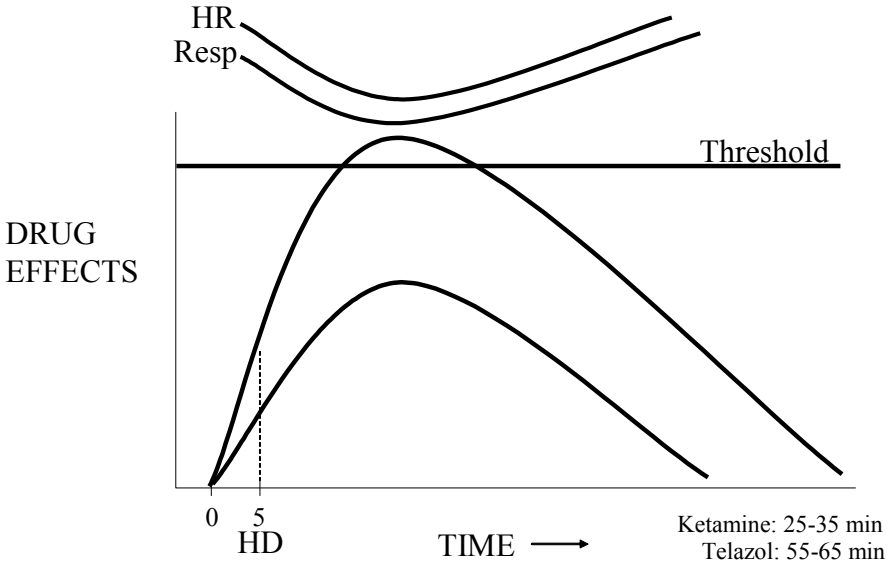


B. KETAMINE/XYLAZINE INTERACTIONS

Drug	*Effects on Animal*
1. Ketamine	→
	→
	→
2. Xylazine	→
	→
	→
3. K/X Combination	→
	→
	→

ADMINISTERING THE DRUG

A. GENERAL SCENARIO

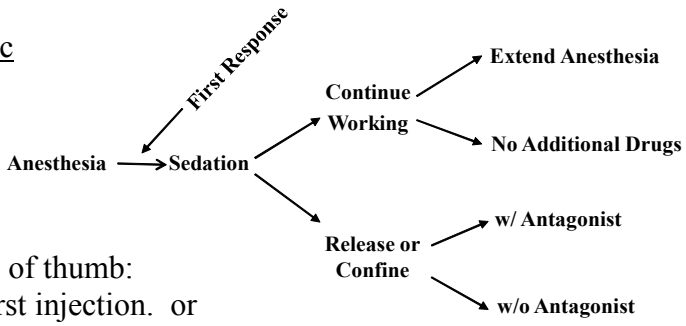


B. OPTIONS WHEN ANESTHETIZED ANIMAL BEGINS TO RESPOND

1. Continue working

a. Extend anesthesia (redosing)
Give ½ original ketamine dose IM.
or give ¼ original ketamine dose IV for brief unresponsiveness

b. Work without more anesthetic
Check headcover.
Minimize stimulus.



2. Release (free-ranging) animal

a. Antagonize drug – two rules of thumb:
1) Give 45 minutes after first injection. or
2) Give 20 minutes after first response.

b. Allow animal to awake slowly without an antagonist
Reduces hypersensitivity when waking in a confined space.

LAB 2: Patient Monitoring Lab (with live animals)

Preparing for the final drugging lab on Day 3
Become confident with the stethoscope and monitoring vital signs with awake animal
Become comfortable working with the field form, animal, and team members
Practice conducting a physical exam and find blood vessels

ADDRESSING ANIMAL HEALTH

A. BASIC CARE

1. Ground Cloth

Another tool good for the animal, biologist, and profession.
Canvas - make with untreated canvas
(Vendor: Montana Canvas, *http://www.montanacanvas.com;* request wildlife handling cloth designed by Global Wildlife Resources; 3'x 5' or 5'x 5')
(Vendor: MegaMover Portable Transport Unit by Graham Professional *www.grahammedical.com*) Strong and light, may be less durable.

2. Body position

a. Sternal -
To ensure airway is open.
When animal is hot – exposes "armpits" (axillas) and groin to cool ground.
Strive to work ungulates in sternal position to minimize bloat. Position to encourage belching. Hold drugged ungulate with neck upright to prevent bloat and chin lower than larynx to move saliva away from larynx and prevent regurgitation.

b. Lateral (laying on side) - When animals are cold.
If ungulate is on side, keep right side down to observe left flank for bloat.

3. Headcover ± eye solution - ALWAYS USE A HEAD COVER (See Handout L)

All animals benefit from a head cover. Design a headcover to put them in the dark.
Good for animal. Safer for the biologist. Looks more caring and professional.
(Canids: Four Flags Over Aspen, *http://www.fourflags.com*
Ophthalmic solution may be better than ointment – Neither should ever have steroids

B. PATIENT MONITORING

1. Physical Exam (See Handout M)

This is the first procedure to do when the animal is in hand.
Create a customized exam and examine each animal. This includes first TPR.

2. TPR (Vital Signs)

a. **T**emperature – *Guide the body temperature, don't react to it.*
Ask two questions:
1. What temperature is the animal?
2. Which direction is the temperature going? – Record in chronological order.
A healthy temperature range for temperate climate mammals is 100-103 degrees F.

b. **P**ulse (Heart Rate) -
Use stethoscope to monitor heart rate. Find heart using hands on both sides of chest.
Search where elbow meets middle of rib cage (about 7th rib). Strongest on left side.
For back up use femoral pulse. Located in "femoral triangle" on inside of leg
Write femoral pulse in Comments on field form separate from Pulse (heart rate).

c. **R**espiration - Ask two questions:
1) What is the respiratory rate? (evaluate both rate and size of breath)
Watch chest or abdomen.
2) How does the airway sound? Listen to larynx with stethoscope for gurgling.
Adjust body position to minimize gurgling when possible.

d. Capillary Refill Time (CRT) and color of the gums.
Press on gums above canines (predators) or on dental pad (ungulates)
A healthy CRT is less than 2 seconds. Pink is healthy color.
Use CRT and color of gums to evaluate if heart rate and respiratory rates are within healthy range.

e. Pulse oximeter – seriously consider adding a pulse oximeter to your field equipment; monitors heart rate and oxygen in blood (SPO_2).

VETERINARY EMERGENCIES

A. Hypothermia –low body temperature, affects health and metabolism of drug

1. Prevention – regular monitoring and recording of body temperature, ground cloth, attention to weather conditions

2. Treatment – Move into sun (address where each person is standing), change body position, padding under the animal, sleeping bags, cover w/ reflecting blanket, chemical heat pads

B. Hyperthermia – high body temperature from internal or external sources; more common and serious for the animal. Reduces ability for blood to carry O_2 to the brain; rapid pulse and breathing, dark mucous membranes

1. Prevention – limit chase time, regular monitoring and recording of temperature, body position sternal to expose armpits and groin, attention to weather conditions.

2. Treatment – move into shade, wet ground and body, water and alcohol mix for severe conditions. Provide oxygen. stomach tubes w/ electrolytes IV fluids. Cold water enemas are *not* recommended – ineffective and removes ability to monitor temp.

C. Trap Injuries - be aware of the potential for pressure necrosis which is not visible.

1. Punctures – trim hair over puncture and flush with 10% betadine or nolvasan solution

2. Abrasions - trim hair around, clean debris from wound and flush repeatedly with 10% betadine or nolvasan solution

3. Cuts - trim adjacent hair to keep wound open, remove debris, flush repeatedly with 10% betadine or nolvasan solution, possibly pack w/ nolvasan ointment

4. Fractures and severed limbs **Never release an animal with a bandage, no exceptions!**

RECOVERY

Trapline - professional standard is to stay with animal until his head is up, it can swallow, and negotiate his airway.

Captive wolves - Allow to wake up separated from other wolves. Offer quiet and visual security.

LAB 4: Chemical Immobilization with <u>live animals</u> (hand injection):

1. Chemical immobilization and learning the animal's response to immobilizing drugs
2. Monitoring temperature, pulse, and respiration and other vital signs
3. Processing procedures (blood collection, radio-collaring, etc) appropriate for canids
4. Documenting chemical immobilization on a field form
5. Professional mannerisms maximizing animal care and field success

TOPICS FOR DISCUSSION

Debriefing to discuss chemical immobilization of red wolves

Open discussion and addressing loose ends.

Evaluations and Pass out Certificates of Training

Mark R. Johnson DVM.

Dr. Mark is the wildlife veterinarian and founder of Global Wildlife Resources (GWR) in Freeland, WA. GWR specializes in wildlife capture and handling and provides the most current and extensive training in wildlife chemical capture. His courses are invaluable to college students, state/federal/tribal wildlife professionals, zoo caretakers, game farms, veterinary technicians, veterinarians, and animal control officers.

Dr. Mark was Project Veterinarian for the U. S. Fish and Wildlife Service's 1995-96 gray wolf reintroduction program into Yellowstone National Park and central Idaho and was the wildlife veterinarian for Yellowstone National Park for four years - the first veterinarian working for NPS. He has taught canid capture and handling to the MN and Fargo Zoos as well as to many captive wolf programs. He is a primary instructor for USDA Wildlife Services and has taught exclusive courses for Michigan and Maine biologists. He is Affiliate Faculty of University of Montana.

In the past several years, his experience in handling wolves has led him to teach humane capture and handling of feral dogs around the world. This training is helping countries on every continent with rabies eradication programs & supporting humane methods for managing dog overpopulations. He assisted with three rescue trapping operations after Hurricane Katrina and his on-site courses included training in India and Palau.

With every course Dr. Johnson strives to support and empower each student and professional as well as improve the well-being of each animal handled for wildlife research and management. He is also learning from every course with new information, tools, and techniques and has acquired an exceptionally strong understanding of wildlife chemical immobilization in North America.

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FACEBOOK for wildlife handling - See reviews

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF NORTH CAROLINA
NORTHERN DIVISION
No. 2:15-CV-42-BO

RED WOLF COALITION, DEFENDERS OF WILDLIFE, and ANIMAL WELFARE INSTITUTE, Plaintiffs, v. UNITED STATES FISH AND WILDLIFE SERVICE; JIM KURTH, in his official capacity as Acting Director of the United States Fish and Wildlife Service; and MIKE OETKER, in his official capacity as Acting Regional Director of the United States Fish and Wildlife Service Southeast Region, Defendants.[1]	)	ORDER

This cause comes before the Court on cross-motions for summary judgment pursuant to Rule 56 of the Federal Rules of Civil Procedure. The appropriate responses and replies have been filed, and a hearing was held before the undersigned on October 17, 2018, at Raleigh, North Carolina. In this posture, the motions are ripe for ruling.

BACKGROUND

Factual[2] and procedural background

The wild red wolf, or *Canis rufus*, is again close to extinction, with as few as forty wolves identified in the wild in April 2018. [DE 88 at 5]. In 1967, the red wolf was designated as an

[1] Jim Kurth and Mike Oetker have been substituted for defendants Daniel M. Ashe and Cynthia Dohner pursuant to Fed. R. Civ. P. 25(d).

[2] The factual background is comprised primarily of public record and undisputed facts as proffered by plaintiffs and reflected in defendants' combined response to plaintiffs' statement of uncontested facts and affirmative statement of uncontested facts. [DE 87]. Plaintiffs' appendices are at [DE 82, 83].

endangered species under the Endangered Species Preservation Act of 1966,[3] and, in 1980, the species was declared extinct in the wild. In 1986, the United States Fish and Wildlife Service (USFWS) instituted a special rule under Section 10 of the Endangered Species Act of 1973 to establish the reintroduction of red wolves in North Carolina, specifically on the Alligator River National Wildlife Refuge in Dare County. *See* 51 Fed. Reg. 41,790 (Nov. 19, 1986); 50 C.F.R. § 17.84.[4] The red wolf was designated as a non-essential experimental population under the Endangered Species Act–experimental status[5] would allow USFWS more discretion in devising an active management program and the non-essential designation was applied because the species was considered to be fully protected in six separate captive locations. *Id.* Four captive-bred pairs of red wolves were released to the Alligator River reintroduction site in 1987. The Red Wolf Recovery Area currently encompasses approximately 1.7 million acres in Dare, Hyde, Tyrrell, Washington, and Beaufort Counties, and includes four national wildlife refuges, a U.S. Air Force bombing range, state-owned, and private lands. *See* 60 Fed. Reg. 18,940.

The red wolf 10(j) rule prohibits the take[6] of a red wolf except in those limited circumstances. 50 C.F.R. § 17.84(c)(2). Intentional or willful takes of red wolves are not permitted in the Red Wolf Recovery Area unless it is in defense of a person's own life or the lives of others; the animal is in the act of killing livestock or pets; or the take has been authorized by USFWS project personnel after efforts by USFWS to capture the animal have been abandoned, provided

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[3] Pub. L. 89-669, October 15, 1966, 80 Stat. 926, a predecessor to the Endangered Species Act of 1973.

[4] Referred to herein as the 10(j) rule or red wolf rule.

[5] An experimental designation further means that red wolves are treated as threatened, rather than endangered, species for purposes of Sections 4(d) and 9 of the ESA. *See Gibbs v. Babbitt*, 214 F.3d 483, 487 (4th Cir. 2000).

[6] "Take" is defined by the ESA to mean "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." 16 U.S.C. § 1532(19).

that the USFWS project leader has approved of the take in writing. *Id.* § (c)(4)(i); (iii); (v). All takes are additionally subject to reporting requirements. *Id.*

From the red wolf recovery program's inception, it was understood that the interaction between red wolves and humans in the Red Wolf Recovery Area would be an issue which would require effective management in order for reintroduction of the species to be successful. *See* Pl. App. 333-357 (USFWS Red Wolf Recovery/Species Survival Plan). To that end, USFWS issued an internal document in January 1999 entitled "Guidelines for Applying the Current Red Wolf Rule (April 13, 1995) to Requests to Remove red wolves from private land." Pl. App. 723. The 1999 Guidelines distinguished between problem wolves and non-problem wolves. Problem wolves are wolves which have engaged in actions that directly caused the loss of personal property and wolves which are exhibiting inappropriate behavior, such as a tolerance of humans, which may suggest the wolf would become a more serious problem. Under the 1999 Guidelines, reports of problem wolves would be addressed by field personnel within forty-eight hours, and problem wolves would be captured and removed if feasible, or authorization to landowners to effect a lethal or non-lethal take would be given. *Id.* Requests to retrieve non-problem wolves from private land, however, would be addressed within manpower limits, and whether traps would be set to capture the non-problem wolf would be subject to certain criteria. *Id.*

The 1999 Guidelines for implementing the red wolf 10(j) rule were drafted in response to continuous requests from two or three private landowners to remove red wolves from their property, in combination with the increase in red wolf population and the logistical and economic difficulties with continuing to try to honor all requests for red wolf removal. Pl. App. 731. USFWS noted that removal of non-problem wolves "may be detrimental to the conservation of the species by preventing natural expansion and recovery of the species, and by contributing to the

establishment of coyotes." *Id.*; *see also* Pl. App. 723. In essence, beginning in the late 1990s, USFWS focused efforts on addressing landowner complaints about problem wolves, and shifted away from making efforts to remove every wolf identified on private property. The 1999 Guidelines referenced addressing landowner concerns regarding the presence of non-problem wolves primarily in terms of capture and removal and other non-lethal take methods.

Coyotes were not present in the Red Wolf Recovery Area when the red wolf reintroduction program was initiated. As the presence of coyotes in the area increased in the late 1990s, USFWS implemented an adaptive management work plan to prevent coyote-red wolf interbreeding, which included the sterilization of coyotes in the wild and use of sterile coyotes as placeholders; placeholder coyotes would hold territories as against other coyotes territories until the placeholder territories were taken over by red wolves either naturally or by management action. *See* Pl. App. 500. In 2005, the Red Wolf Recovery Adaptive Work Plan included the dual goals of reducing interbreeding between red wolves and coyotes and building and maintaining the wild red wolf population in the Northeastern North Carolina recovery area. Pl. App. 808-814. Pup fostering, or placing captive-born red wolf pups in the den of wild wolf parents, was determined to be a "significant and useful population management tool in red wolf recovery". Pl. App. 470. In the 2007 Red Wolf 5-year Status Review, Pl. App. 491-548, the reintroduction of red wolves to the Red Wolf Recovery Area was determined to be a "remarkable success," with nearly 130 red wolves in the wild. *Id.* at 523.

"Recall[ing] that wolves were rather easily exterminated from the U.S. during the predator control efforts of the early 20th century, while at the same time the range of the coyote increased," Pl. App. 820, the 2010-2012 Red Wolf Adaptive Management Plan recognized that eliminating the breeding potential of eastern coyotes within the red wolf area would support increasing the red

wolf population. Pl App. 820-827. These same goals of reducing coyote interbreeding and increasing the wild red wolf population were repeated in the 2013-2015 Red Wolf Adaptive Management Plan. Pl. App. 846-859. Other than coyote interbreeding, the 2007 Status Report cited human interaction and gunshot mortality as the primary areas of concern for the viability of the wild red wolf population. Pl. App. 523-24.

On February 6, 2014, USFWS issued the first lethal take authorization to a private landowner under 50 C.F.R. § 17.84(c)(4)(v). Pl. App. 938-940. The authorization was in a letter from Leopoldo Miranda, Assistant Regional Director, Ecological Services. Pl. App. 938-940. USFWS renewed the February 2014 take authorization twice – once on September 23, 2014, and again on April 27, 2015.

In September 2014, USFWS noted that, over a period of several weeks, 228 letters requesting that red wolves be removed from private land had been received, Pl. App. 949, and by October 30, 2014, USFWS had received 405 individual requests to remove red wolves from private land. Pl. App. 951. On follow-up from USFWS personnel, however, it was determined that numerous individuals who had signed letters had thought they were signing a coyote hunting petition, while others stated that that they did not have red wolves on their property, or that they did not object to having red wolves on their property; other requests for removal contained no contact information or were duplicate requests from the same address. Pl. App. 949-951.

Citing population decline and growing stakeholder concerns, USFWS hired the Wildlife Management Institute "to conduct an independent evaluation of the Red Wolf Recovery Program that focused on supporting science, program management, and human dimensions." [DE 88 at 11] Miranda-Castro Decl. ¶ 4. On January 29, 2015, the North Carolina Wildlife Resources Commission passed resolutions requesting that defendants declare the red wolf extinct in the wild

in North Carolina and terminate the Red Wolf Reintroduction Program for free-ranging red wolves. Pl. App. 972-74.

Beginning in the winter of 2015, USFWS stopped conducting coyote sterilizations. Pl. App. 23, Harrison Dep. at 96. Releases of red wolves into Eastern North Carolina were also discontinued in 2015, as was pup fostering. Benjamin Dep. at 227-28; *see also* [DE 88 at 271] (June 30, 2015 Press Release: Service Halts Red Wolf Reintroductions Pending Examination of Recovery Program).

A second take authorization was granted by Pete Benjamin, Field Supervisor, to two additional landowners on May 20, 2015, Pl. App. 1006-7, which resulted in the lethal take of a red wolf on June 17, 2015. Pl. App. 1009. The red wolf that was killed was a non-problem, six-year old denning mother. Pl. App. 1013. In June 2015, USFWS issued an internal memorandum providing revised procedures for responding to landowner requests for removal of red wolves. Pl. App. 1020-22. The 2015 procedures provide that lethal take authorizations for specific wolves will be provided to landowners where removed wolves return to the subject property or where reasonable efforts to capture known wolves are unsuccessful. Unlike the 1999 Guidelines, the 2015 procedures do not distinguish between problem and non-problem wolves. *Id.* On June 30, 2015, USFWS publically announced that it would be conducting a "thorough and deliberate evaluation of the red wolf recovery program" and confirmed its commitment to "get[ting] the science right, [and] rebuild[ing] trust with our neighbors . . . state partners and many stakeholders . . .." [DE 88 at 272].

In October 2015, USFWS estimated there were 50-75 red wolves in the wild, and the last publically released population estimate shows an estimated 46-60 red wolves in the wild. Pl. App. 1114. Plaintiffs instituted this action in November 2015, and the Court issued a preliminary

injunction preventing the take of non-problem wolves on September 28, 2016. As of November 2017, as few as two or three breeding pairs of red wolves remain in the wild population. Pl. App. 258-59, Benjamin Dep. II at 145-46.

In May 2017, USFWS published an advance notice of its intent to develop a proposed rule, prepare a NEPA document, and convene two public scoping meetings. Miranda-Castro Decl. ¶ 7. USFWS completed a five-year status review of the red wolf on April 23, 2018, and intends to finalize its NEPA document and to either finalize or withdraw its proposed rule by November 30, 2018. *Id.* ¶¶ 9, 12, 13. During the rule-making process, USFWS states that it is continuing to actively manage the red wolf population by monitoring radio-collared red wolves; using remote sensing cameras and scent stations to assess movement, pack dynamics, and the general health of the wolves; and by using captive red wolves for educational purposes. *Id.* ¶ 14.

Plaintiffs' claims

Plaintiffs' amended complaint alleges that defendants have violated the Endangered Species Act (ESA), 16 U.S.C. § 1531 *et seq.*, as follows: that defendants have violated Section 9 by authorizing private take of red wolves without satisfying the requirements of 50 C.F.R. § 17.84(c)(4)(v); that defendants have violated Section 4 by administering the red wolf rule in a manner that is failing to provide for the conservation of red wolves; that defendants have violated Section 4 by failing to conduct the mandatory five-year status review of the red wolf species; and that defendants have violated Section 7 by failing to administer the red wolf recovery program in furtherance of the conservation purposes of the ESA and by failing to ensure that administration of the red wolf recovery program pursuant to 50 C.F.R. § 17.84(c) is not likely to jeopardize the red wolf's continued existence. [DE 20] Amd. Cmpl. ¶¶ 114-145. Plaintiffs further allege that defendants have violated the National Environmental Policy Act (NEPA), 42 U.S.C. §§ 4321-47,

by modifying their administration of the red wolf rule without completing an environmental assessment or environmental impact study. Amd. Cmpl. ¶¶ 146-151. At bottom, plaintiffs challenge defendants' actions in authorizing the lethal or non-lethal take of red wolves on private land without first satisfying the requirements of the governing regulations and in shifting their efforts and administering the red wolf rules and regulations in a manner resulting in a failure to provide for the conservation of the wild red wolf population.

DISCUSSION

In their motion for summary judgment, plaintiffs asks this Court to find that defendants are violating and will continue to violate the ESA and its implementing regulations as well as NEPA. Plaintiffs further request that the Court, pursuant to its equitable authority: maintain the injunction against the capturing and killing of non-problem wolves as issued by the Court as a preliminary injunction; order the USFWS to, within thirty days of the date of entry of this order, reinstate the coyote sterilization program and red wolf releases or explain why such action is not necessary for the conservation of the red wolf; and require that any subsequent modification to the historic implementation of the red wolf rule or the longstanding red wolf adaptive management program go through the required analysis under the ESA, NEPA, and the Administrative Procedures Act before they take effect.

In response, defendants argue that, due to recent changes to management of the red wolf population, plaintiffs' claims are moot and the Court lacks subject matter jurisdiction to consider them. Defendants further argue that, if plaintiffs' claims are not found to be moot, the USFWS' actions regarding the red wolves comply with the ESA and NEPA; defendants also contend that plaintiffs' request for mandatory injunctive relief must be denied because it lacks any basis in law or equity.

I. Standard of review

Generally, a motion for summary judgment may not be granted unless there are no genuine issues of material fact for trial and the movant is entitled to judgment as a matter of law. Fed. R. Civ. P. 56(a). Under the Administrative Procedures Act (APA), 5 U.S.C. § 702, which the Court has previously determined applies to plaintiffs' claims, "[s]ummary judgment . . . serves as the mechanism for deciding, as a matter of law, whether the agency action is supported by the administrative record and otherwise consistent with the APA standard of review." *Sierra Club v. Mainella*, 459 F. Supp. 2d 76, 90 (D.D.C. 2006). Thus, when reviewing agency action under APA, a court does not consider whether there are disputed issues of material fact, but rather must "determine whether or not as a matter of law the evidence in the administrative record permitted the agency to make the decision it did." *Occidental Eng'g Co. v. I.N.S.*, 753 F.2d 766, 769 (9th Cir. 1985).

Under the APA, agency action shall be set aside by a reviewing court if its "arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with law." 5 U.S.C. § 706(2)(A). "Courts must conduct a 'searching and careful' inquiry into the agency decision, although this review is ultimately a 'narrow' one." *J.H. Miles & Co., Inc. v. Brown*, 910 F. Supp. 1138, 1146 (E.D. Va. 1995) (quoting *Citizens to Preserve Overton Park, Inc. v. Volpe,* 401 U.S. 402, 416 (1971)). Review of agency action under the APA is highly deferential, *Ohio Valley Envtl. Coal. v. Aracoma Coal Co.*, 556 F.3d 177, 192 (4th Cir. 2009), but a court must be mindful not to rubber-stamp agency decisions, as doing so would abdicate the judiciary's responsibility under the Act. *Nat. Res. Def. Council, Inc. v. Daley*, 209 F.3d 747, 755 (D.C. Cir. 2000) (citation omitted). Agency action must be deemed arbitrary and capricious where the agency has "relied on factors which Congress has not intended it to consider, entirely failed to consider an important aspect of

the problem, offered an explanation for its decision that runs counter to the evidence before the agency, or is so implausible that it could not be ascribed to a difference in view or the product of agency expertise." *Motor Vehicle Mfrs. Ass'n of U.S., Inc. v. State Farm Mut. Auto. Ins. Co.*, 463 U.S. 29, 43 (1983).

II. Mootness

As it concerns a threshold inquiry, the Court considers first defendants' argument that the Court now lacks subject matter jurisdiction over this case because plaintiffs' claims are constitutionally or prudentially moot.

Article III of the United States Constitution limits federal court jurisdiction to actual "cases" and "controversies" and requires that a dispute remains "live"; litigants must maintain a "personal stake" in the outcome throughout the course of litigation. *U.S. Parole Comm' n v. Geraghty*, 445 U.S. 388, 395– 96 (1980). "The requisite personal interest that must exist at the commencement of the litigation (standing) must continue throughout its existence (mootness)." *Id.* at 397 (quotation omitted). "Simply stated, a case is moot when the issues presented are no longer 'live' or the parties lack a legally cognizable interest in the outcome." *Powell v. McCormack*, 395 U.S. 486, 496 (1969). A federal court lacks subject matter jurisdiction to decide a case which is moot due to Article III's case or controversy requirement. *Com. of Va. ex rel. Coleman v. Califano*, 631 F.2d 324, 326 (4th Cir. 1980).

The doctrine of prudential mootness permits a court to, in its discretion, decline to enter injunctive and declaratory relief where the court can no longer provide an effective remedy and it would be imprudent to decide the case. *S-1 v. Spangler*, 832 F.2d 294, 297 (4th Cir. 1987); *Feldman v. Pro Football, Inc.*, 579 F. Supp. 2d 697, 706 (D. Md. 2008). In deciding whether issues have become prudentially moot, courts consider three factors: whether the specific relief

sought no longer has sufficient utility to justify a decision on the merits; the difficulty and sensitivity of the core issues in the case; and finally whether the challenged acts are capable of repetition yet likely to evade review. *Spangler*, 832 F.2d at 297-298; *see also Smyth v. Carter*, 88 F. Supp. 2d 567, 571 (W.D. Va. 2000). If a case or claim is determined to be prudentially moot, a court may avoid deciding the constitutional question of Article III mootness. *United States v. Under Seal*, 757 F.2d 600, 602 (1985); *Smyth*, 88 F. Supp. 2d at 570.

Defendants argue first that plaintiffs' third claim for relief, which seeks the undertaking of a five-year review of the red wolves as required by Section 4 of the ESA, 16 U.S.C. § 1533(c)(2), is constitutionally moot. The last five-year Section 4 species review had occurred in 2007, and, at the time of the filing of plaintiffs' complaint in 2015, no five-year review had been conducted since that time. Defendants assert that a new species status assessment of the red wolf was completed on April 19, 2018, and a five-year status review was completed on April 23, 2018. As the Court could not order defendants to conduct the Section 4 five-year review because it was conducted in April 2018, the Court, in its discretion, finds that its inability to order an effective remedy has rendered this claim prudentially moot. The Court need not, therefore, consider the constitutional question and plaintiff's third claim for relief is dismissed.

As to plaintiffs' remaining claims, the doctrine of prudential mootness is not applicable. Defendants argue[7] that because they have undertaken new rulemaking, and anticipate that a new red wolf 10(j) rule will be final by November 30, 2018, plaintiffs' claims which are based on the current 10(j) rule are moot. However, the claims before the Court are not particularly sensitive or difficult, and the specific relief sought by plaintiffs continues to have utility – while defendants have initiated the proposed rulemaking process, and *contend* that they will have a final rule in

[7] Defendants argue only that plaintiffs' remaining claims are prudentially moot.

place by November 30, 2018, there is no impediment to this Court enjoining defendants or providing declaratory relief pending publication of a final rule. *See Defs. of Wildlife v. Jackson*, 791 F. Supp. 2d 96, 111 (D.D.C. 2011) (request to prevent agency action until ESA Section 7 consultation has been completed not moot where consultation has been initiated during pendency of case). Because the "conclusion of the [rulemaking] process . . . lies somewhere in the [] future" plaintiffs' remaining claims are not prudentially moot and the Court will consider them on the merits. *W. Virginia Highlands Conservancy v. Norton*, 161 F. Supp. 2d 676, 680 (S.D.W. Va. 2001).

III. Analysis

Plaintiffs' ESA Section 9 claim relates to the grant of two lethal take authorizations under 50 C.F.R. § 17.84(c)(4)(v). It is well-established that "an agency action may be set aside as arbitrary and capricious if the agency fails to comply with its own regulations." *Nat'l Envtl. Dev. Ass'ns Clean Air Project v. Envtl. Prot. Agency*, 752 F.3d 999, 1009 (D.C. Cir. 2014) (internal quotation and citation omitted); *see also Steenholdt v. Fed. Aviation Admin.*, 314 F.3d 633, 639 (D.C. Cir. 2003) (federal agencies must follow own rules). The take authorizations issued in 2014 and 2015 failed to comply with the red wolf 10(j) rule, and therefore violated Section 9 of the ESA. *See Gibbs v. Babbitt*, 214 F.3d 483, 488 (4th Cir. 2000) (Section 9 take prohibition extended to experimental red wolf populations subject to exceptions). The take authorizations were issued under 50 C.F.R. § 17.84(c)(4)(v), which provides that:

> Any private landowner may take *red wolves* found on his or her property in the areas defined in paragraphs (c)(9)(i) and (ii) of this section *after* efforts by project personnel to capture such animals have been abandoned, *Provided* that the Service project leader or biologist has approved such actions in writing and all such taking shall be reported within 24 hours . . ..

50 C.F.R. § 17.84(c)(4)(v) (some emphasis added).

Contrary to defendants' arguments, the take authorizations failed to comply with the plain language of the red wolf 10(j) rule, which requires that red wolf take authorizations for a private landowner be approved "after efforts by project personnel to capture such animals have been abandoned." The February 2014 take authorization refers to unconfirmed canids[8] on the subject property, the extent of whose use of the property was also unconfirmed. The May 2015 take authorization cites no direct evidence of wolves on the subject property. However, in both authorizations, after noting that the properties are adjacent to a National Wildlife Refuge on which red wolves are known to occur, USFWS states that, in light of staffing commitments and lack of access to trap on the subject property, USFWS was foreclosed from pursuing animals that may be on the subject land "and *in that sense* must abandon efforts to capture and relocate the animal ourselves." *See* Pl. App. 939 (emphasis added).

The 2014 and 2015 take authorizations were issued because landowners had refused to give USFWS access to continue trapping or engaging in other efforts. Abandonment of USFWS efforts based on a landowner's refusal to grant USFWS access to their property cannot serve as a proper basis for issuing a lethal take authorization under § 17.84(c)(4)(v), as doing so would impermissibly tip the scales in favor of public demand and away from USFWS' congressionally mandated goal to recover and rehabilitate the red wolf in the wild. In addition to requiring USFWS to *actually* abandon attempts to capture red wolves on private land prior to issuing a take authorization, the red wolf 10(j) rule contemplates that USFWS would have abandoned efforts to capture *specific* red wolves prior to issuing a take authorization. The 2015 take authorization, for example, plainly states that USFWS has not even confirmed the presence of a red wolf on the

[8] Canid is defined as "any of a family (Canidae) of carnivorous animals that includes the wolves, jackals, foxes, coyote, and the domestic dog." https://www.merriam-webster.com/dictionary/canid (last visited October 30, 2018).

subject property. USFWS' expansive reading of the circumstances which would support issuing a take – including lethal take – authorization to a private landowner under the red wolf 10(j) rule impermissibly broadens the scope of wolves subject to take authorizations, and therefore conflicts with the ESA's "purpose to protect endangered and threatened" species. *Hill v. Coggins*, 867 F.3d 499, 510 (4th Cir. 2017) (quoting *Babbitt v. Sweet Home Chapter of Cmtys. for a Great Oregon*, 515 U.S. 687, 700 (1995)).

While the Court must afford deference to USFWS' construction of its 10(j) rule, where, as here, its interpretation operates against the USFWS' goal to recover the red wolf in the wild, the agency's "disregard for the statutory and regulatory context deserves no deference." *Nat'l Wildlife Fed'n v. Nat'l Marine Fisheries Serv.*, 524 F.3d 917, 931 (9th Cir. 2008). The take authorizations are further at odds with at least one USFWS scientist with the Red Wolf Recovery Program, who noted on several occasions that "our understanding [is] that foreclosure to access does not equate to abandonment of effort". Pl. App. 968 (Nov. 20, 2014 email from Beyer to Benjamin); Pl. App. 991 (Mar. 19, 2015 email from Beyer to Benjamin) ("My understanding is we would have to issue a permit after attempts to remove wolves have been abandoned. In this case we are not even recognizing or aware of any wolves present, have not made any capture efforts, and have denied similar requests.").

The 2014 and 2015 take authorizations represent a departure from long-standing USFWS guidelines to issue take authorizations only for problem wolves and were issued in conflict with the applicable red wolf 10(j) rule. The authorizations thus violated the ESA.

Plaintiffs remaining claims concern defendants' compliance with the ESA's conservation and consultation mandates and well as NEPA's requirement that agencies take a hard look at proposed actions which may have significant effects on endangered or threatened species. Section

4(d) of the ESA requires that the red wolf 10(j) rules must provide for the conservation of the listed species. 16 U.S.C § 1533(d); *see also Defs. of Wildlife v. Tuggle*, 607 F. Supp. 2d at 1116 (10(j) rules are "by definition the promulgation of the protective regulations for the species pursuant to the authority of ESA section 4(d)."). Section 7(a)(1) of the ESA, 16 U.S.C. § 1536(a)(1), "*requires* the Secretary [of the Interior] and the heads of all other Federal departments and agencies to use their authorities in order to carry out programs for the protection of endangered species." *Tennessee Valley Auth. v. Hill*, 437 U.S. 153, 182-83 (1978) (citation omitted) (emphasis added in *Tennessee Valley*). Section 7(a)(1)'s requirements apply to the USFWS. *Nat'l Wildlife Fed'n v. Norton*, 386 F. Supp. 2d 553, 567 (D. Vt. 2005).

Section 7(a)(2) of the ESA requires that each federal agency consult with the Secretary of the Interior ensure that agency action is not likely to jeopardize the continued existence of any endangered or threatened species. 16 U.S.C. § 1536(a)(2); *see also Fla. Key Deer v. Paulison*, 522 F.3d 1133, 1138 (11th Cir. 2008) (Section 7(a)(2) imposes two obligations on federal agencies, the first being "procedural and requir[ing] that agencies consult with the FWS to determine the effects of their actions on endangered or threatened species and their critical habitat" and the second being "substantive and requir[ing] that agencies insure that their actions not jeopardize endangered or threatened species or their critical habitat."). NEPA seeks to prevent damage to the environment by focusing government attention on the environmental effects of proposed agency action. *Marsh v. Oregon Nat. Res. Council*, 490 U.S. 360, 371 (1989). Any agency action having adverse effects on an endangered or threatened species may properly be considered significant action triggering NEPA hard-look requirements. *See Ctr. For Biological Diversity v. Nat'l Highway Traffic Safety Admin.*, 538 F.3d 1172, 1220 (9th Cir. 2008).

The Red Wolf Program having been declared a success in 2007, defendants, beginning in approximately 2014 and without consultation or formal review, determined to disregard management guidelines which had been in place since 1999 which distinguished between problem and non-problem wolves in regard to landowner take requests, to cease introductions of wolves into the wild, to cease pup-fostering, and to cease actively attempting to manage the threat from coyotes on the viability of the wild red wolf population. While a shift in any one or some of these activities may fall within the agency's discretion, when taken together, these actions go beyond the agency's discretion and operate to violate USFWS' mandate to recover this species in the wild. As defendants point out, due to a number of factors, including gunshot mortality and the increased presence of coyotes, the wild red wolf population began to gradually decline starting in 2006, but more than 100 red wolves remained in the wild in 2012-2013. *See* [DE 88 at 322]. Notably, however, the wild red wolf population saw a drastic decrease from 2013 to 2015, with only approximately fifty wolves in the wild in 2015. *See* Pl. App. 739. The population decrease coincides with defendants' making internal revisions to its guidelines and management policies, in response at least in part to mounting public pressure against red wolf recovery efforts, and defendants have failed to proffer any other evidence which could be deemed responsible for such change.

Allowing the wild red wolf population to continue to decline, while having access to methodologies which were previously successful in increasing or maintaining the wild population of the species, is an interpretation and application of the red wolf 10(j) rule that "is so implausible that it could not be ascribed to a difference in view or the product of agency expertise." *Motor Vehicle Mfrs.*, 463 U.S. at 43. It is undisputed that the reintroduction of the red wolf into the Red Wolf Recovery Area is not without its challenges, but absent a change in Congress' mandate or a

decision to delist or reclassify the red wolf under the ESA, the recent USFWS decisions to discontinue successful population management tools while increasing the likelihood that landowner lethal takes will be approved for wolves which historically would not have been subject to take, amount to a failure comply with its affirmative duty to "carry out conservation measures until conservation [is] no longer necessary." *Ctr. for Biological Diversity v. Vilsack*, 276 F. Supp. 3d 1015, 1031 (D. Nev. 2017); *see also Defs. of Wildlife v. Tuggle*, 607 F. Supp. 2d at, 1116-17 (Under ESA Section 4(d), USFWS has discretion to issue the regulations it deems necessary and advisable, but the regulation "shall" provide for the conservation of such species.").

Defendants' argument that their current red wolf management efforts are sufficient and within their discretion fails.

> while agencies might have discretion in selecting a particular program to conserve . . . they must in fact carry out a program to conserve, and not an "insignificant" measure that does not, or is not reasonably likely to, conserve endangered or threatened species. To hold otherwise would turn the modest command of section 7(a)(1) into no command at all by allowing agencies to satisfy their obligations with what amounts to total inaction.

Fla. Key Deer, 522 F.3d at 1147. Moreover, as was aptly stated by USFWS in 1999, "[w]ildlife are not the property of landowners but belong to the public and are managed by Federal and State governments for the public good. Such concepts and laws do not provide for taking or removal of wildlife from private lands in the absence of a problem." Pl. App. 730.

Defendants themselves have stated that actions such as those it has already undertaken would require compliance under ESA Section 7 and NEPA, Pl. App. 977, and there is no doubt that defendants' decisions to cease wolf introductions while simultaneously increasing the likelihood of authorized lethal takes by landowners "may adversely affect an endangered or threatened species". *Ctr. for Biological Diversity*, 538 F.3d at 1220 (quoting 40 C.F.R. § 1508.27(b)(9) and noting that action would trigger NEPA compliance if this factor is present).

In sum, plaintiffs' have satisfied their burden to demonstrate the above-described actions of defendants were arbitrary and capricious and otherwise violated Sections 9, 4, and 7 of the ESA as well as NEPA.

IV. Appropriate Relief

As the Court has found that summary judgment in favor of plaintiffs is appropriate as to all but plaintiffs' third claim for relief, the Court orders the following injunctive and declaratory relief.

A. Injunctive relief

On September 29, 2016, the Court entered a preliminary injunction enjoining defendants from taking red wolves, either directly or by landowner authorization, pursuant to 50 C.F.R. §§ 17.84 (c)(4)(v) and (c)(10) without first demonstrating that such red wolves are a threat to human safety or the safety of livestock or pets. The preliminary injunction remains in place and no appellate review has been conducted. Plaintiffs having demonstrated that judgment in their favor is appropriate all but one of their ESA and their NEPA claims, the Court finds that the preliminary injunction should be made permanent. Accordingly, defendants are hereby ENJOINED from taking red wolves, either directly or by landowner authorization, pursuant to 50 C.F.R. §§ 17.84 (c)(4)(v) and (c)(10) without first demonstrating that such red wolves are a threat to human safety or the safety of livestock or pets.

B. Declaratory relief

Plaintiffs have further demonstrated that they are entitled to declaratory relief as follows:

1. Defendants have violated the red wolf rule, 50 C.F.R. § 17.84(c)(2), and Section 9 of the ESA, 16 U.S.C. § 1538(a)(1)(G), by authorizing private landowners to take red wolves on their property without satisfying the express terms of 50 C.F.R. § 17.84(c)(4)(v);

2. Defendants have violated Section 4 of the ESA, 16 U.S.C. § 1533(d), by failing to provide for the conservation of the red wolf and failing to administer the red wolf

program in furtherance of the purposes of the ESA through its new interpretation and application of 50 C.F.R. § 17.84(c);

3. Defendants have violated Section 7(a)(1) of the ESA, 16 U.S.C. § 1536(a)(1), by failing to administer the red wolf recovery program in furtherance of the purposes of the ESA;

4. Defendants have violated Section 7(a)(2) of the ESA, 16 U.S.C. § 1536(a)(2), by failing to ensure that implementation of 50 C.F.R. § 17.84(c), in light of new information and modifications to the application of the red wolf rule, is not likely to jeopardize the continued existence of the red wolf;

5. Defendants have violated NEPA, 42 U.S.C. § 4332(2)(c), by failing to comply with NEPA requirements to determine the impacts of interpreting the take exemptions of the red wolf rule.

CONCLUSION

Accordingly, for the foregoing reasons, plaintiffs' motion for summary judgment [DE 79] is GRANTED IN PART and DENIED IN PART. Plaintiffs' third claim for relief is DISMISSED as MOOT, and plaintiffs' are entitled to summary judgment in their favor on their remaining claims. Defendants' motion for summary judgment [DE 85] is GRANTED IN PART as to plaintiffs' third claim for relief and DENIED IN PART as to plaintiffs' remaining claims. Declaratory and injunctive relief is ORDERED as provided above.

SO ORDERED, this 4TH day of November, 2018.

Terrence W. Boyle

TERRENCE W. BOYLE
CHIEF UNITED STATES DISTRICT JUDGE

From the Field: Implementing recovery of the red wolf—integrating research scientists and managers



Michael K. Stoskopf, Karen Beck, Bud B. Fazio, Todd K. Fuller, Eric M. Gese, Brian T. Kelly, Frederick F. Knowlton, Dennis L. Murray, William Waddell, and Lisette Waits

Abstract The United States Fish and Wildlife Service (USFWS) developed guidelines for the composition and role of endangered species recovery implementation teams, but few teams have been established and their success has not been evaluated. Using the recovery program of the red wolf (*Canis rufus*) as a model, we describe the genesis, function, and success of the Red Wolf Recovery Implementation Team (RWRIT) in helping guide the establishment of a viable red wolf population in eastern North Carolina. In operation since 1999, the RWRIT meets bi-annually to review USFWS progress and provide recommendations aimed at maximizing success of species recovery. The team is comprised of 8 research scientists from disciplines including population genetics, canid ecology, population ecology, veterinary medicine, and captive management. Representation from each of these disciplines is deemed necessary for proper evaluation of recovery progress and assessment of future needs. Meeting attendance by the USFWS field management team ensures both proper reporting of past progress and future implementation of management recommendations. Over time, RWRIT members have assumed specific assignments for data analyses, further contributing to the recovery effort. Through the combined efforts of the USFWS field team and the RWRIT, the threat of introgression of coyote (*Canis latrans*) genes into the red wolf population has been substantially curtailed within the recovery area, and red wolf numbers and range have increased. The RWRIT serves as an example of a recovery implementation team that is successfully incorporating the principles of adaptive management and whose template could be adapted to other endangered species.

Key words adaptive management, *Canis rufus*, endangered species, implementation, recovery, red wolf

Recovery of any endangered species is influenced by a range of political, economic, social, as well as biological issues (Tear et al. 1993, Scott et al. 1995, Lundquist et al. 2002). Reconciling disparate concerns and perspectives into a cohesive program requires planning and decision-making processes that consider conflicting interests of various stakeholders. However, for a recovery program to succeed, it is equally critical that professionals tasked with the responsibility for managing endangered species be able to move forward with timely decisions based on practical management needs and scientific knowledge (Westrum 1994). The United States Fish and Wildlife Service (USFWS) red wolf (*Canis rufus*) recovery program is an example of a program faced with complex issues, where man-

agement successes have been strengthened and accelerated by integrating active adaptive management with careful and timely scientific inquiry. This paper describes how this integration is being achieved via a designated "recovery implementation team."

The red wolf is an endangered species that once roamed an extensive range including the southeastern United States, and possibly the entire woodlands of eastern North America (Wilson et al. 2000, Nowak 2002, Grewal et al. 2004). Although listed as endangered in 1967 (USFWS, 1967), population decline and apparent hybridization with coyotes (*Canis latrans*) were recognized in the early 1960s (McCarley 1962, McCarley and Carley 1979). The remaining red wolves were removed from the wild in the mid- to late 1970s with the goals of establishing a captive breeding program and eventually restoring captive-bred animals to portions of their historical range (U.S. Fish and Wildlife Service [USFWS] 1989). In 1987 the first red wolves were released in easternmost North Carolina (Figure 1) with the plan to establish a viable population (Parker 1987). The reintroduction efforts faced a myriad of social, political, and biological issues as the Red Wolf Recovery Plan (USFWS 1989) was implemented (Henry and Lucash 2000, Phillips et al. 2003).

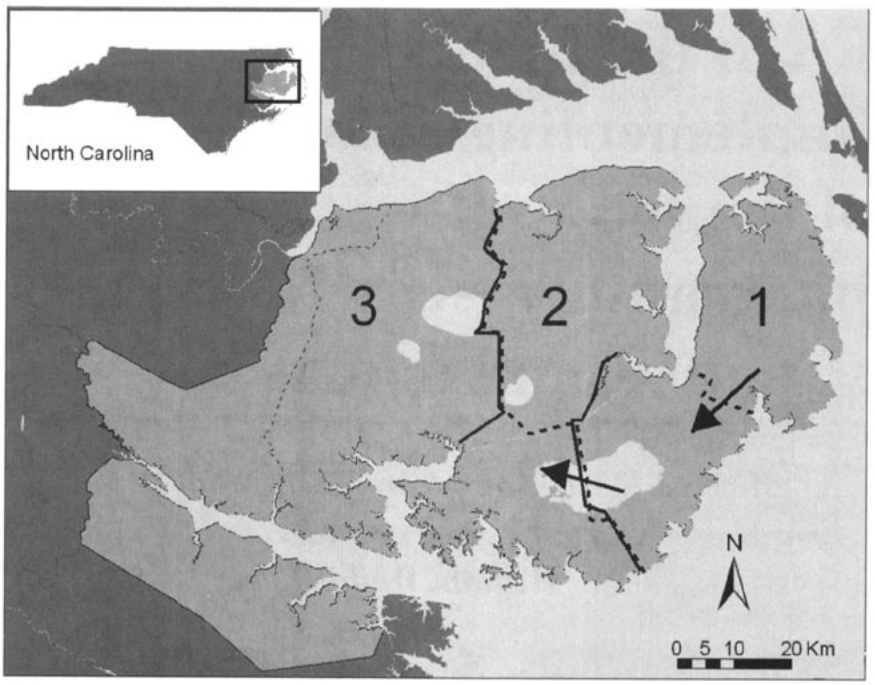


Figure 1. Changes in management zone boundaries within the Red Wolf Recovery Area of eastern North Carolina, as made in accordance with Red Wolf Adaptive Management Plans. The boundaries of the original management Zones 1, 2, and 3 (dashed lines) were first established in April 2000. In March 2002, as red wolf recovery proceeded, boundaries in the southern parts of the zones were moved west (solid lines); part of Zone 2 became Zone 1, while part of Zone 3 became Zone 2 (arrows). In August 2003 some management aspects of canids (i.e., sterilization vs. euthanasia) captured in the eastern half of Zone 3 (thin dotted line) began to follow guidelines applied to Zone 2.

Although the reintroduction area was initially considered uninhabited by coyotes, by the mid-1990s it was apparent coyotes had infiltrated the area and hybridization with red wolves was recurring (Phillips et al. 2003). Due primarily to the renewed hybrid threat and termination of the reintroduction of red wolves into Great Smoky Mountains National Park (Henry 1998), the USFWS decided it needed to re-evaluate its red wolf recovery effort in light of what had been learned over the previous decade. A key step in this review process involved a Population and Habitat Viability Assessment (PHVA) organized by the USFWS in 1999 and facilitated by the Conservation Breeding Specialists Group of the World Conservation Union, Species Survival Commission (IUCN SSC) (Kelly et al. 1999). The diverse assemblage of attendees, representing a variety of expertise and interests, agreed that introgression of coyote genes into the red wolf population was the principal threat to recovery success (Kelly et al. 1999). The group also recognized this issue required urgent attention before hybridization became so pervasive as to virtually ensure the genetic swamping of the only extant free-ranging population of red wolves. However, 2 views of how to address the hybrid threat emerged from the PHVA; one believed research was integral to addressing the problem, and the other expressed concern that research efforts would distract from the primary goal of maintaining the only free-ranging population of red wolves in the world. A consensus agreement was reached on this debate and resulted in an overarch-

ing workshop statement, including:

> "...our primary recovery focus must be protecting and promoting the growth of a self-sustaining, non-hybridizing population of red wolves in the wild and sustaining an active captive component. Actions to be taken will use an adaptive management approach that will not compromise the ability to achieve this goal." (USFWS 1999:52)

This level of agreement among the diverse participants of the PHVA set the stage for designing an adaptive management plan (*cf.* Lancia et al. 1996) that would reduce the threat of wolf-coyote hybridization. This plan (Kelly 2000) diverged from conventional endangered species management because it involved an incremental process tailored to modify field protocols according to past success in eliminating the threat of hybridization. Specifically, it required the release area to be segregated into several defined management zones, each managed to provide an integrated optimization of risk reduction within the resource limitations available to the project (Figure 1). As nonwolf canids were removed from given zones and replaced with red wolves, management options could be adapted by modifying zone boundaries or adjusting specific management protocols.

Adoption of this plan, requiring frequent re-evaluation of data and attendant management adjustments, spawned close interactions between USFWS field biologists and scientists with backgrounds relevant to the work being undertaken. A Red Wolf Recovery Implementation Team (RWRIT) was formed to advise USFWS as they implemented the adaptive management plan; this team was created pursuant to Section 4(f)(2) of the amended Endangered Species Act (ESA), which authorizes the Secretary of the Interior to procure the services of appropriate public and private agencies, institutions, and other qualified persons to help implement endangered species recovery plans. Other USFWS-designated species-specific implementation teams, as opposed to planning teams, have been formed (e.g., black-footed ferret [*Mustela nigripes*], northern right whale [*Eubalaena glacialis*], Okaloosa darter [*Etheostoma okaloosae*], and southern sea otter [*Enhydra lutris*]; USFWS files), but they are rare and no formal description of one's workings or success has yet been documented.

Recovery implementation team composition

Selection of the RWRIT scientists and their leadership was important to the success of implementing and evaluating the adaptive management plan. The PHVA helped the USFWS identify individuals with the combined expertise and personality considered important in a functional RWRIT. The PHVA also provided insight to the breadth of expertise needed over the long term. This expertise included such diverse fields as systematics, genetics, population modeling, health management, and canid biology, behavior, ecology, and management. Social scientists were not required in this case because those issues were, and continue to be, successfully dealt with by the USFWS field management team in conjunction with non-governmental organizations (Henry and Lucash 2000). Direct experience with the red wolf was not a requisite criterion for RWRIT membership. In fact, due to the long and controversial scientific history of the red wolf, some team members were sought for their naiveté of red wolves to minimize preconceived notions regarding the problems the adaptive management plan addressed. Thus, a mixture of experienced and young research scientists with strong records of scientific productivity and interpersonal skills was selected. Each member of the RWRIT had to be willing to use a data-driven approach to decision-making while remaining open to challenges of interpretation. Each member also had to be willing to accept group decisions as well as devote considerable personal time toward solving issues associated with the red wolf program.

The RWRIT needed to be large enough to provide the scientific diversity needed to assess the broad range of critical issues, but small enough to support close working relationships among members and result in productive meetings (Clark and Westrum 1989). A basic philosophy was that if the RWRIT needed expertise from individuals or disciplines outside the RWRIT to address specific issues, guest scientists would be invited to participate in the appropriate meetings. Initially, a goal of 8 members and 4 alternates was considered. Interactions of the group and reliability of participation in early meetings were used to identify the core members of the RWRIT. Since then, the size and composition of the RWRIT (8 members, no alternates) has worked well, sustaining effective decision-making with absences at meetings being rare. The leader of

the RWRIT needed to moderate meetings efficiently while allowing for creative interactions among RWRIT members. To ensure this, a senior scientist at a local university was selected due to his demonstrated scientific and leadership skills.

Experienced and stable field team

The USFWS field team involved in the day-to-day operation and management of the red wolf recovery program was key to the success of the RWRIT. The field team attended all RWRIT meetings as nonvoting members and provided the necessary data and expertise for the meetings to progress effectively. This distinction between the teams initially caused some anxiety, but this subsided once roles had been fully elucidated. The field team is remarkably stable and has worked cohesively on the red wolf project for many years (Phillips et al. 2003). Scientists of the RWRIT recognize the field team as the most experienced red wolf biologists and essential for successful functioning of the RWRIT itself. In turn, the field team's willingness to listen to and implement recommendations made by the RWRIT has been a critical factor in the success of the program. Open communications between the 2 teams keeps RWRIT scientists aware of the implementation of recommendations and fosters respect for the dedication of the field team.

Getting started

The first meeting of the RWRIT was important in establishing the tenor of group interactions and future functioning. Subsequent meetings would focus on examining data related to specific questions within an established agenda, but the first meeting focused on developing operating procedures for decisions as well as the types of data and data formats the team preferred for review and evaluation. This was a step that helped acquaint members of the team and recognize proper working protocols. It also ensured that all members of the team had a common understanding of the Red Wolf Adaptive Management Plan (RWAMP).

The charge of the RWRIT was established a priori by the Team Leader of the Red Wolf Recovery Program (i.e., "Red Wolf Program Leader"). This task was defined specifically as reviewing progress on the RWAMP and recommending changes to the plan based on data provided by the USFWS. As the team gained experience, this charge evolved to include recommendations for data relevant to answering specific questions important to the field team in the day-to-day management of the wild red wolf population. The 2 charges were closely related, frequently blended, seldom distinct, fundamental to the Adaptive Management Paradigm (Walters 1986), and are the responsibilities that drive efforts of RWRIT members. From the beginning, per the ESA, RWRIT recommendations were strictly advisory, with decisions for implementation being at the discretion of the USFWS.

Ground rules established in the first meeting have rarely been adjusted. Some established the mechanics of operations. For example, it was decided a minimum of 6 RWRIT members would be required as a quorum for a functional meeting. Failure to achieve quorum would trigger an evaluation by the RWRIT Leader and the Red Wolf Program Leader to assess whether the RWRIT remained an appropriate mechanism. To date this has not been necessary due to continued strong and enthusiastic attendance.

Other rules provided guidance for RWRIT interactions. To reduce stifling potentially meritorious but perhaps unconventional ideas, the team adopted a basic rule indicating that speakers must present alternative solutions when challenging or negating a proposed idea or approach. Ideas would be withdrawn from consideration only after careful efforts to refine them failed to produce workable solutions. To the fullest extent possible, data would be used to support all positions.

Other procedural mechanisms established in the first meeting have had a beneficial effect on RWRIT operations. For example, tentative dates, times, and location of future meetings are established jointly early in the agenda of each meeting. In addition, the agenda of the next meeting is established near the completion of the current session, which probably produces a more dynamic agenda than a call just before the meeting. Opportunities to add agenda items at any time remain, but the draft of the agenda appears in the final minutes; serving as a reminder for participants as they prepare for the coming meeting.

An important activity reserved for the end of each meeting is an exercise in prioritizing "action items", which are further classified as either "tasks" (expected to be accomplished within the time frame of the meeting or between meetings); "projects" (longer duration activities); or "manuscripts" (the drafting of information for publication).

Individual RWRIT members are recognized as responsible for addressing each item. With many issues to consider and an active agenda, many more action items are identified than can typically be accomplished with the resources available. The action items established throughout the meeting and recognized as "projects" are assembled in a descriptive list and as a final exercise, each member of the RWRIT assigns a priority level to each item and the mean rating is computed. This rating is offered to the Red Wolf Program Leader as a recommendation for activities to pursue or fund. At the first meeting, a pattern was established where RWRIT members worked to identify key management questions and to focus scientific inquiry in areas of need with constant reference to the adaptive management plan. Assets are identified and resource limitations discussed so recommendations have a reasonable likelihood of implementation. Short proposals outlining the objective of projects and the team member(s) involved in the work are distributed to the RWRIT via the team's webpage. The webpage also includes team member contact information, minutes of meetings (see below), data sets, reports, press releases, publications, project descriptions, manuscripts in progress, and upcoming meeting agendas and related materials such as reports and summaries.

Since 2000 the RWRIT has met bi-annually, which is sufficient to respond in a timely manner to questions from the field and to strengthen collegial bonds among members. This schedule also allows sufficient time for the field team to implement recommendations and to document their progress and for RWRIT members to work independently on action items. Other factors affecting meeting schedules include a need to make recommendations ahead of budget deadlines and to accommodate schedules of the individual RWRIT members and the field team. The current pattern of meetings includes 1 meeting in March prior to the denning season and a second in October prior to intensive trapping efforts.

Staying flexible

Any group with dynamic tasks needs a mechanism for adjusting the nature of the group as it matures and as tasks change (Clark and Reading 1994). The concept of alternate members soon was abandoned because of the strong attendance by RWRIT members and because it reduced inefficiencies associated with updating new attendees. The ability to invite experts in areas not represented on the RWRIT provides a mechanism to maintain flexibility and adaptability. Periodic review of expertise needed for specific tasks and projects of the RWRIT keeps the issue of change before the team. In addition, there exists ample opportunity to discuss candidly both the pros and cons of the teams' efforts, either formally at the end of each meeting or informally during meals or after hours. The RWRIT Leader needs to recognize dissenting views and address contentious issues promptly and effectively. The fact that for most meetings the entire RWRIT was communally housed in rented accommodations further ensured the establishment of favorable personal relationships benefiting RWRIT interactions and discussion.

Complete minutes of RWRIT deliberations provide documentation of the team's discussions and recommendations. An iterative process of editing minutes is used by the RWRIT, ensuring important information developed at each meeting is recorded accurately and in language deemed appropriate by the participants. Notes are converted into a draft each evening and individualized, and printed copies are distributed to attendees the following morning for editing. All drafts are synthesized into the penultimate draft for further comment, which is followed by a final draft distributed electronically shortly after completion of the meeting. The RWRIT members have a week to return any corrections, after which the final minutes are completed and distributed electronically. The deliberations of the RWRIT are considered privileged communication, and all meeting participants are asked to limit discussions of information received at the meetings to individuals within their respective research groups. This policy allows RWRIT members access to sensitive and preliminary data and provides more freedom of discussion without concerns about inappropriate disclosure. Distribution of the minutes beyond the RWRIT is at the discretion of the Red Wolf Program Leader.

How well does it work?

The test of any system is how well it functions to meet the goals and objectives of the program it serves. In the 4 years since the first formal meeting of the RWRIT, key challenges to implementing the plan developed at the PHVA have been identified and strategies have been devised to provide practi-

cal solutions and evaluate success of recovery efforts. Perhaps more importantly, all RWRIT members and the entire red wolf field team have become close colleagues who look forward to each meeting. We enjoy the frank and open exchange of ideas, the ability to quickly address both practical and theoretical problems and make changes in management practices, and the successes in the field that result from the collaboration. The details of these changes and successes are the basis of several scientific papers, some already published or in press and others currently in preparation, but a brief summary is warranted.

Prior to 1998 all canids captured in the red wolf recovery area were assumed to be wolves unless they were so small as to be considered coyotes, if they were black, or if they looked part dog. If there was some indication that a single female wolf was consorting with a coyote or dog, pups she produced were removed (A. Beyer, USFWS, personal communication). Thus, the basic challenge of rapidly and confidently identifying animals as red wolves versus hybrids or coyotes, especially young animals, was identified early as a key concern of the PHVA and the field team. The RWRIT served as catalyst for developing an enhanced and improved genomic testing protocol by expanding the ability to assess alleles at 19 loci (Miller et al. 2003). A priority placed on obtaining genomic assessments of the entire group of founders in the captive breeding program, as well for coyotes in the vicinity of the wolf release zones, greatly improved the confidence in the genomic data now available. Genetic analyses were integrated with pedigree and morphometric data to develop decision trees for all captured animals (Table 1). Extension of the DNA analysis capabilities to fecal samples increased the potential for assessing presence of red wolves, as well as undesired non-red wolves, in the field samples without the need of capturing and handling animals (Adams et al. 2003). Additional research efforts were directed at using this technology for assessing red wolf population size (J. R. Adams and L. P. Waits, University of Idaho, unpublished data).

To evaluate progress of the adaptive management plan, RWRIT scientists wanted detailed and current descriptions of animal locations, their genotypes, and canid inventory efforts in relation to geographic areas. A coordinated Geographic Information System (GIS) database system is now used at all RWRIT meetings to examine recovery progress. This is steadily approaching the goal of a real-time data view as data entry and validation challenges are addressed and data summaries are refined. These tools help identify areas where data are insufficient to define the status of canids and help develop strategies to eliminate so-called "areas of ignorance" by concentrating efforts in areas needing more attention. In addition, they have lead to improved ground telemetry efforts and more efficient use of resources and personnel.

Modeling effects of coyote genomic intrusion, using more refined data sets and newer models than available at the PHVA, provided RWRIT scien-

Table 1. Decision path for genetic results of red wolves (RW) captured in the experimental population area in northeastern North Carolina, applied in fall of 2003 (explanation of genetic result classifications given in Miller et al. 2003). Decision parameters listed in the following priority: Genetic testing; Pedigree; Morphology; Mate.

	Capture location[a]	
Decision parameter	Zone 1	Zone 2
1. Genetic test: 100% RW (pedigree 100% RW)	Release	Release
1. Genetic test: 100% RW but cannot exclude 75% RW hypothesis	Consider pedigree (go to 2)	
2. Pedigree is 100% to 87.5% RW	Release	Release
2. Pedigree is 87% to 75% RW or unknown	Consider morphology (go to 3)	
3. Morphologically "hybrid-like"	Euthanize	Sterilize
3. Morphologically "RW-like"	Consider mate (go to 4)	
4. Mate is ≥75% RW	Release	Release
4. Mate is <75% RW or uncertain	Euthanize	Sterilize 1 mate
1. Genetic Test: 75% RW or 75% RW but cannot exclude 50% RW hypothesis	Consider pedigree (go to 5)	
5. Pedigree is <75% RW	Euthanize	Sterilize
5. Pedigree is ≥75% RW or unknown	Consider morphology (go to 3)	

[a] See Figure 1.

tists new insights into impacts of genomic intrusion (e.g., Miller et al. 2003). This allowed for key insights to establishing acceptable risks defined in the decision trees. This also assisted in the making of informed recommendations for modifying approaches to the various management zones for red wolf recovery. Recently, the RWRIT initiated an effort to conduct detailed analyses of home range, spatial interactions, habitat use, and demographic attributes of all radiomonitored red wolves since 1986, with the objective of developing a population viability model to help guide future management and recovery actions. Den management techniques via implementation of early genomic sampling and use of cross-fostering of wild-caught and captive bred pups into wild litters have been developed (cf. Kitchen and Knowlton, *in press).* Methodology also has been enhanced to conduct surgical procedures to support the use of hormonally intact but sterile hybrids and coyotes to serve as sterile buffers (i.e., temporary territory placeholders that discourage establishment of new, intact nonwolves) in peripheral management zones (Figure 1).

The net result of such activities has led to an increase in the area occupied by red wolves, total number of red wolves, and number of red wolf social units, as well as a major decrease in the total area where the status of canids, in general, is unknown (B. B. Fazio, USFWS, unpublished data). Such changes in these metrics were identified in the RWAMP as key indicators of the successful management of wolf-coyote hybridization. Importantly, coyotes or hybrids have essentially been eliminated from fully half of the red wolf recovery area. To date, genetic intrusion into the red wolf population has been largely controlled, albeit through aggressive intervention.

The effective functioning of the RWRIT has ensured that issues identified at the PHVA as described in the RWAMP have been, or are being, successfully addressed by USFWS. And as should be expected, the original red wolf adaptive management plan is now revised to include 5 years of evolving adaptive management (Fazio et al. 2004). The approach taken by the RWRIT represents a good example of successful application of the Adaptive Resource Management paradigm and is likewise consistent with, and respectful of, concerns raised by the participants at the PHVA that the primary goal of conserving the only free-ranging population of red wolves not be overshadowed by the desire to conduct research. Indeed, the USFWS recently highlighted the efforts of the Red Wolf Recovery Program in a videotape on how the use of sound science is key to meeting its mission.

We believe the recent tangible success in red wolf recovery is a direct result of conducting the PHVA, crafting a RWAMP, establishing the RWRIT, and the cooperation and close interaction between the RWRIT and the USFWS field team directly tasked with red wolf recovery. Endangered species recovery should involve a strong linkage between scientific investigation under the rubric of adaptive management and the appropriate blend of social, political, and economic issues (Clark et al. 1994). In light of the mixed past success in recovering endangered species in the United States (Crouse et al. 2002, Gerber and Hatch 2002), we believe, based on the success of the RWRIT, that recovery implementation teams can serve as an effective vehicle for helping guide recovery programs and actions.

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The collaborators on this paper have a variety of academic degrees, work experiences, and publications in a wide selection of fields and disciplines and have studied species from A to Z. They include (seated, from left to right) ***Karen Beck*** (ecological epidemiologist), ***Buddy Fazio*** (fiscal conservationist), ***Todd Fuller*** (quasi-experimental theoriologist), ***Eric Gese*** (investigative carnivologist), and ***Brian Kelly*** (politico-ecologist), and (standing, left to right) ***Fred Knowlton*** (historical canidilist), ***Dennis Murray*** (taxon-free numero-ecologist), ***Michael Stoskopf*** (conservation metabonomist), ***Will Waddell*** (ex-situ zoologist), and ***Lisette Waits*** (pan-molecular faecologist).

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Factors influencing red wolf–coyote hybridization in eastern North Carolina, USA

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ABSTRACT

Understanding the mechanisms that govern interspecific hybridization is vital to mitigating its impacts on endangered species. Research suggests that behavioral mechanisms such as mate choice and social disruption can regulate the rate at which hybridizing species interbreed. We investigated hybridization events between endangered red wolves (*Canis rufus*) and coyotes (*Canis latrans*) in eastern North Carolina to evaluate potential factors that may promote hybridization between these species. Specifically, we examined spatial location, breeding experience, breeder origin (captive vs wild), breeder ancestry (pure vs hybrid), and past history of the animal. There were over four times (126 vs 30) as many red wolf litters as hybrid litters over a 13 year time period. Over half of the hybridization events followed the disruption of a stable breeding pair of red wolves due to mortality of one or both breeders. Of these 69% were due to anthropogenic causes, primarily gunshot mortality prior to the red wolf breeding season. Both male and female red wolves interbred with coyotes, although a majority (90%) of the events we observed involved females. Wolves that produced hybrid litters tended to be young, first-time breeders with slightly higher levels of coyote ancestry. Only 16% of the hybrid litters were produced in the inner core of the red wolf recovery area. Our results suggest that disruption of stable breeding pairs of red wolves facilitates hybridization, jeopardizing future recovery of the red wolf. They also indicate the importance of behavioral forces, especially social stability, in regulating hybridization.

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1. Introduction

Human activity has the potential to disrupt dynamics between hybridizing species, which can cause hybridization and introgression to emerge as conservation threats (Rhymer and Simberloff, 1996; Allendorf et al., 2001). As with any conservation problem, developing solutions requires recognizing the mechanisms that influence the process. For hybridization, that requires understanding the mechanisms that cause previously reproductively isolated species to interbreed. Species introductions (Rhymer and Simberloff, 1996; Stigall, 2010), habitat destruction and ecological homogenization (Seehausen et al., 2008; Crispo et al., 2011), and the spread of domesticated species (Likre et al., 2010; Champagnon et al., 2012) have been implicated as processes that may facilitate these shifts.

Still, these forces primarily influence whether hybridizing species come into contact, not necessarily whether individuals will interbreed. There is increasing recognition that behavioral processes such as mate choice (Pfennig, 2007; Reyer, 2008; Svedin et al., 2008; Gilman and Behm, 2011; Robbins et al., 2014), interspecific competition (Wolf et al., 2001; Krosby and Rohwer, 2010; Sacks et al., 2011), and Allee effects (Lode et al., 2005) can influence the rate of hybridization. The potential for behavioral forces to moderate hybridization and introgression may be a critical factor that would influence conservation schemes.

Understanding the mechanisms that govern interspecific mating is vital to recovery of species threatened by hybridization, especially the critically endangered red wolf (*Canis rufus*) in eastern North Carolina. Historically red wolves were distributed across eastern North America, but overharvest, habitat destruction, and hybridization with coyotes (*Canis latrans*) led to extinction in the wild by 1980 (Paradiso and Nowak, 1972; Nowak, 2002; USFWS, 1990). Beginning in 1987, captive red wolves were reintroduced into eastern North Carolina and today a population of about 80–100 individuals occupies the 600 000 hectare Albemarle Peninsula (Phillips and Parker, 1988; Phillips et al., 2003; Bartel and Rabon, 2013).

At the same time, coyotes expanded their range into North Carolina (Hill et al., 1987) and in 1993 the first hybridization event between a reintroduced red wolf and a coyote was detected (Phillips et al., 2003). A subsequent population viability analysis

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suggested that hybridization was the greatest threat to red wolf recovery (Kelly et al., 1999). This led to the development of an aggressive adaptive management plan by the US Fish and Wildlife Service (USFWS) and the Red Wolf Recovery Implementation Team (RWRIT, Stoskopf et al., 2005) to limit hybridization and introgression. The genetic composition of the population is managed by an active monitoring program combined with genetic testing to remove hybrid individuals from the landscape (Stoskopf et al., 2005; USFWS, 2007; Bartel and Rabon, 2013).

Such aggressive practices have been implemented based on the hypothesis that a small red wolf population would be genetically swamped by coyotes without human intervention (Kelly et al., 1999). This is predicated on the assumption that when sympatric, red wolves and coyotes will breed indiscriminately. However, this assumption has not been tested empirically. Fredrickson and Hedrick (2006) modeled red wolf viability and found that positive assortative mating and aggressive interactions between the species were the most important factors in maintaining population viability. They developed hypothetical values for those parameters because empirical estimates did not exist. USFWS field biologists have observed red wolves displacing and occasionally killing coyotes and hybrids (USFWS, 2007). Otherwise, there is little understanding of how mate choice and social structure influence interactions between these species. Given the importance of social dynamics on the ecology of mammalian carnivores, there is potential for behavioral processes such as mate choice, social structure, and competition to limit hybridization (Rutledge et al., 2010; Sacks et al., 2011; Shurtliff, 2011). Conversely, disrupting these social systems may in turn influence reproductive patterns (Brainerd et al., 2008; Borg et al., in press) and hybridization rates (Rutledge et al., 2010).

We examined breeding records and individual histories of red wolves involved in hybridization events from 2001 to 2013 to elucidate factors that facilitate interbreeding between these species. Specifically, we asked the following questions: (1) Do age, prior breeding experience, and origin of the wolf influence the likelihood of hybridization, (2) are individuals with mixed red wolf/coyote ancestry more likely to hybridize, (3) are hybridization events evenly distributed across the recovery area, and (4) are hybrid litters produced under particular scenarios or breeder histories? If breeding between these species is indiscriminate, we would expect young dispersing red wolves to be the most likely individuals to encounter and breed with a coyote. Breeding opportunities within wolf packs are often restricted to a dominant breeding pair, which forces individuals in search of mates to disperse outside the pack (Mech and Boitani, 2003; Sparkman et al., 2012). In this system dispersing would increase the likelihood of an individual encountering a coyote considering that wolf packs are known to exclude coyotes within their range (USFWS, 2007). This is similar to observations of eastern wolf (*Canis lycaon*) packs in southern Canada (Benson and Patterson, 2013). We predicted that hybridization would increase from east to west, since the western portion of the study area has the fewest wolves, least stringent management, and closest proximity to the mainland coyote population. Also, we hypothesized that individuals with mixed red wolf/coyote ancestry would be involved in more hybridization events. By examining the characteristics and history of red wolves responsible for hybridization events with coyotes, we can better understand the mechanisms that govern hybridization, aiding recovery of this species.

2. Materials and methods

2.1. Genetic monitoring

Every spring USFWS biologists track female red wolves to locate active dens that contain pups. Blood samples are collected from pups and genetic testing is conducted to assess their ancestry and place them within the red wolf pedigree (Adams, 2006; Bohling et al., 2013). Since the implementation of the adaptive management plan in 2000 monitoring of red wolf dens and genetic testing of captured canids, including pups, became standard, which improved detectability of hybridization events (Stoskopf et al., 2005; USFWS, 2007). As a result, we only considered hybridization events that have occurred since 2000 for this study. USFWS biologists possessed permits for capturing and handling red wolves that have been jointly issued by the USFWS, Association of Zoos and Aquariums Reintroduction Scientific Advisory Group, and IUCN Species Survival Commission Reintroduction Specialist Group.

Parentage for red wolf and hybrid litters was determined following the methods of Adams (2006) and Bohling et al. (2013). To summarize, each pup was genotyped at 17 microsatellite loci and assigned to red wolf parents using genetic and field data, allowing for $\leqslant 1$ mismatch for a parent pair. Based on this pedigree we were able to estimate an individual's ancestry by averaging the amount of red wolf ancestry possessed by the parents as traced through the pedigree. In the case of hybrid litters, typically only the red wolf parent was identified, although in several situations the non-red wolf parent was later captured and determined to be a parent using genetic analysis. Several hybrid litters were detected when hybrid offspring were captured as juveniles and later assigned to a red wolf parent. Three hybrid litters fit this scenario; thus, the exact size of those litters could not be determined.

2.2. Location

The adaptive management plan divided the peninsula into three zones with different management goals (Stoskopf et al., 2005) (Fig. 1). Zone 1, the easternmost portion of the peninsula, serves as the core red wolf population and coyotes and hybrids captured in this area are euthanized. In Zone 2, directly west of Zone 1, hybrid individuals are euthanized but coyotes are sterilized under the hypothesis that sterile individuals would serve as territorial placeholders that discourage undetected coyotes from dispersing into the peninsula (Bartel and Rabon, 2013). Zone 3 is the furthest west section and falls at the junction of the peninsula and the mainland. Management practices in Zone 3 vary, but many sections of this area are managed similarly to Zone 2. This entire region has been designated as the Red Wolf Experimental Population Area (RWEPA).

We classified each hybrid and red wolf litter to a Zone based upon where it was detected (Zone 1, 2, or 3) and used a χ^2-squared test of independence to evaluate the distribution of each type of litter across all three zones. As noted, some hybrids were discovered as adults. In these situations, once the red wolf parent was identified via genetic testing we assigned the location of these litters according to the home range of that red wolf during the prior breeding season.

2.3. Breeder experience

To examine the impact of breeder experience on hybridization we compared both the age and prior breeding experience of red wolves that produced hybrid and red wolf litters. For breeding experience we classified each litter according to whether it was produced by a first-time breeder or an experienced breeder. This was only performed for females since the sample size of male red wolves was low (see Section 3.1). We defined first-time breeder as any individual producing its first known litter of pups, regardless of whether it was a hybrid or red wolf litter. An individual was considered an experienced breeder once it had produced a second litter. We compared the proportion of total red wolf and hybrid litters that were born to experienced breeders using a χ^2

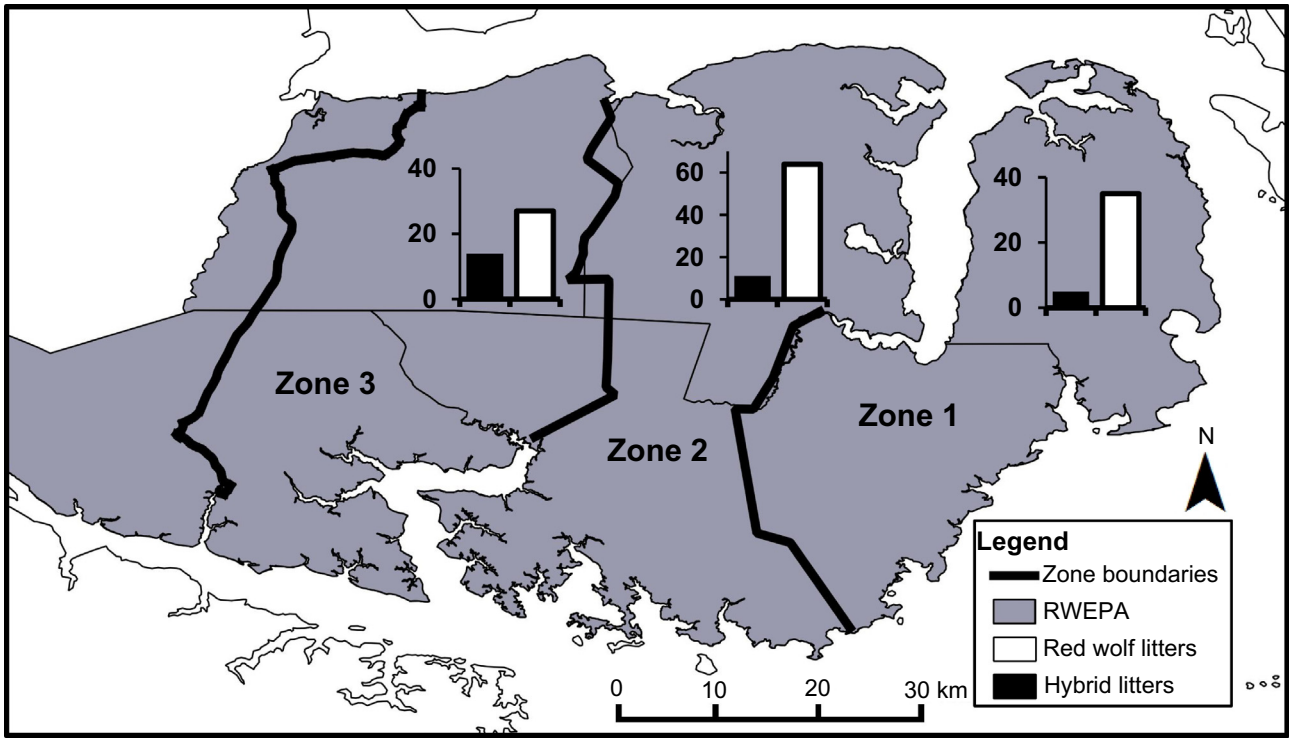


Fig. 1. Map of the Red Wolf Experimental Population Area (RWEPA) and the spatial distribution of hybrid and red wolf litters from 2001 to 2013. The thick black lines indicate the boundaries of the management zones 1, 2, and 3. The number of hybrid and red wolf litters per zone indicated by the graphs within each zone boundary. White columns represent red wolf litters, black hybrid litters.

test of independence. The effect of breeder age was measured by comparing the overall age of individuals responsible for hybridization events to the age of individuals producing red wolf litters. For three females the year of birth was unknown (Table 1).

2.4. Breeder origin

Over the past two decades the USFWS has released captive individuals and individuals raised in island-propagation programs to augment the wolf population. The island-propagation program consists of releasing captive red wolves to isolated, unoccupied barrier islands in the southeastern US so they can acclimate to the wild (Phillips et al., 2003). We hypothesized that the unfamiliarity of captive and island-raised individuals with the RWEPA would inhibit their ability to locate red wolf mates, increasing the likelihood that they would encounter and breed with a coyote. Using the pedigree we were able to determine the origin of each red wolf (wild, captive, and island-born) and whether it produced any litters. We also noted wolves produced through cross-fostering, which involves integrating recently born captive pups into wild litters to provide an input of genetic diversity (Bartel and Rabon, 2013).

2.5. Breeder ancestry

The hybridization event that occurred in 1993 between a female red wolf and male coyote resulted in introgression of coyote genetic material into the red wolf population. Two F1 hybrid males from this event bred with female red wolves and their offspring backcrossed with the red wolf population. The USFWS and RWRIT decided that any individual possessing >87.5% red wolf ancestry based on pedigree assignment would remain in the population (Stoskopf et al., 2005). A large segment of population now consists of these backcrossed individuals that have a slight amount of known coyote ancestry (87.5–98% red wolf) (Adams, 2006; Bohling et al., 2013). Our goal was to determine whether these admixed individuals had a higher propensity to hybridize than 'pure' wolves. We calculated the average ancestry of individuals involved in hybridization events using the pedigree and compared that to the ancestry of individuals producing red wolf litters using a two-tailed *t*-test. We applied an arcsin transformation to ancestry values prior to analysis.

Even though red wolves and coyotes hybridize, there are noticeable differences in morphology, behavior, and ecology between the species (Phillips and Henry, 1992; Nowak, 2002; Phillips et al., 2003; Hinton and Chamberlain, 2014). Hybrids are intermediate between the two species; thus, we predicted that a red wolf would be more likely to select a hybrid as a mate than a coyote. However, since aggressive management practices remove hybrids from the landscape, we hypothesized that the production of hybrid litters would be primarily driven by interbreeding with coyotes. Since the non-red wolf parent was identified for several hybrid litters, we evaluated the ancestry of these animals using two methods to determine if they were coyotes or individuals of mixed ancestry. First, ancestry of non-red wolf individuals was assessed using the Bayesian clustering program STRUCTURE 2.3 (Pritchard et al., 2000; Falush et al., 2003). We used four known genetic groups as training sets: coyotes ($N = 94$) from North Carolina, Virginia, and Texas; gray wolves ($N = 38$) (*Canis lupus*) from Idaho and Alaska; domestic dogs ($N = 28$); and founders of the captive red wolf population ($N = 17$). Our previous work (Bohling and Waits, 2011; Bohling et al., 2013) showed that these four groups form distinct clusters when applied to STRUCTURE in a free-clustering framework. In the STRUCTURE analysis, individuals from our four known genetic groups were assigned a POPFLAG designation of 1 and the 'Use Population Information' option was used as the ancestry model with the default parameter settings and the correlated allele frequency model. Unknown individuals were given the

Table 1
Characteristics of the individual wolves involved in hybridization events.

Year	Wolf[a]	Sex[b]	% Red wolf ancestry[c]	Origin[d]	Year born	First breeding event	Litter size	Zone[h]	Coyote ID[i]	History[j]
2001	11100	F	100	Wild[e]	NA[f]	Yes	6	2		Wolf dispersed
2001	11055	F	75	Wild	NA	No	3	3	30145	No previous history[k]
2001	10884	F	100	Wild	1995	Yes	9	3		No previous history
2001	11049	F	87.5	Wild	1999	Yes	6	3	20271	No previous history
2002	10947	M	75	Wild	NA	No	5	1	30214	Mistaken identity[l]
2002	11168	M	87.5	Wild	NA	Yes	NA[g]	1	30218	Breeder killed-poison
2002	11231	F	87.5	Wild	NA	No	NA	3	30272	Breeder killed-gunshot
2002	11030	F	100	Wild	1999	Yes	6	3	30205	Mistaken identity
2003	11030	F	100	Wild	1999	Yes	5	3	30205	Mistaken identity
2005	11037	F	87.5	Wild	1999	No	9	1		Breeder killed-gunshot
2005	11049	F	87.5	Wild	1999	No	6	3	20290	Breeder killed-gunshot
2006	11132	F	87.5	Wild	2001	No	9	2	20377	Breeder killed-natural
2006	11163	F	93.75	Wild	2001	Yes	6	2	20375	Breeder killed-trap injury
2006	11049	F	87.5	Wild	1999	No	1	3		Breeder killed-gunshot
2006	11248	F	100	Wild	2003	Yes	5	3		Breeder killed-gunshot
2006	11148	F	87.5	Wild	2001	Yes	6	3		Wolf displaced
2007	11323	F	96.9	Wild	2004	Yes	2	3		Coyote displaced
2008	11541	F	100	Wild	2006	Yes	4	1		Breeder killed-mange
2008	11517	F	100	Wild	2006	Yes	7	2		Breeder killed-gunshot
2008	11301	M	93.75	Wild	2004	No	NA	3	20493	Coyote displaced
2009	11440	F	93.75	Wild	2005	Yes	6	2		No previous history
2009	11429	F	96.9	Wild	2005	Yes	6	3		Breeder killed-gunshot
2010	11298	F	87.5	Wild	2003	No	8	2		Breeder killed-intraspecific mortality
2011	11779	F	90	Wild	2009	Yes	5	2		Previous breeder disappeared
2011	11630	F	96.9	Wild	2007	No	6	2		No previous history
2011	11725	F	100	Island	2007	Yes	5	2		No previous history
2012	11725	F	100	Island	2007	No	4	2		No previous history
2013	11837	F	100	Wild	2010	Yes	4	2		Breeder killed-gunshot
2013	11693	F	96.9	Wild	2008	No	6	3		Previous breeder disappeared
2013	11819	F	93.8	Wild	2010	Yes	4	1		Breeder killed-gunshot

[a] Identification number of the individual wolf involved in the hybridization event.
[b] F – female; M – male.
[c] Based on the red wolf pedigree.
[d] Birth location of individual.
[e] Wild-born individual from the reintroduced population in North Carolina.
[f] For these individuals the age of birth could not determined.
[g] These litters were detected after USFWS biologists captured the hybrids as juveniles and genetic testing assigned parents.
[h] Refers to the management zone that the litter was discovered.
[i] The individual that bred with the red wolf was unable to be determined for all litters.
[j] History of the location and/or red wolf prior to the production of the hybrid litters.
[k] No significant history was recorded for these individuals.
[l] The individual the red wolf had paired with had been erroneously identified as a red wolf.

POPFLAG = 0 designation, which means their genotypes were not used to estimate allele frequencies. The number of populations was set to four with a burn-in period of 100 000 reps followed by 1 000 000 MCMC repetitions.

For each genetic cluster STRUCTURE produces a probability value that an individual's genotype originated from that group. We considered an individual 'admixed' using two different criteria following Bohling and Waits (2011). If an individual had a probability of assignment $\geqslant 0.1$ for two or more species, we considered that evidence of admixture under our 'Relaxed' criterion. STRUCTURE estimates credibility intervals around each probability value. If the 90% credibility intervals for the values of two or more genetic groups did not overlap zero, we considered this strong evidence of admixture under our 'Conservative' criterion. Our reasoning was to provide two perspectives for interpreting individual ancestry (Bohling and Waits, 2011; Latch et al., 2011). A concern with comparing these results with the red wolf pedigree is that the pedigree is based on theoretical expectations of inheritance while the STRUCTURE results are based on model-estimates using genetic data. To examine if there was any bias in using ancestry estimates based on the pedigree, we compared ancestry estimates produced by both methods for all red wolves involved in hybrid and wolf reproductive events using a paired *t*-test.

Miller et al. (2003) developed a maximum-likelihood assignment test specifically for this red wolf–coyote system. This Canid Assignment Test (CAT) uses genotypes of founders of the captive red wolf population and coyotes from Texas, Virginia, and North Carolina to simulate genotypes of red wolves, coyotes, F1 and F2 hybrids, and F1 × backcrosses with each parental species. Maximum-likelihood tests are then used to estimate the probability of an individual's genotype originating from those six classes. This test is used by the USFWS in conjunction with the pedigree assignment in management decisions and we included those results for another perspective on ancestry.

2.6. Breeder history

We assessed breeder history for each red wolf involved in known hybridization events. The information we collected focused on qualitative descriptions of specific events experienced by the wolves and/or the pack they were associated with. These events were documented by USFWS biologists as they monitored individual wolves over the course of the main period of dispersal and breeding (October–March). Examples of significant events included but were not limited to dispersal, displacement, formation of a new pack, disruption of breeding pairs, and mortality of an associated breeder. In the case of mortalities, a necropsy was conducted to determine whether the cause of mortality was natural or anthropogenic.

3. Results

3.1. Location

From 2001 to 2013, 30 hybrid litters and 126 red wolf litters were documented by USFWS biologists and confirmed via genetic testing (Fig. 2). The mean number of hybrid litters per year was 2.2 ($\pm 1.4\sigma$) whereas the mean number of red wolf litters was 9.7 ($\pm 1.7\sigma$). The average number of pups were higher in hybrid litters (5.5) than red wolf litters (4.2) ($p = 0.001$). In a majority of the cases (27 of 30) a female was confirmed as the red wolf parent of a hybrid litter. A total of 23 female red wolves were involved in hybridization events; most only produced one hybrid litter. Two females were responsible for two hybrid litters each and another was responsible for three. The three male red wolves that produced hybrid litters were responsible for one each.

A majority of the hybrid litters were found in Zones 3 ($n = 14$) and 2 ($n = 11$), with the lowest number in Zone 1 ($n = 5$) (Fig. 1). Conversely, red wolf litters were more evenly distributed (Zone 1 = 35, Zone 2 = 64, Zone 3 = 27). The distribution of red wolf and hybrid litters across the zones was significantly different ($\chi^2 = 8.05$, $p = 0.02$). All red wolves that produced hybrid litters were originally born in the wild except for one female wolf that was born in the island propagation program. Most of the females responsible for red wolf litters were also wild-born ($n = 43$), but four cross-fostered and three island-born females also produced litters. Among males that produced red wolf litters, 47 were wild-born, six island-born, one captive-born, and one cross-fostered.

3.2. Breeder experience

Since a majority of the hybrid litters were produced by females, we only examined breeding age and experience for female red wolves. Among hybrid litters, 16 of 27 involved a female breeding for the first time. This was a significantly higher ($\chi^2 = 8.8$, $p = 0.003$) than the proportion of red wolves litters that involved a first-time breeding female (35 out of 120). Across all litters, the average age of female red wolves responsible for hybrid litters (4.2 years ± 1.6σ) was less than the average age of those responsible for red wolf litters (5.2 years ± 2σ; $p = 0.007$).

3.3. Breeder ancestry

There was no significance difference between the values of ancestry produced by the pedigree and STRUCTURE for individual red wolves ($p = 0.89$). Thus, we report results from the pedigree. Due to the low number of males involved in hybrid litters, we restricted comparisons to female wolves to ensure adequate sample sizes. The average red wolf ancestry of females involved in hybrid events was 0.939 while those involved in red wolf litters had an average of 0.963. Following data transformation, these values were not significantly different ($t = 2.02$, $p = 0.128$). For males, the average amount of red wolf ancestry was 0.947 for those that produced red wolf litters and 0.854 for those producing hybrid litters, but we did not test statistical significance due to low sample size.

The suspected non-red wolf parent was identified by USFWS biologists using field observations for 16 hybrid litters. Two litters involved the same non-red wolf parent: a male that had been mistakenly identified as a red wolf based on morphological examination in the field. Genotypes were obtained for 10 of these non-red wolf parents. Based on the STRUCTURE results, only three individuals appeared to be pure coyotes using the 0.9 q-value threshold (Fig. 3). Two additional individuals also appeared to be coyotes, for they had q-values of 0.81 and 0.77, respectively, for the coyote cluster and no other q-value >0.1. For these five individuals the credibility interval surrounding the q-value for only the coyote cluster did not overlap zero. Four of these individuals we classified as coyotes by the CAT; one, 30272, was classified as a coyote × F1 backcross (Table 2).

Two individuals had q-values indicative of F1 coyote–red wolf hybrids (Fig. 3). Using the red wolf pedigree, we were able to identify the red wolf and coyote parent for both of these individuals, confirming that they were F1 hybrids. Individual 30205 was the only individual for which the credibility intervals for the coyote and red wolf cluster did not overlap zero. Both individuals were classified as F1 hybrids by the CAT (Table 2). Two other individuals appeared to be F1 × red wolf backcrosses (75%), which were confirmed using the pedigree, and one (30145) produced credibility intervals for two clusters that did not overlap zero. The CAT also classified these individuals as F1 × red wolf backcrosses. One individual appeared to be a F1 coyote–dog hybrid × coyote backcross (~75% coyote, ~25% dog) using the 'Relaxed' criterion. To the CAT, which does not incorporate dog ancestry, this individual was a coyote.

3.4. Breeder history

Seven of the 30 hybrid litters had no notable previous history associated with the red wolf responsible for the litter (Table 1). Only two instances resulting in hybrid litters involved red wolves that were considered 'dispersers'. One was a female red wolf that had been displaced by a neighboring female wolf and settled with a non-red wolf mate. The other was a female that exhibited wide movement patterns during the breeding season and never paired

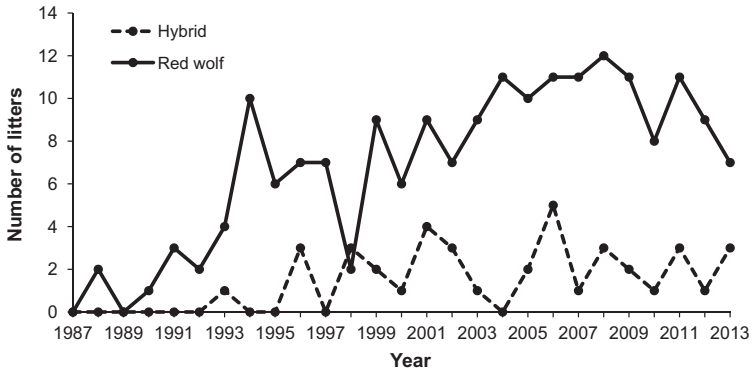


Fig. 2. Number of red wolf and hybrid litters produced each year since the reintroduction of red wolves into North Carolina. Beginning in 2000 the FWS implemented an adaptive management program to genetically monitor the population and reduce hybridization. As a result, for this study we focused solely on litters produced after 2001.

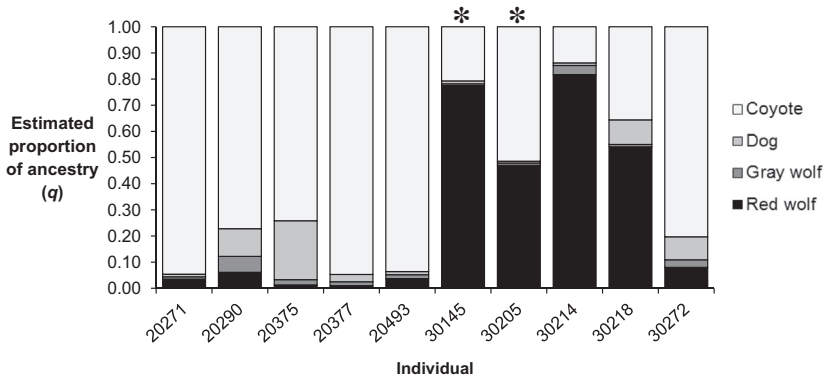


Fig. 3. STRUCTURE ancestry coefficients for the non-red wolf individuals responsible for hybridization events. Each bar represents an individual ancestry composition and each color reflects the ancestry value assigned to each species. This analysis was conducted with a dataset containing 17 polymorphic microsatellite loci. For individuals with a * above their bar plot, the STRUCTURE 90% credibility intervals did not overlap zero for two genetic groups. Individuals 30205 and 30218 were determined to be F1 coyote–red wolf hybrid using the pedigree. Individuals 30145 and 30214 were determined to be F1 × red wolf backcrosses using the pedigree.

Table 2
Results from the Canid Assignment Test (CAT) for non-red wolf individuals responsible for hybridization events. This test uses maximum-likelihood statistics to evaluate the probability of an individual belonging to six separate ancestry classes. The six classes are the two parental species (red wolf, coyote), F1 and F2 hybrid, and F1 backcrosses with each parental species. Values indicated the probability (p) that an individual's genotype can be excluded from that ancestry class. The most likely class is indicated by the term 'LMI'. Coyotes Specific Alleles (CSA) refers to number of alleles possessed by an individual that are found only in coyotes and not the founders of the red wolf population.

Individual	Most likely classification	Maximum-likelihood probability of assignment						CSA
		Red wolf	Coyote	F1	RWBC[a]	CoyBC[b]	F2	
20271	Coyote	0.004	LMI	0.004	0.004	0.072	0.004	11
20290	Coyote	0.004	LMI	0.004	0.004	0.0112	0.008	10
20375	Coyote	0.004	LMI	0.004	0.004	0.028	0.004	16
20377	Coyote	0.004	LMI	0.004	0.004	0.012	0.004	13
20493	Coyote	0.004	LMI	0.004	0.004	0.124	0.004	10
30145	RWBC	0.004	0.004	0.004	LMI	0.004	0.052	3
30205	F1	0.004	0.004	LMI	0.004	0.024	0.04	5
30214	RWBC	0.004	0.004	0.004	LMI	0.004	0.02	2
30218	F1	0.004	0.004	LMI	0.004	0.036	0.048	5
30272	CoyBC	0.004	0.044	0.004	0.004	LMI	0.036	10

[a] Red wolf × F1 hybrid backcross.
[b] Coyote × F1 hybrid backcross.

with a male red wolf. Three hybridization events were the result of a red wolf pairing with an individual that was previously believed to be a red wolf until genetic testing revealed otherwise. The previous history of these females was unknown. All three of these cases occurred in 2002 and 2003, soon after the implementation of the new management plan and strict genetic testing. Two of these cases involved the same female red wolf and male non-red wolf.

Half of the hybrid litters (16 of 30) followed the disruption of a stable breeding pair of red wolves prior to or during the breeding season. Most of these litters ($n = 9$) followed the death of one or both members of a breeding pair of red wolves by gunshot. Another two followed the death of a red wolf breeder by either poison or a trap injury. Two hybrid litters followed the "disappearance" of a breeder, meaning the FWS has lost radio contact with a breeding member of a red wolf pack. Five hybrid litters followed the disruption of a breeding pair by natural causes. One involved a female wolf whose male partner died naturally after a foreign object punctured a lung, causing a systemic lung infection. Another occurred when a female wolf mated with a non-red wolf after both the breeders in her pack died of mange. The third case involved a female whose mate was killed by another wolf. In two other situations a female red wolf had been paired with a sterilized coyote that was subsequently displaced or killed by a red wolf from another pack; these female red wolves then mated with non-red wolves.

To summarize, excluding the seven cases with no known history, 78% (18/23) of the hybrid events followed disruption of social groups. Of these, 61% (11/18) followed anthropogenic mortality, which could be an underestimate if the two individuals that "disappeared" had a similar fate. In situations of breeder disruption either the remaining breeder ($n = 7$) or a previously unmated member of the pack ($n = 9$) interbred with a non-red wolf.

4. Discussion

Exploring individual records of hybridization events in this red wolf–coyote system provides insights into mechanisms that may regulate interactions between these two species. There are several observations we can draw from the wolves involved in these events. First, a large number (90%) of hybridization events involved female red wolves. Based on genetic data, researchers have hypothesized that introgression between wolves and coyotes predominantly occurred when male wolves bred with female coyotes (Lehman et al., 1991; Mozón et al., 2014); our findings refute that hypothesis and support the genetic results of Hailer and Leonard (2008). It also matches the predictions of Wirtz (1999) that hybridization is driven by females from the rarer species selecting heterospecific mates from the more common species.

Ultimately, it appears that hybridization events tend to follow the disruption of stable breeding pairs of wolves, frequently due to anthropogenic actions such as gunshot mortality. In this system canids begin establishing pair bonds during a period that corresponds with the onset of hunting seasons for large mammals. The elimination of red wolf breeders during the breeding season forces reproductively active red wolves to quickly locate another

mate. A higher percentage of hybrid than red wolf litters were produced by first-time female breeders, which is likely due to the low natural turnover in red wolf breeders from year to year (Sparkman et al., 2011). We hypothesize that as stable red wolf pairs dissolve a social 'release' occurs for young wolves providing them with the opportunity to breed, which echoes findings from other wolf populations (Brainerd et al., 2008). The inexperience of these animals coupled with the timing of pair dissolution during the breeding season may facilitate selection of a heterospecific mate.

Such findings correspond with those from other mammalian carnivore social systems that have demonstrated sensitivity to disruption due to human activity (Tuyttens and Macdonald, 2000; Loveridge et al., 2007; Packer et al., 2009; Wallach et al., 2009; Rutledge et al., 2010; Davidson et al., 2011; Borg et al., in press). By pooling data from multiple wolf populations across Europe and North America, Brainerd et al. (2008) found breeder loss facilitated pack dissolution and abandonment of territory. Disrupting stable social systems in canids has cascading effects on intraspecific and, as shown by this red wolf system and wolves in southeastern Canada (Rutledge et al., 2010, 2011), interspecific interactions. Management of wolves must take into account the consequences of breeding pair dissolution for these events can facilitate genetic introgression into small populations.

The disparity between the number of red wolf and hybrid litters suggests that red wolf pairings are more common than those between red wolves and coyotes, which is encouraging considering coyotes outnumber wolves in portions of the RWEPA (USFWS, 2007; Bohling, 2011; Bartel and Rabon, 2013). Such patterns are heavily influenced by human management, which impacts our interpretation of these results. Regardless, the low number of hybridization events that could be attributed to naturally dispersing individuals suggests that even when sympatric these species do not breed randomly and red wolves seek conspecific mates. This is despite the fact that the red wolf population is increasingly inbred (Brzeski et al., 2014) and genetic diversity has declined over time (Bohling et al., 2013). Inbreeding avoidance can facilitate selection of a heterospecific mate (Palmer and Edmunds, 2000; Gee, 2003). In pack-forming canids inbreeding avoidance is linked with dispersal from natal packs (Sillero-Zubiri et al., 1996; vonHoldt et al., 2008; Sparkman et al., 2012), which could facilitate hybridization if dispersing increases the probability of interacting with heterospecifics. Despite the abundance of coyotes and limited gene pool, hybridization does not appear to be fueled by dispersing red wolves, which indicates some form of assortative mating may be operating in this system.

Many of the non-red wolf parents involved in these hybridization events had mixed ancestry. With the removal of hybrids from the landscape, we expected most hybridization events to involve coyotes; these results, however, suggest that red wolves may be selecting for admixed mates over pure coyotes if available. Both traditional trapping (USFWS, 2007; Bartel and Rabon, 2013) and non-invasive genetic sampling (Adams et al., 2007; Bohling, 2011; Bohling and Waits, 2011) reveal that coyotes vastly outnumber hybrids in this landscape, yet admixed individuals were responsible for 40% of the hybridization events when the non-wolf parent was identified. In hybrid systems in which there is a morphological, behavioral, ecological, or size disparity between the parental groups suggest, hybrids can serve as a bridge between the two parental groups and facilitate introgression (Dowling and Secor, 1997; Goodman et al., 1999; Seehausen et al., 2008; Duvernell and Schaefer, 2014). If red wolves are preferentially selecting admixed mates in this landscape, then efforts to remove hybrids must remain a management priority.

Characterizing the wolves involved in hybridization events is difficult due to the circumstances that surround these events. Any observed patterns could simply be a result of a random artificial selection due to the stochastic nature of anthropogenic mortality. For example, wolves involved in hybridization events tended to have slightly higher levels of coyote ancestry. However, this was not a strong pattern and could be a random artifact. Low sample size of hybridization events relative to red wolf litters, although good for red wolf conservation, limits our ability to draw inferences. Ascertainment bias may also influence the results since the breeding habits of red wolves that are not monitored are difficult to determine. This may explain the overwhelming bias toward female red wolves producing hybrid litters: USFWS biologists monitor female wolves as they begin to localize around a den site so they can locate the pups but do not do the same for males. Questions regarding the impact of genetic ancestry, breeding experience, and sex on hybridization could be best answered with mate choice experiments.

The realization that hybridization tends to follow the disruption of stable breeding pairs is important for management of the red wolf population. There has been a dramatic increase in the amount of gunshot and overall human-caused mortality over the past decade (Bartel and Rabon, 2013). For the adaptive management plan to be successful, more effort must be placed in reducing the number of red wolves killed by gunshot to facilitate efforts to restrict hybridization. A recent agreement between the North Carolina Wildlife Resources Commission and several environmental groups to limit coyote hunting in the RWEPA is a positive step toward achieving this goal (SELC, 2014).

Interpreting the spatial distribution of hybridization events and their significance for red wolf conservation is more complex. Trapping surveys indicate that wolves and coyotes are not evenly distributed across the RWEPA (USFWS, 2007; Bartel and Rabon, 2013). Non-invasive genetic surveys suggest that over 80% of the canids in Zone 1 are red wolves, whereas coyotes composed 70% of the population in Zone 3 (Bohling, 2011). Zone 2 is close to a 50–50 split between the two species. Thus, the abundance of hybridization events in Zone 3 could be simply a result of an abundance of coyotes and the inability of wolves to locate conspecifics, which matched our initial expectations and the classic 'desperation hypothesis' (Hubbs, 1955).

The distribution of hybrid events may also be linked to human social factors and land use practices. Zone 1 is predominantly composed of protected areas under public ownership and the first reintroductions occurred in this area, meaning the USFWS has longstanding relationships with many of the landowners. Expansion of the red wolf population westward has mainly occurred on private lands. Many of these landowners did not anticipate wolf colonization of their property, which has created friction between local communities and the USFWS as was highlighted in an independent review of the red wolf program (WMI, 2014). This conflict, combined with lack of protected refuges for wolves, lack of awareness among the hunting community, and proximity to the mainland coyote population, likely facilitates breeding pair disruption and the spatial pattern of hybridization events.

The management approach taken by the USFWS places value on protecting the genetic 'purity' of the population by limiting hybridization. Such efforts hinge on the commitment to protect a species that today is populated by descendants from just a few founders. The taxonomy and ancestry of these founders has been the source of controversy and some genetic studies suggest the red wolf is a relatively recent product of hybridization between coyotes and gray wolves (Lehman et al., 1991; Roy et al., 1996; vonHoldt et al., 2011). An alternative perspective is that red wolves align closely with eastern wolves in southeastern Canada, which represent a North American-derived wolf sharing a close evolutionary relationship with coyotes (Wilson et al., 2000; Hedrick et al., 2002; Kyle et al., 2006; Rutledge et al., 2012). The debate concerning these alternative hypotheses is ongoing (vonHoldt et al., 2011;

Rutledge et al., 2012). This uncertainty has fueled debate regarding the efficacy of investing resources in the protection of a population potentially derived from hybridization (Gittleman and Pimm, 1991; O'Brien and Mayr, 1991; Jenks and Wayne, 1992; vonHoldt et al., 2011). Further complicating matters is the perception that red wolves have a high propensity to hybridize, leading some to suggest management should be lessened allowing the population to assimilate with the surrounding coyote population (Kyle et al., 2006).

Our results provide a new perspective in this debate by revealing the extent to which human factors, both positive and negative, govern hybridization dynamics in this system. The opposing forces of management designed to maintain the red wolf gene pool and human disruption eroding reproductive boundaries impact our perception of potential red wolf recovery. The current introduced population has remained morphologically (Hinton and Chamberlain, 2014) and genetically (Adams et al., 2007; Bohling et al., 2013) distinct from the resident coyote population. We must recognize that human management as a principle factor in maintaining this pattern. At this point, though, management may operate as a zero-sum game, with facilitation of red wolf reproduction counteracting the impacts of pack disruption. In this case, the infrequency and stochasticity of hybridization events and low number of hybrids across this landscape (Adams et al., 2007; Bohling, 2011; Bohling and Waits, 2011) suggest behavioral processes play a role in maintaining the distinctiveness of the red wolf population.

Research has demonstrated the importance of behavioral forces in regulating interspecific hybridization and species boundaries (Wolf et al., 2001; Pfennig, 2007; Reyer, 2008; Svedin et al., 2008; Krosby and Rohwer, 2010; Sacks et al., 2011; Robbins et al., 2014). Even in the face of introgression, boundaries between parental groups can be maintained through behavioral mechanisms. Our findings mirror those of eastern wolves around Algonquin Park in which hunting disrupted pack dynamics and facilitated coyote introgression (Rutledge et al., 2010, 2011). Following restrictions on hunting in areas surrounding the park, the social dynamics of the population were restored and introgression became less frequent. Reducing manipulation, especially pack disruption, would reveal whether red wolves are capable of maintaining their genetic profile as eastern wolves have. Decisions regarding the future of red wolf management must account for the fact that human activity can facilitate hybridization and in turn impacts our interpretation of the relationship of this species to other canids.

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Population Estimate 2018

Pack/Area	Known Collared	Known Uncollared or Inactive Collared	Suspected Uncollared	Known Pups	Suspected Pups	
Milltail	11849F	12046M				
	12044M					
	12186M					
	12225F					
	12226F					
	12228M					
	12182F					
	11835M					
					Estimated Total	**9**
Northern	11872M				4	
	11985F					
	12280F					
					Estimated Total	**7**
Ventures/Floyd	11747M					
	12029F					
	12281F					
	11965F					
					Estimated Total	4
Beech Ridge	11963M				4 (Suspected DNS)	
	12195F					
	12194F					
					Estimated Total	3
West Milltail	12045F					
					Estimated Total	**1**
Pungo	12197F					
					Estimated Total	**1**
Kilkenny	11958M					
					Estimated Total	**1**
Gator		11743F				
					Estimated Total	**1**

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Cc: roslyn_sellars@fws.gov; thomas_irwin@fws.gov; catherine_gulac@ios.doi.gov
Subject: Updated invitation: Red Wolf Program Update - Rm 6136 @ Wed May 23, 2018 10am - 11am (EDT) (greg_j_sheehan@fws.gov)
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Red Wolf Program Update - Rm 6136
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Where Changed: 6136 CALL IN- (877)988-2994 code 7728906 (map <https://maps.google.com/maps?q=6136+CALL+IN-+%28877%29988-2994+code+7728906&hl=en>)
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You are receiving this email at the account greg_j_sheehan@fws.gov because you are subscribed for updated invitations on calendar greg_j_sheehan@fws.gov.
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Using the "placeholder" concept to reduce genetic introgression of an endangered carnivore

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ABSTRACT

One of the most endangered species is the red wolf, *Canis rufus*. Reintroduction of the red wolf began in 1987, but in 1993 hybridization between coyotes (*Canis latrans*) and wolves was documented. To reduce genetic introgression, coyotes and coyote–wolf hybrids were captured, sterilized, and released as "placeholders". Placeholders held territories until either displaced or killed by a wolf, or management personnel removed them before releasing a wolf. We evaluated the placeholder concept by examining the number of animals sterilized and released, likelihood of displacement by a wolf, factors influencing displacements, territory fidelity of placeholders, and survival rates and causes of mortality of placeholders and wolves. Of the 182 placeholders, 125 were coyotes and 57 were hybrids. From 1999 to 2013, 51 placeholders were displaced or killed by wolves, and 16 were removed by management personnel. Thus, 37% of the placeholders were displaced leading to occupancy by a wolf. Most displacements occurred in winter (43%) and were always by the same sex. Males were more likely to be displaced than females. Home range characteristics influencing the probability of displacement included home-range size (i.e., more placeholders displaced from larger home ranges) and road density (i.e., more placeholders displaced from home ranges with lower road density). Annual survival of placeholders was higher than wolves in 12 of 14 years, with cause-specific mortality similar among wolves and placeholders. Placeholders provided territories for wolves to colonize, yet reduced the production of hybrid litters, thereby limiting genetic introgression to <4% coyote ancestry in the wolf population.

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1. Introduction

There is increasing concern about the status and distribution of many carnivore populations throughout the world (Schaller, 1996; Gittleman et al., 2001; Woodroffe, 2001; Ripple et al., 2014). With increasing human populations, many populations of carnivores are exposed to changes in land-use practices, increased habitat loss and fragmentation, increased human persecution, declines in natural prey species, increased disease transmission from domestic and wildlife species, illegal poaching, and increased competition with other carnivores (Gese, 2001; Sillero-Zubiri et al., 2004; Loveridge et al., 2010). As a result of these varied and diverse influences, many populations of large, medium, and small-bodied carnivores have undergone a general decline with some species now occupying a fragment of their former range (IUCN, 1990; Cole and Wilson, 1996; Woodroffe, 2001).

One threat facing a few carnivore species is hybridization resulting in genetic introgression with sympatric species (Wayne et al., 2004). While hybridization is an important evolutionary process (Allendorf et al., 2001), it poses a threat to the persistence and conservation of several wild canid species. Hybridization with domestic dogs poses a threat to the Ethiopian wolf (*Canis simensis*; Gottelli et al., 1994) and the European gray wolf (*Canis lupus*). Hybridization among several related canids in Ontario, Canada, could threaten the genetic integrity of a population of eastern wolves (*Canis lycaon*) in Algonquin Provincial Park (Patterson and Murray, 2008). In the United States, hybridization between red wolves (*Canis rufus*) and coyotes (*Canis latrans*) was identified as one of the greatest threats to conservation efforts and recovery of red wolves in eastern North Carolina (Kelly et al., 1999; Stoskopf et al., 2005). Reducing genetic introgression of coyote genes into the red wolf population presents a unique challenge for the U.S. Fish and Wildlife Service (USFWS), the agency charged with reintroducing and managing the current red wolf population (U.S. Fish and Wildlife Service, 1989, 2007).

In 1987, four pairs of red wolves were released at the Alligator River National Wildlife Refuge (ARNWR) in eastern North Carolina (Phillips and Parker, 1988). By 1993, the wolves had successfully bred and re-establishment of a free-ranging experimental population was considered to be a success (Phillips et al., 2003). The experimental population area primarily encompassed the Albemarle Peninsula, which did not have coyotes present during the initial reintroduction. However, by the early 1990s the presence of coyotes was documented and shortly thereafter hybridization between red wolves and coyotes occurred

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(Adams et al., 2003; Phillips et al., 2003). In 1999, a population and habitat viability assessment recognized several threats to the free-ranging red wolf population (Kelly et al., 1999), with hybridization with coyotes being the greatest threat to recovery of the species. Subsequently, the USFWS adopted a Red Wolf Adaptive Management Plan (RWAMP) with one of the objectives to reduce hybridization between coyotes and red wolves (Kelly, 2000).

As part of the RWAMP (Kelly, 2000), sterilization of coyotes and hybrid animals was proposed to reduce genetic introgression into the red wolf population. While sterilization has been tested as a management tool to reduce predation on domestic livestock and wild neonatal ungulates (Bromley and Gese, 2001a; Seidler et al., 2014) and proposed as a method for population control (Mech et al., 1996; Haight and Mech, 1997), using sterilization to reduce genetic introgression was a novel application. In essence, sterilized coyotes and hybrids would be allowed to remain on the landscape, maintaining social bonds and territories (Bromley and Gese, 2001b; Seidler and Gese, 2012), and serve as "placeholders" that would maintain territories, thereby reducing residency of home ranges in the recovery area by reproductive coyotes or hybrids, and thus reducing the threat of hybridization with a red wolf (i.e., producing hybrid offspring if pairing with a red wolf occurred; Stoskopf, 2012) and facilitating expansion of the red wolf population. The sterile placeholders could be displaced from their territories by a red wolf, or the USFWS could remove these sterile animals and release red wolves at that site when either a captive or wild-born red wolf was available for release. Sterilization was not used to control or manage the coyote population in the recovery area, but to create non-reproductive territories with sterile animals that were incapable of successfully reproducing with intact red wolves.

In late 1999, a plan to sterilize coyotes and hybrids to serve as placeholders in the Red Wolf Recovery Experimental Population Area (RWREPA) in eastern North Carolina was initiated. In this paper, we introduce and evaluate the placeholder concept as a management tool, covering its use in the red wolf recovery area from 1999 to 2013. As part of this evaluation, we examined (1) the number of animals (coyotes and hybrids) that were sterilized and released as placeholders, (2) the likelihood of a placeholder being displaced by a red wolf and the biotic and abiotic factors influencing these displacements, (3) the degree of territory fidelity of placeholders (i.e., the likelihood of dispersing after being sterilized), (4) survival rates and causes of mortality of both placeholders and red wolves, and (5) the number of hybrid litters born per year in the recovery area. Ultimately, the management goal is the reduction and eventual elimination of genetic introgression from coyotes into the red wolf population, thus allowing for continued persistence of a free-ranging population of red wolves in the wild.

2. Materials and methods

2.1. Study area

The Red Wolf Recovery Experimental Population Area (RWREPA) study area was located in northeastern North Carolina on the Albemarle Peninsula and encompassed approximately 4900 km^2 (Fig. 1). The peninsula is part of the South Atlantic Coastal Plain and is a combination of tidal (estuarine) and non-tidal (palustrine) wetlands, and mixed upland forests. The western region is dominated by mixed pine-hardwood forests of loblolly pine (*Pinus taeda*), white oak (*Quercus alba*), hickory (*Carya tomentosa*), beech (*Fagus grandifolia*), tulip tree (*Liriodendron tulipifera*), sweetgum (*Liquidambar styraciflua*), and red maple (*Acer rubrum*) (Hartshorn, 1972). Pocosins are palustrine wetlands endemic to the Atlantic coast and are found throughout the study area. The acidic and nutrient poor soils of pocosins facilitate dominance by pond pine (*P. serotina*) although loblolly and longleaf pine (*P. lalustris*) are common. The vegetation of the central region exhibits a gradual west-to-east change from upland species to palustrine wetlands dominated by tupelo (*Nyssa sylvatica*), Atlantic white cedar (*Chamaecyparis thyoides*), loblolly pine, and bald cypress (*Taxodium distichum*) (Lynch and Peacock, 1982; Moorhead and Brinson, 1995). Estuarine wetlands have their highest incidence in the eastern region of the study area (mainly Dare and Hyde counties), primarily along the coastline and are dominated by black rush (*Juncus roemerianus*) with areas of wetland grasses (*Spartina alterniflora*, *S. patens*, *Cladium jamaicense*), marsh elder (*Iva frutescens*), and false willow (*Baccharis angustifolia*) (Moorhead, 1992).

Within the RWREPA the principal landowners were private timber and agricultural corporations with federal and state governments having the next highest proportions of land ownership. There were numerous wildlife refuges contained within the study area with the two largest being the ARNWR and Pocosin Lakes National Wildlife Refuge

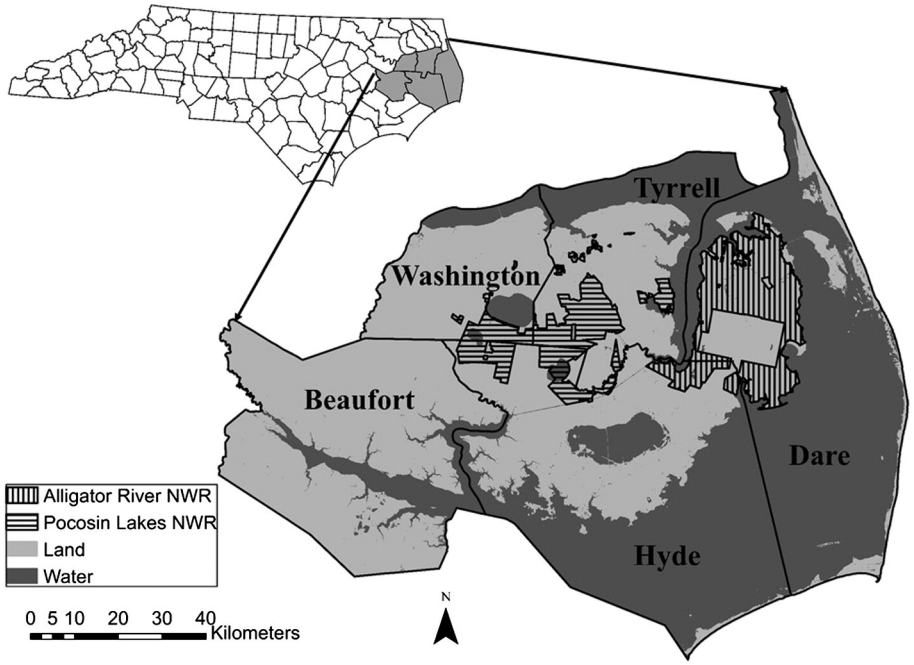


Fig. 1. The five county Red Wolf Recovery Experimental Population Area in northeastern North Carolina including the location of the two largest National Wildlife Refuges.

(PLNWR; Fig. 1). The ARNWR was located in the extreme northeastern section of the study area and was designated as the initial red wolf reintroduction site in 1987 due to a lack of coyotes and human presence, but with abundant prey (Phillips and Parker, 1988). Contained within the ARNWR was a 19,020-ha U.S. Air Force bombing range. The average annual rainfall for ARNWR was 145 cm without seasonal fluctuations, although 4.8 cm of snow falls annually during the winter (U.S. Department of the Interior, 2008). The 44,560-ha PLNWR was located in the central portion of the study area (Fig. 1). The total human population for the study area in 2010 was 105,124 people (U.S. Census Bureau, 2010).

2.2. Capture, sterilization, and monitoring of study animals

All capture, handling, aerial telemetry, and monitoring of red wolves, coyotes, and hybrids was conducted by USFWS personnel. Genetic analysis of blood samples collected from captured animals was used for species identification (Miller et al., 2003; Adams, 2006; Bohling et al., 2013). Beginning with the reintroduction in 1987, all red wolves released from captivity were equipped with a very high frequency (VHF) radio-collar (Telonics, Mesa, Arizona, USA; Phillips and Parker, 1988). Adults (>9 months old) born in the wild were trapped with a padded, foot-hold trap, immobilized, and fitted with a VHF radio-collar, body measurements and weight recorded, and a blood sample drawn. Pups born in the wild were implanted with an integrated transponder (PIT) tag (Trovan®; Beck et al., 2009). Radio-collared adult red wolves were located 2–3 times/week from an airplane or ground based vehicle. Starting in 2007, many red wolves were fitted with a GPS radio-collar (Lotek Wireless, Newmarket, Ontario, Canada) which obtained a location every 5 h (Dellinger et al., 2013).

Starting in 1999 and continuing through to 2013, adult (>9 months old) coyotes and hybrids within the RWREPA were sterilized to examine the feasibility of the placeholder concept. Captured coyotes and hybrids were either sterilized or removed (euthanatized) from the recovery area (Kelly, 2000; Gese et al., 2015), and thus there were no intact coyotes and hybrids monitored during this study. Upon capture in a padded, foot-hold trap, coyotes and hybrids were transported to a surgical facility, sterilized, then fitted with a VHF radio-collar (Telonics, Mesa, Arizona, USA), body measurements and weight recorded, and blood drawn. Females were sterilized by tubal ligation or spay, while males were vasectomized or neutered (Bromley and Gese, 2001b; Seidler and Gese, 2012). Animals spayed or neutered were classed as "hormones not intact", while animals undergoing tubal ligation or vasectomy were classed as "hormones intact" (Asa, 2005). All surgical procedures were conducted by a licensed veterinarian after the animals were anesthetized. Animals were monitored overnight for post-operative complications and released at their capture site the following day. Research techniques and animal care procedures were conducted under permits and standard operating protocols approved by the U.S. Fish and Wildlife Service.

Sterilized coyotes and hybrids wearing VHF radio-collars were located on a regular basis (2–3 times/week) during the same aerial telemetry flights as the red wolves. Locations of the placeholders provided spatial information including home range location and boundaries (USFWS, unpublished data) for the 182 placeholders (Fig. 2). Data were also recorded for the date of displacement, the species which displaced or killed the coyote or hybrid, and if available, the specific individual that displaced the placeholder. Because aerial telemetry was conducted during the day, we were concerned if the home ranges determined from daytime locations may underestimate space use (Gese et al., 1990). However, the average home range size of the 182 VHF radio-collared resident placeholders in the study area was 23.5 ± 12.0 (range 5.5–64.5 km^2), similar to the mean home range of 27.2 km^2 for coyotes later equipped with GPS-collars (Hinton, 2014).

2.3. Biotic and abiotic factors influencing displacement

For each placeholder's home range, we determined the percent composition of 10 land cover types within their home range using ArcGIS 10.2.2 (ESRI, Redlands, California, USA). Land cover types were obtained from LANDFIRE 1.3.0 (LANDFIRE 1.3.0., 2012) and included agriculture, sparse, developed, herbaceous, marsh, riparian, shrubland, swamp, forest, and water. Land ownership was compiled from state GIS databases and included federal, state, private, and non-governmental organizations (NGO). A digital representation of primary and secondary roads was obtained from the North Carolina Department of Transportation (https://connect.ncdot.gov/resources/gis/; accessed July 2014). The length of primary and secondary roads in each home range was

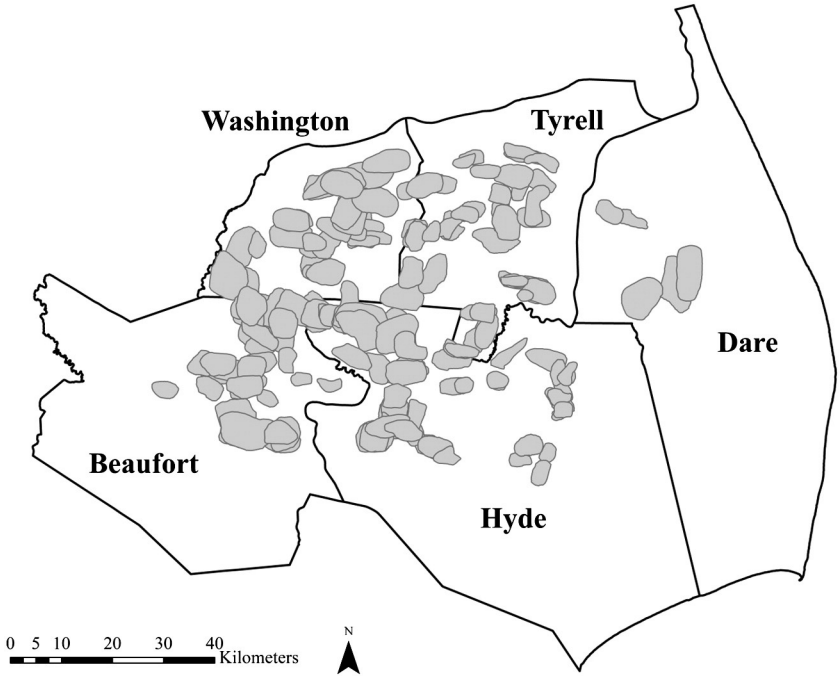


Fig. 2. Home ranges of placeholders (i.e., sterilized coyotes and hybrids) in the Red Wolf Recovery Experimental Population Area, North Carolina, 1999–2013.

converted to road density (km/km^2). We used generalized linear models (GLM) with a binomial distribution and logit link function to examine the influence of abiotic (home range characteristics) and biotic (placeholder characteristics) factors on the probability of being displaced ($y = 1$) or not displaced ($y = 0$) by a red wolf. Home range characteristics were assessed for each placeholder's home range, including home range size (km^2), road density (km/km^2), percent occurrence of each land cover type, dominant land cover type, percent occurrence of each land owner type, and dominant land owner type. Placeholder characteristics included sex of the placeholder, body length, and sterilization procedure (hormones intact or not intact). We developed separate GLMs to examine the effects of the home range and placeholder characteristics. Correlated variables ($r > 0.25$) were not allowed to enter the same model as additive or interactive effects.

We ranked all home range and placeholder characteristic GLMs and the null model using the Bayesian Information Criteria (BIC; Schwarz, 1978). Variables from the highest ranked model of home range characteristics were combined with variables from the highest ranked model of placeholder characteristics to generate a set of models containing both combinations of predictor variables, and we again used BIC (Schwarz, 1978) to compare models (Scheiner, 2004). All model development and analysis was conducted in the R statistical software (R Core Team, 2014).

2.4. Cause-specific mortality and survival rates

Radio-collared adult red wolves, coyotes, and hybrids were monitored 2–3 times/week allowing for the early detection of a mortality signal and facilitating recovery of the carcass to determine the cause of death. If applicable, a field necropsy was conducted, or if the cause of death was not apparent, the carcass was examined by a veterinary pathologist. We classified mortalities into one of three classes: anthropogenic, natural, or unknown. Anthropogenic mortality included any human-caused death not due to removal of coyotes or hybrids by agency personnel to make that home range available to a red wolf. Thus, anthropogenic mortality included causes of death from gunshot, vehicle collision, foul play, trapping, and poisoning. Foul play included suspected gunshot or suspected illegal take. Natural mortalities included health-related incidences such as disease or parasite load, and interspecific and intraspecific aggression resulting in death of the animal. A total of 182 placeholders and 410 red wolves were monitored from 1 January 1999 to 31 December 2013. We calculated annual survival rates for red wolves, sterile coyotes, and sterile hybrids using the program MICROMORT (Heisey and Fuller, 1985), but limited our survival analysis to the time period of 2000 to 2013 as there was only one sterile coyote and four sterile hybrids available for monitoring in 1999.

2.5. Composition of litters

During spring, personnel from the USFWS monitored radio-collared red wolves and located breeding females at active dens to determine the composition of the litter (Bohling and Waits, 2015; Gese et al., 2015). Pups born in the wild were implanted with an integrated transponder (PIT) tag (Trovan®; Beck et al., 2009) for future identification during subsequent capture operations in the fall when pups were large enough to be radio-collared. If the genetic origin of the litter was questionable, blood samples were obtained and examined using 18 nuclear DNA microsatellite loci to determine their ancestry and red wolf pedigree (Miller et al., 2003; Adams, 2006; Bohling et al., 2013).

3. Results

3.1. Displacement events

From 1999 to 2013, the USFWS captured, sterilized, and released 218 animals to serve as placeholders within the RWREPA. Of these, 15 were classed as transients (cf Gese et al., 1988), 13 were killed <3 months after release, and 8 disappeared (i.e., lost contact with the radio-collar) <3 months after release, thereby leaving 182 individuals for analysis. These 182 placeholders included 66 female and 59 male coyotes, and 26 female and 31 male hybrids. Of the 182 placeholders monitored, 51 were displaced by wolves (37 were spatially displaced by wolves from their territories and 14 were killed by a red wolf). In addition, 16 placeholders were removed by USFWS personnel and a red wolf released into the territory. Thus, 67 (37%) of the 182 placeholders were naturally displaced or artificially removed, leading to occupancy of the territory by a red wolf. During the same time period, 146 (35%) displacements out of 410 red wolves monitored were also documented. No coyote or hybrid displaced a red wolf; red wolves were displaced only by another red wolf. All displacements (100%) of placeholders were by a red wolf of the same sex. Similarly, for red wolves 98% of red wolf displacements were by a red wolf of the same sex.

Of the 51 naturally occurring displacements of placeholders, the frequency of displacements varied seasonally ($\chi^2 = 9.37$, df = 3, $P = 0.025$) with the most displacements occurring in winter (43%; 1 December–28 February), followed by spring (25%; 1 March–31 May), fall (18%; 1 September–30 November), and summer (14%; 1 June–31 August). Similarly, the 146 displacements of red wolves by red wolves varied seasonally ($\chi^2 = 31.64$, df = 3, $P < 0.001$) with most displacements occurring in winter (41%), followed by spring (26%), fall (25%), and summer (8%).

Although there were similar numbers of female (n = 92) and male (n = 90) placeholders, sterilized males were more likely to be displaced than sterilized females (males: 34.4% displaced, females: 21.7% displaced; $\chi^2 = 3.64$, df = 1, $P = 0.056$), regardless if the male was a sterile coyote (32.2%) or a sterile hybrid (38.7%; Fig. 3). Female placeholders that underwent tubal ligation and were hormonally intact were no more likely to be displaced than females that underwent a spay and were not hormonally intact (tubal ligation: 19.4% displaced; spay: 30.0% displaced; $\chi^2 = 1.025$, df = 1, $P = 0.31$; Fig. 4). Similarly, males that underwent vasectomy and were hormonally intact were also no more likely to be displaced than males that underwent a neuter surgery and were not hormonally intact (vasectomy: 32.9% displaced, neuter: 42.3% displaced; $\chi^2 = 0.519$, df = 1, $P = 0.47$; Fig. 4). The weight at capture of displaced female placeholders (13.21 ± 2.57 kg, standard deviation [SD]) was no different than female placeholders that were not displaced (13.50 ± 2.58 kg; $t = 0.450$, df = 30.499, $P = 0.65$). Similarly, the weight at capture of male placeholders that were displaced (15.84 ± 3.48 kg) was not different than the male placeholders that were not displaced (14.94 ± 2.58 kg; $t = -1.265$, df = 47.725, $P = 0.2119$).

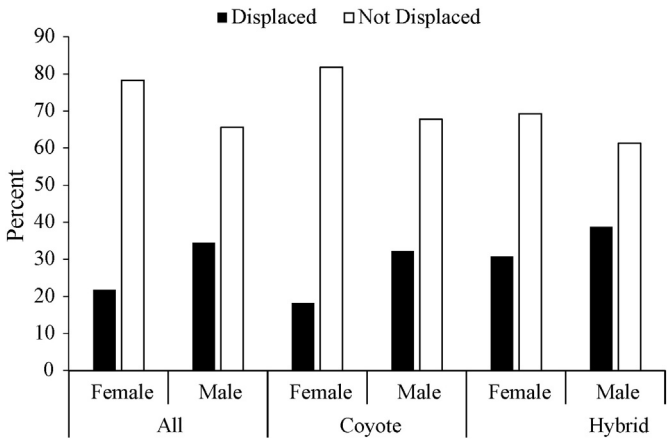


Fig. 3. The percent of male and female coyotes and hybrids serving as placeholders that were displaced and not displaced by red wolves in the Red Wolf Recovery Experimental Population Area, North Carolina, 1999–2013.

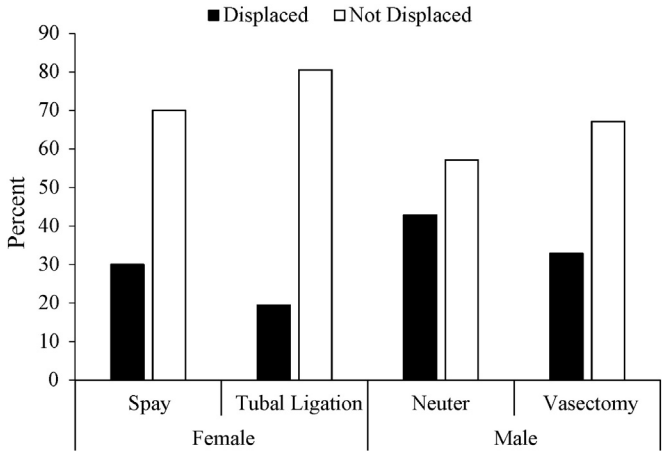


Fig. 4. The percent of 182 placeholders, sterilized by four methods, which were displaced and not displaced by red wolves in the Red Wolf Recovery Experimental Population Area, North Carolina, 1999–2013.

3.2. Biotic and abiotic factors influencing displacement

We examined the abiotic (home range characteristics) and biotic (placeholder characteristics) factors influencing the likelihood of a placeholder being displaced. Of the 63 models of home range characteristics examined plus the null model, the highest ranked was the null model followed by models containing home-range size or road density (Table 1). We found that the percent of placeholders displaced by a red wolf increased as home-range size increased (Fig. 5A). At home ranges <20 km^2, 17 of 85 (20%) placeholders were displaced by red wolves, while in contrast, 10 of 26 (38%) of the placeholders with home ranges >35 km^2 in size were displaced. In contrast, we found that the percent of placeholders displaced by a red wolf decreased with increasing road density, with displacements being highest at low road densities (Fig. 5B). All other models of home range characteristics had ΔBIC values >10 and model weights <0.01, thus home-range size and road density were carried forward to the combined models (Burnham and Anderson, 2002). Interestingly, neither the composition of land ownership or the dominant land ownership, nor the composition of land cover type or dominant land cover type influenced whether a placeholder was displaced by a red wolf.

Of the seven models of placeholder characteristics and the null model, the highest ranked was the null model followed by the univariate model of placeholder sex (Table 2). As described previously, we found male placeholders were more likely to be displaced than female placeholders (males: 34.4%, females: 21.7%). All other models of placeholder characteristics had ΔBIC values >4 and model weights <0.08, thus placeholder sex was the single variable carried over to generate the combined models. Of the eight combined models examined and the null model, the highest ranked model was the null model followed by the univariate model containing placeholder sex, then the univariate models containing home-range size and road density (Table 3).

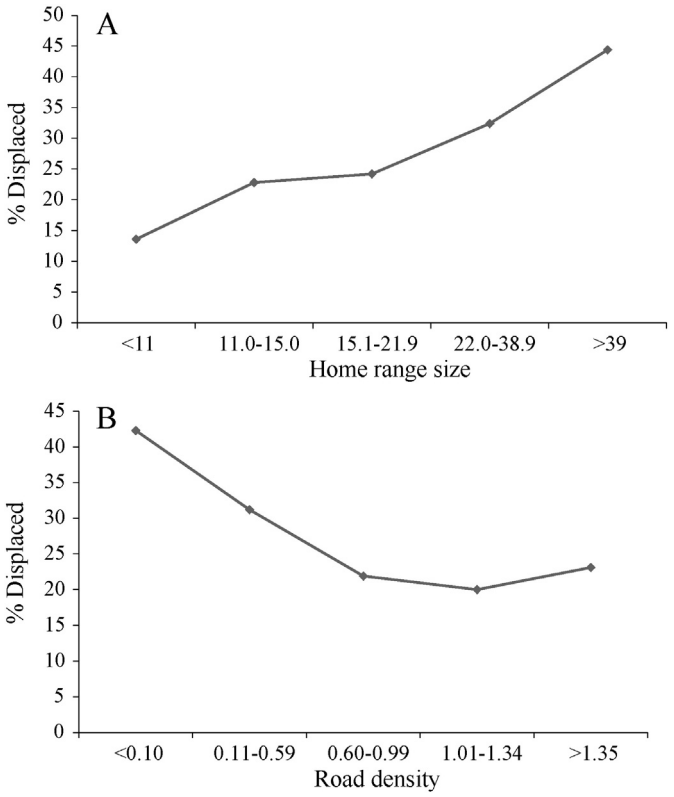


Fig. 5. The percent of placeholders displaced by a red wolf across (A) five classes of home-range size (km^2) of the placeholder, and (B) five classes of road density (km/km2) within a placeholder's home range, Red Wolf Recovery Experimental Population Area, North Carolina, 1999–2013.

3.3. Territory fidelity

Dispersal of juvenile animals from their natal home range is a common occurrence among most canid species. However, we emphasize that because only adult coyotes and hybrids >9 months of age were sterilized and used as placeholders, we only examined territory fidelity for adult canids in the study area (i.e., we did not include juvenile dispersal from their natal home ranges). Territory fidelity of adult canids was high during the study. During the 14 years of monitoring (2000–2013), of the 125 adult coyotes serving as placeholders, only 2 (1.6%) adult sterile coyotes dispersed from their resident territory. Of the 57 adult hybrid animals serving as placeholders, 4 (7.0%) adult hybrids dispersed from their territory. Similarly, of the 410 adult red wolves monitored during the same time period, 11 (2.7%) adult red wolves dispersed from their resident territory. In contrast to and for

Table 1
The ΔBIC and model weights for the generalized linear models and the null model examining the influence of home range characteristics within a placeholder's home range and the likelihood of being displaced by red wolves in the Red Wolf Recovery Experimental Population Area, North Carolina, 1999–2013.

Model	ΔBIC	df	Weight
Null	0.0	1	0.68
Home-range size (km^2)	2.6	2	0.19
Road density (km/km^2)	3.8	2	0.10
Home-range size (km^2) + Road density (km/km^2)	7.0	3	0.02

Table 2
The ΔBIC and model weights for the generalized linear models and the null model examining the influence of placeholder characteristics on the likelihood of being displaced by red wolves in the Red Wolf Recovery Experimental Population Area, North Carolina, 1999–2013.

Model	ΔBIC	df	Weight
Null	0.0	1	0.56
Sex	1.5	2	0.26
Hormones intact	4.1	2	0.07
Body length (cm)	5.2	2	0.04
Sex + Hormones intact	5.3	3	0.04
Sex + Body length (cm)	6.6	3	0.02
Hormones intact + Body length (cm)	9.3	3	0.01
Sex + Hormones intact + Body length (cm)	10.4	4	0.00

Table 3
The ΔBIC and model weights for eight generalized linear models and the null model combining biologically meaningful characteristics of the placeholder and the placeholder's home range on the likelihood of being displaced by red wolves in the Red Wolf Recovery Experimental Population Area, North Carolina, 1999–2013.

Model	ΔBIC	df	Weight
Null	0.0	1	0.48
Sex	1.5	2	0.22
Home-range size (km^2)	2.6	2	0.13
Road density (km/km^2)	3.8	2	0.07
Home-range size (km^2) + Sex	5.0	3	0.04
Road density (km/km^2) + Sex	5.0	3	0.04
Home-range size (km^2) + Road density (km/km^2)	7.0	3	0.01
Home-range size (km^2) + Road density (km/km^2) + Sex	9.1	4	0.00
Home-range size (km^2) * Road density (km/km^2) + Sex	10.4	5	0.00

comparative purposes, we found that 103 (25.1%) of the juvenile red wolves dispersed at some time from their natal home range.

3.4. Survival rates and cause-specific mortality

We estimated annual survival rates for the 182 adult placeholders that were monitored for 137,784 radio-days (sterile coyotes: 84,093 radio-days; sterile hybrids: 53,691 radio-days) during 1999 to 2013. For comparison, we examined survival rates of 410 adult red wolves monitored for 388,587 radio-days during the same time period. In general, the sterilized adult placeholders (coyotes and hybrids combined) had higher survival rates than adult red wolves (Fig. 6). Mean annual survival was highest for sterilized hybrids (0.876 ± 0.11, standard deviation, SD), lowest for red wolves (0.80 ± 0.04) and intermediate for coyotes (0.843 ± 0.12). Red wolves exhibited higher annual survival than the placeholders in only two (14%) of the 14 years of the study, while placeholders had the highest survival in 12 (86%) of the 14 years monitored. Interestingly, sterilized coyotes had the highest survival in 6 (43%) of the 14 years and hybrids also had the highest survival in 6 (43%) of the 14 years.

Some sources of mortality among adult red wolves and adult placeholders were similar, while some specific causes were more species related (Table 4). Anthropogenic causes of mortality was similarly high for both adult red wolves and adult placeholders (red wolves vs. placeholders: $\chi^2 = 0.47$, 1 df, $P = 0.49$), and the number of deaths due to natural and unknown causes was similar

Table 4
Anthropogenic, natural, and unknown causes of mortality for adult red wolves and sterile placeholders (coyotes, hybrids) in the Red Wolf Recovery Experimental Population Area, northeastern North Carolina, 1999–2013.

	Red Wolves % (n)	Sterile Coyotes % (n)	Sterile Hybrids % (n)
Anthropogenic			
Gunshot	37.1 (91)	23.8 (10)	33.3 (8)
Vehicle	17.6 (43)	19.0 (8)	8.3 (2)
Foul Play	4.1 (10)	14.3 (6)	8.3 (2)
Trapping	2.4 (6)	4.8 (2)	4.2 (1)
Poisoning	2.4 (6)	0 (0)	0 (0)
Total	63.7 (156)	61.9 (26)	54.2 (13)
Natural			
Health-related	11.8 (29)	0 (0)	4.3 (1)
Interspecific	0 (0)	19.0 (8)	20.8 (5)
Intraspecific	5.7 (14)	0 (0)	0 (0)
Total	17.6 (43)	19.0 (8)	25.0 (6)
Unknown	18.8 (46)	19.0 (8)	20.8 (5)
Total deaths	245	42	24

(Table 4). A similar high percentage of red wolves and placeholders were killed by gunshot and foul play (red wolves vs. placeholders: $\chi^2 = 0.07$, 1 df, $P = 0.788$). Six red wolves were killed by poisoning and no placeholders were killed by poisoning (red wolves vs. placeholders: $\chi^2 = 1.65$, 1 df, $P = 0.199$). No red wolves were killed by placeholders (sterile coyotes or sterile hybrids), but 19% of the sterile coyote mortalities and 21% of the sterile hybrids mortalities were caused by interspecific aggression from red wolves (red wolves vs. placeholders: $\chi^2 = 50.36$, 1 df, $P = 0.0001$). Red wolves were rarely killed (~6% of mortality) by conspecifics (i.e., intraspecific aggression) and no placeholders were recorded as killed by conspecifics (red wolves vs. placeholders: $\chi^2 = 3.95$, 1 df, $P = 0.0469$).

3.5. Composition of litters

In general there was little variation in the number of hybrid litters from 2000 to 2013 with a mean of 2 hybrid litters/year (±1, standard deviation) with a maximum of 5 litters in 2006 and no hybrid litters in 2004 (Fig. 7). During the same time period, the number of red wolf litters has varied with a mean of 9 litters (±2) and ranged from 6 to 12 litters each year.

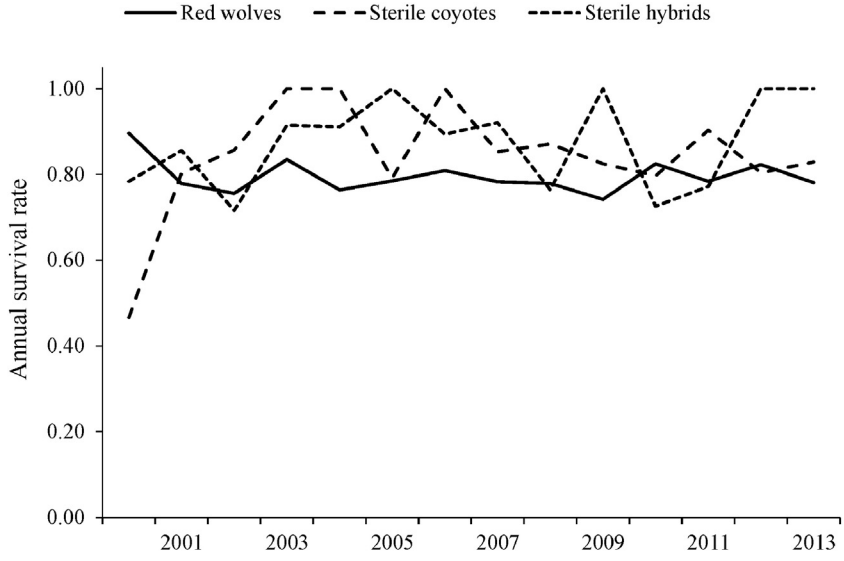


Fig. 6. Annual survival rates of adult red wolves (n = 410), sterilized adult coyotes (n = 125), and sterilized adult hybrids (n = 57), in the Red Wolf Recovery Experimental Population Area, North Carolina, 2000–2013.

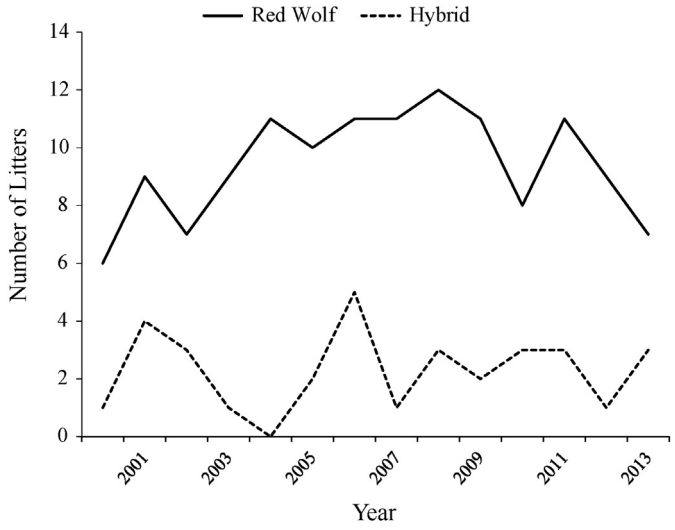


Fig. 7. The number of red wolf and hybrid litters in the Red Wolf Recovery Experimental Population Area, North Carolina, 2000–2013.

4. Discussion

Many factors threaten the persistence of canid populations throughout the world (Gittleman et al., 2001; Woodroffe, 2001; Ripple et al., 2014). Hybridization with coyotes followed by genetic introgression was identified as one of the greatest threats to recovery of red wolves in North Carolina (Kelly et al., 1999). Sterilization of coyotes and hybrid individuals was proposed to serve as placeholders to reduce hybridization and genetic introgression of the red wolf population (Kelly, 2000). This is the first documented case of using sterilization and the placeholder concept to mediate hybridization and genetic introgression between similar taxonomic canids. The primary objective of the placeholder concept was to limit opportunities for intact red wolves to produce viable offspring during mating events with coyotes or hybrid animals, as well as keeping space available for red wolves without the threat of producing hybrid offspring if pairing with a red wolf occurred (Stoskopf, 2012). These sterile placeholders could then be displaced from these territories by a red wolf, or these sterile animals could be removed and red wolves released into the now empty territory. Sterilization was not used to control or manage the coyote population in the recovery area, but to create non-reproductive territories with sterile animals that were incapable of successful reproduction (i.e., hybridization).

Natural displacements and strategic management removals of placeholders resulted in 37% of those sterile placeholders being replaced by red wolves in that territory. Displacements were unidirectional with red wolves displacing and replacing placeholders, but no placeholder displaced red wolves during the 14 years of monitoring. Interestingly, animals not having hormonal systems intact (i.e., animals spayed or neutered) were not displaced at a higher frequency than sterile animals with intact hormones (i.e., animals tubal ligated or vasectomized). Intact hormonal systems are generally believed to be necessary for pair bonding and territorial maintenance (Asa, 1995). The higher frequency of displacements in winter is not surprising given that the breeding season would compel animals to seek mating opportunities. The finding that male red wolves displaced male placeholders, and female red wolves displaced female placeholders reinforces the mating opportunity hypothesis.

We found that home range size and road density influenced the percentage of placeholders displaced by red wolves. At home ranges <20 km^2, 20% of the placeholders were displaced by red wolves, while 38% of the placeholders with home ranges >35 km^2 were displaced. Red wolves have larger home ranges (Chadwick et al., 2010) than coyotes, and may thus prefer to acquire larger areas in which to establish residency. Similarly, home ranges of placeholders that contained low road densities were preferred by red wolves, leading to higher displacement rates. Dellinger et al. (2013) reported red wolves avoided areas with high human density, and suggested red wolves will use human-associated landscapes, but modify their habitat selection patterns with increased human presence. Thus large home ranges with low road density appear to be preferred by red wolves and placeholders occupying said home ranges have a higher likelihood of being displaced. Interestingly, of the 26 placeholders with home ranges >35 km^2, the 10 placeholders displaced had a median home range size of 47 km^2 and a median road density of 0.48 km/km^2, while the 16 placeholders not displaced had a median home range size of 41 km^2 and a median road density of 0.63 km/km^2. Past studies on gray wolves have suggested wolves tended to survive where human density was low and road density was <0.58 km/km^2 (Thiel, 1985; Mech et al., 1988). Red wolves and coyotes used similar habitats and space (Hinton, 2014), thus the lack of habitat variables influencing displacements was likely due to similar habitat selection and requirements.

Annual survival rates of placeholders were higher than red wolves in 12 of the 14 years of monitoring. Coyotes and hybrids each had the highest survival rates in 6 of the 14 years. Even first generation hybrids had survival values more similar to coyotes than red wolves, indicating that hybridization conferred some level of increased survival abilities more reminiscent of coyotes. Perhaps the smaller body size, dietary breadth (Hinton, 2014), and behavioral plasticity of hybrids, which are more similar to coyotes than red wolves, also allowed for increased survival rates. Coyotes are adaptable to human-modified environments (Bekoff and Gese, 2003; Gehrt, 2004; Gese et al., 2012), and hybridization appeared to confer similar "coyote-like" survival traits to hybrid individuals.

While causes of mortality were similar among red wolves, coyotes, and hybrid animals, red wolves did experience a higher frequency of gunshot and health-related mortality. The high red wolf mortality due to gunshot is cause for concern as many of these mortalities occurred in the breeding season during the past 2–3 years (Hinton et al., in review) and not only limited potential litter production of red wolf pairs in the last 2 years (Fig. 7), but also opened opportunities for hybridization between red wolves and coyotes by reducing mating opportunities with red wolves (Bohling and Waits, 2015; Gese et al., 2015). While sterilization of placeholders does limit successful reproduction between red wolves and coyotes, it is impractical to capture and sterilize all coyotes in the recovery area.

While only 37% of the placeholders were naturally or artificially displaced leading to red wolf occupancy of the territory, the remaining 63% did protect space in which no hybrid litters could be produced. Ultimately, limiting genetic introgression into the red wolf population is the overall goal of the use of the placeholder concept. In 2014, the genetic composition of the wild red wolf population was estimated to include $<4\%$ coyote ancestry from recent introgression since reintroduction (Gese et al., 2015). Use of placeholders, combined with removal of coyotes and hybrids, release of captive adult red wolves, and cross-fostering of captive pups into wild red wolf litters, appeared to be effectively limiting genetic introgression into the red wolf population (Gese et al., 2015). Continued intensive management will likely be necessary in the future to limit hybridization and genetic introgression. Using the placeholder concept to limit hybridization in other canid species has potential. Hybridization with domestic dogs poses a threat to the Ethiopian wolf (Gottelli et al., 1994) and the European gray wolf, but sterilization to generate placeholders may not be an effective strategy in these situations because domestic dogs are the introgressing species and sterilizing all free-ranging domestic dogs would be impossible. Using the placeholder concept to reduce or limit hybridization among several related canids in Ontario and reduce the threat of genetic introgression into a population of eastern wolves in Algonquin Provincial Park (Patterson and Murray, 2008) may be more practical.

5. Conclusions

Sterilization has been used in the recent past to reduce predation rates by coyotes on domestic and native ungulates (Bromley and Gese, 2001a; Seidler et al., 2014), but using sterilization to limit genetic introgression into the red wolf population is the first use of sterile animals within the context of the "placeholder" concept. We emphasize that sterilization was not used to limit the distribution or size of the coyote population, but to reduce the incidence of hybridization between coyotes and red wolves and genetic introgression into the red wolf population. Results from this experiment demonstrate the utility of the placeholder concept to limit genetic introgression of coyotes into the recovering red wolf population in northeastern North Carolina. Territories were held by sterilized placeholders and then being successfully displaced by red wolves resulting in red wolf occupancy. Equally important was production of hybrid litters was limited to a few each year in the recovery area, and the genetic composition of the red wolf population in 2014 contained <4% coyote introgression. The utility and application of the placeholder concept may be practical for limiting genetic introgression in similar situations where an introgressing species threatens the genetic integrity of a sympatric carnivore.

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STATE: North Carolina

GRANT TITLE: W79-Wildlife Management

PROJECT TITLE: Pilot Study – Using Fine Scale GPS Technology to Research Sympatric Canid Population Dynamics (Job 2.0?)

A. Problem and Need

The coyote (*Canis latrans*) is now abundant throughout the 100 counties in North Carolina (NC), and is managed as nongame with no closed season or bag limit (NC Wildlife Resources Commission 2016). Previously restricted to the West and Midwest regions of the United States, by the early 1990s coyotes had expanded their range into the Albemarle Peninsula (AP), which is situated in the northeast coastal plain region of NC (Hinton et al. 2012, Murray et al. 2014). In recent years as coyotes have increased their population, some have begun to make use of the Outer Banks region.

The United States Fish and Wildlife Service (USFWS) released a non-essential, experimental population of captive-bred red wolves (*Canis rufus*) on the Alligator River National Wildlife Refuge (ARNWR) in 1987 (Hinton et al. 2013). This population increased until 2008 and peaked at around 130 individuals (Group Solutions, Inc. 2016), short of the recovery goal of 220 in the wild (USFWS Red Wolf Recovery Program 2013). The AP has an estimated carrying capacity of 140-150 wolves (Hinton et al. 2013, Kelly et al. 1999, USFWS Red Wolf Recovery Program 2007). The exact number of red wolves is not known, but USFWS staff report a population estimate of 45-60 individuals with eight mortalities to date in 2016 (https://www.fws.gov/redwolf/index.html August 2016). Hybridization with coyotes and inbreeding depression are suspected factors that have affected red wolf population growth and viability since the inception of the Red Wolf Recovery Program (RWRP), while vehicular and gunshot mortality are known factors (Hinton et al. 2013). Because of hybridization between red wolves and coyotes, the AP supports a continuum of sympatric canids, hereafter referred to as "sympatric canids."

As part of a recent program review, the USFWS halted many aspects of the RWRP in 2015 and discontinued the coyote sterilization program, potentially affecting the spatial

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distribution and population dynamics of sympatric canids. Telemetry data from coyotes on the AP suggests that about 70% of coyotes are residents (i.e., those that defend set territories) while the other 30% are transients, with most being dispersing juveniles (Hinton et al. 2015). Transient coyotes do not defend set territories. Coyotes can travel long distances and become transient even as adults, especially when they lose their mate. Recently described as using "compensatory immigration," coyotes opportunistically fill spatial resource gaps by periodic transiency; when spots come open, individuals that do not yet have permanent territories and have been roaming in the area, are able to inhabit the new openings (Hinton 2016). These periods of transiency can sometimes bring coyotes into conflict with other canids and humans, especially when they are utilizing of anthropogenic resources.

Though a rural area, human land uses occupy a significant portion of space on the AP. The AP is comprised of approximately 30% agricultural fields, 50% forest and coastal marshes, and 20% "other" land cover types on federal, state and private lands (Dellinger 2011). Concerns about fear of attacks on humans and domestic pets, the effects of sympatric canids on white-tailed deer and other game populations, and homeowner property damage comprise many of the conflict calls regarding sympatric canids on the AP (Responsive Management, forthcoming data). Wildlife managers in this region frequently receive requests for information on canid management (C. Turner, personal communication, 2016).

The changes in state and federal canid management rules have resulted in confusion regarding residents' rights and options for management of property damage by sympatric canids. As a result, some citizens are unsure of the legal and most effective methods for canid conflict management. Adding to management complexity is the need to manage canids for conservation purposes, such as reducing predation on at-risk ground nesting species or reducing hybridization of sympatric canids.

In 2013, NCWRC and USFWS established a committee to oversee the collaborative management and conservation of sympatric canids on the AP. A USFWS and NCWRC joint memorandum documented detailed action items for the joint management of sympatric canids on the AP, including specific research objectives which this proposal seeks to address (Attachment 2). As sympatric canids on the AP increase in number, monitoring their

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movements, particularly in relation to individuals of differing ancestry, could provide important data to NCWRC and USFWS staff for science-based local and landscape-level decisions about sympatric canid populations and conflict management. Collection of finer temporal scale location data would help to manage interactions of sympatric canids with humans, as well as to support development of dynamic stochastic population models.

B. Objectives (after December 1, 2016-November 30, 2018)

Objective 1: Use GPS collar and proximity sensor technology to test performance under various conditions and evaluate the frequency and accuracy of the scheduled fix rates.

Objective 2: Use fine scale GPS data collection for investigating annual and seasonal spatial dynamics of sympatric canids: home range and core area sizes, amount of overlap in home range and core areas, movement pathways and daily activity patterns, and cover type selection and preference.

Objective 3: Use fine scale GPS data collection for investigating the number and age structure of offspring for family groups of collared sympatric canids.

Objective 4: Use fine scale GPS data collection for investigating sources of mortality for sympatric canids.

Objective 5: Use fine scale GPS data collection for preventing and mitigating canid conflicts with landowners.

Objective 6: Determine genetic profiles of sympatric canids through DNA identification of all captured individuals, parentage, and presence of hybridization.

At the end of this two-year pilot study, we will deliver an observational summary detailing the use of the GPS and sensor technology for spatial and population dynamics research on sympatric canids on the AP.

C. Expected Results and Benefits

As part of a pilot study, we will monitor the status of collared individuals by using a finer scale assessment of space and habitat use than previous studies. Earlier research focused on many of the same objectives we suggest investigating here, but during a time of intense, active

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management. Specific management techniques are no longer being carried out and dynamics between sympatric canids are expected to have changed substantially. The uncertainty regarding current dynamics presents a need for additional research in order to inform actions for the management of sympatric canids. Information gained from research may impact management rules and landowner's abilities to manage canids in some areas. Additionally, GPS technology has improved since earlier research was conducted allowing for more temporally detailed data collection and more nuanced analyses. Understanding how sympatric canids collectively use resources in areas of human-dominated landscapes will allow wildlife managers to tailor management options to local conditions. On the AP, row crop agriculture and hunting represent the primary and secondary land uses, respectively. Row crop agriculture is a significant nutrient resource on the landscape and, as opportunists, canids take advantage of such resources when they are available. Non-consumptive wildlife-driven tourism persists in all seasons and wildlife watching is a main draw for tourists in this area. For many tourists, the opportunity to see or hear large carnivores is the sole attraction for traveling to the AP. Information from this study will be provided to local constituents to establish a knowledge base regarding how sympatric canids use resources on private lands. Management and guidance could serve to prevent or minimize conflict while maximizing positive wildlife interaction opportunities for constituents. Development of a common understanding between wildlife managers and landowners based upon factual information is paramount for collaboratively achieving successful management of sympatric canids. The data collected in this pilot study is the foundation upon which this understanding and future management actions will be built.

The current level of hybridization between sympatric canids on the AP will be characterized using DNA gathered during this study. Body size exists as a continuum between coyotes and red wolves and has been documented as the most important factor for successful interspecific breeding pairs of these canids (Hinton 2014). Though both species have been found to use resources in similar manners, red wolves generally have more expansive home ranges and therefore may not use local resources as intensively as coyotes, depending on body size. Obtaining individual identification of study animals will allow managers, armed with spatial information, to infer how and why individuals in the canid species continuum exploit

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anthropogenic resources considering their life history traits.

In conjunction with prior research, data collected will contribute to knowledge on sympatric canid population dynamics on the AP. Estimating population size will allow managers to monitor population trends of sympatric canids and to examine the long and short-term impacts of different management strategies on their populations. While it is unknown whether sample size will allow for population estimation, obtaining population estimates for coyotes would provide wildlife managers with baseline data, when paired with annual mortality estimates, for monitoring changes in population abundance over time. Information on changes in abundance, reproductive dynamics, and habitat use could impact management strategies to influence long-term conservation outcomes. Results of this pilot study will allow managers to determine if future work will be necessary, what amount of effort will be required to achieve each objective, and whether or not population estimates will be an attainable goal.

D. Approach

The official Red Wolf Recovery Area (RWRA) covers approximately 6,900 square kilometers within Beaufort, Dare, Hyde, Tyrrell, and Washington counties (Wildlife Management Institute 2014). However, the USFWS has proposed the RWRA be constricted to the ARNWR and the Dare County Bombing Range in Dare county by the end of 2017. Due to these proposed RWRA changes, this study proposes to capture and radio-collar 25 sympatric canids within Dare, Hyde, and Tyrrell counties (hereafter referred to as “study area”); those counties being within and directly adjacent to the proposed new RWRA. The thematic subheadings below provide detailed descriptions of the approaches required for achieving the pilot study objectives.

Sampling Efforts

Trained NCWRC personnel will conduct live trapping of sympatric canids, with assistance from the USFWS RWRP biologists, and trained, experienced local trappers. NCWRC and USFWS wildlife personnel will select local trappers based on their past performance in trapping sympatric canids, but may also select trappers from the NCWRC coyote trappers list. NCWRC staff will train contracted trappers on specific trapping procedures before every trapping

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season. The project lead will supervise and coordinate all trapping activities including locations for installation and the operation of trap lines and handling of captured animals. Simultaneous personal trapping activities by contracted trappers will not be permitted while performing contracted trapping services, as specified in the draft service contract (Attachment 4).

Trapping efforts will follow a spatial capture-recapture (SCR) framework with a systematic targeted sampling design, focusing on areas that contain resources previously found to be used by sympatric canids (e.g. edge, agricultural fields, secondary roads, etc.) (Harris et al. 2013, Ivan et al. 2013), while attempting to sample a diversity of habitat types. This effort will allow us to increase the probability of detection of sympatric canids on the landscape (Tom 2012). While it is important to sample a wide range of habitats, the most important requirement for SCR is the number of collared individuals; this requirement provides flexibility in the other requirements for field sampling as needed (K. Pacifici, personal communication, 2016). We will initially focus trapping in areas of known red wolf packs, as advised by RWRP.

Trapping will take place during the breeding season when the likelihood of capturing females in the later stages of gestation or whelping females will be low. Capture efforts will be conducted from soon after 1 December 2017 – February 2018 and December 2018 – February 2019. Captured sympatric canids will be surrendered to NCWRC or the USFWS at capture sites. Trapping should occur on both public and private lands to obtain sampling coverage of the study area. Ideally, all federal and state lands would be accessible for trap and release (hereafter referred to as "capture") of sympatric canids, but it is most important to be able to trap and release on Alligator River NWR and the Dare County Bombing Range as those encompass the newly proposed RWRP recovery area and comprise the majority of land area for Dare county. Unlike Dare county, there are ample private lands that surround Pocosin Lakes NWR and Lake Mattamuskeet NWR in both Tyrrell and Hyde counties that may be utilized to effectively sample individuals who may use those federal lands, should they be excluded from capture activities. Capture on federal lands may require USFWS take permits and proposed activities may be subject to a compatibility assessment (P. Benjamin, personal communication, 2016). Scientific collection activities that take place on private lands will require agreements outlining conditions mutually decided by NCWRC and landowners (Attachment 3).

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To increase probability of detection of sympatric canids, the accessible study area will be partitioned by a grid, the cell size of which will based on the average annual home range size of resident coyotes previously reported for the AP, approximately 23 km^2 (Hinton et al. 2015). As a system of sampling, trap lines will be referred here as "traps," and the number of trap sets (i.e. the actual trapping device) and number of each trap set size may vary between traps as necessary. Sampling will be standardized within each grid cell by use of equal number of traps per cell, on average 3 per cell, each at an approximate length of 10 km (Andelt and Gipson 1979, Way et al. 2004).

Target canids will be captured by using Softcatch #3 Coyote 4x4 (Oneida Victor Inc. Ltd., P.O. Box 32398, Euclid, Ohio 44132, Hinton 2014, Schemnitz 1994), the EZ Grip #7 (Livestock Protection Company, P.O. Box 725, Alpine, Texas 79831, Frame and Meier 2007), or equivalent. Various lures and baits will be used to increase trapping efficiency (Frederick et al. 1989, Shipley 2012). Traps will be laid on the Monday of each week and will be opened at the time of deployment. Traps will be checked once daily at dawn, to reduce potential stress to trapped individuals and will not be operated on days where the temperature is expected to reach or exceed 80° F (R. Nordsven, personal communication, 2016) or during times of predicted inclement weather (e.g. snow, hail, high wind, etc., Sikes et al. 2011). To standardize effort and remain logistically realistic, traps should be open for three trap nights in a row before being removed. Trap sets that have been closed due to non-target bycatch or other circumstances may be reopened and all traps should be re-baited and lured as appropriate.

Trap set locations will be marked by NCWRC or USFWS personnel using handheld GPS units (Garmin GPSMAP 64S, 1200 E. 151st St., Olathe, KS 66062-3426) and given a sequential identification number. Traps will also be given an identification number and trap set points will be documented in ArcMap 10.4. Trappers will keep detailed records on trap set operation, non-target species trapped, and other relevant details. Non-target species will be released from traps after an in-field assessment of injuries, if any, and animals with life threatening injuries will be euthanized by the trap operator. Targeted recapture of collared canids will occur annually during the same months, to replace GPS collar batteries and drop-off collar release units in field. Trapping effort will be quantified (trap nights), the effective sample area will be

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estimated, the encounter (detection) probability will be estimated using a Gaussian detection model (Amundson et al. 2014), and an estimate of density for coyotes will be calculated using a modified Huggins closed-capture estimator in program MARK, if sample size allows (Harris et al. 2013, Ivan et al. 2013).

Animal Handling

Handling of canids will follow American Society of Mammalogists (ASM) guidelines (Sikes et al. 2011) and will be performed at the capture site. Chemical immobilization agents may be used depending on the number of field staff during processing (i.e., three or more staff required during non-chemical immobilizations, Craft 2007, M. Morse, personal communication, 2016).

Chemical Immobilization

Unless adequate numbers of personnel are available to safely employ mechanical restraint techniques, target animals will be anesthetized with the chemical immobilization agent BAM (Wildlife Pharmaceuticals, Inc., Windsor, CO 80550). BAM, a combination of Butorphanol tartrate, Azaperone tartrate and Medetomidine HCl., will be delivered by intramuscular injection by syringe pole to the hip. Dosage for canids is based on field trails performed by Wildlife Pharmaceuticals (Wildlife Pharmaceuticals, Inc. 2016) and the recommended dose for coyotes is 0.2CC and red wolves is 0.3CC, with adjunct doses of 0.1-0.2CC delivered if initial dosages do not cause induction (S. Kirschner, personal communication, 2017). Induction times for coyotes and wolves ranged from 5 to 10 minutes after initial and/or adjunct dosages (Wildlife Pharmaceuticals, Inc. 2016). After field handling is concluded the anesthesia will be reversed using two reversal agents, Atipamezole and Naltrexone, at double the CC of Atipamezole to BAM that was delivered (including adjunct doses, if given) and 0.5CC of Naltrexone. Recovery time from the reversal agents ranged from 10 to 25 minutes during field trails (Wildlife Pharmaceuticals, Inc. 2016). Field personnel will observe animals for signs of adverse effects for up to 30 minutes after reversal agents are delivered.

Mechanical Immobilization

Unlike other carnivore families, the submissive behavioral response of canids to

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perceived dominance reduces the need to use immobilization agents. Appropriate mechanical restraint techniques can reduce handling time of animals, allowing animals to reintegrate into social groups more quickly, subsequently reducing overall stress to the individual (Powell and Proulx 2003). Target canids will be mechanically restrained with a restraint pole, until two muzzles can be placed around the snout. While pinned with the restraint pole by one person, a second person will restrain the set of legs not in the trap against the ground and a third person will release the foot from the trap. This set of legs will then be restrained by the 3rd person as the restraint pole is removed. Once the restraint pole is removed the person restraining the front legs will also then restrain the head. The first person will then move forward with processing the captured animal.

Each animal will be placed on a towel or blanket to provide thermal protection from the ground, with eyes covered and lubricated with eye ointment; temperature will be monitored with a rectal thermometer. Overheating occurs at approximately 104-105°F for canids (AZA Canid TAG 2012) and the animal handling crew will monitor temperature at 5-minute intervals; if a temperature reading reaches 104°F, corrective actions will be taken and temperature will be monitored at 1-minute intervals. Should overheating occur, the individual will be removed from insulation to expedite the natural evaporative cooling process. During days that approach 80°F in temperature, measures will be taken to reduce heat stress, such as: wetting the animal with water, application of a cold pack to the groin area between the back legs, application of rubbing alcohol to foot pads, or immediate release (AZA Canid TAG 2012). If the injured individual is suspected to be a red wolf, based on morphometrics, USFWS staff will be contacted for a decision. In the event that trap caused injuries are determined to be life threatening through use of a trap injury score assessment (Frame and Meier 2007) the individual will be euthanized. In the event that NCWRC personnel cannot be present, trained USFWS personnel may collar and measure captured target animals and will provide data sheets to NCWRC staff. Target animals will not be vaccinated or otherwise treated for diseases, regardless of the presence of disease symptoms.

Non-target animals will be released on site. Captured domestic dogs will be immediately released from the trap set following an injury score assessment and only if no life-threatening

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injuries are present. If a domestic dog has sustained life threatening injuries and owner identification information is present on the dog, then the animal will be held in either a transportable kennel, or at a dog pen on a state game land that is equipped with such facilities, until the owner can retrieve the dog. The costs associated with injuries sustained to the dog will be the responsibility of the animals' owner. Law enforcement may be requested to help communicate with the animal's owner. If the animal does not have an identifiable owner and has incurred substantial life threatening injuries (i.e. compound fracture), the dog will be euthanized on site. Target animals showing signs of disease symptoms such as circling behavior, head tilt, muscle twitches, convulsions with jaw chewing movements and salivation ("chewing gum fits"), disorientation, incoordination, staggering caused by paralysis of the hind legs, seizures, and partial or complete paralysis will be euthanized and tested according to protocol set forth by the agency veterinarian, in order to determine if there may be a public health issue (M. Palamar, personal communication, 2016). USFWS will be contacted in cases of suspected red wolves. Staff involved in animal handling duties will have the pre-exposure rabies vaccination series completed prior to field work inception and will maintain rabies titer records through properly licensed medical services providers.

If staff is bitten and skin is broken by an animal while performing handling duties, they will be advised to immediately visit a local hospital or clinic for evaluation by healthcare professionals. The field coordinator will immediately notify supervisory staff and an injury report and workers' compensation claim will be opened for the incident. The animal will be euthanized and the head will be sent to the state lab for rabies testing; the body may be sent to the Southeastern Cooperative Wildlife Disease Study (SCWDS) laboratory for additional disease investigation.

Capture Processing and Marking

During canid handling, NCWRC personnel will record age class, sex, weight, total body length, head width, ear length, and tail length, visually assess ectoparasite load, look for and disinfect with betadine or iodine as needed any minor trap caused injuries, and affix GPS collars (Knick 1990, Sikes et al. 2011). All captured canids will be fitted with appropriately-sized GPS collars in the field based on morphometrics previously indicated as reliable thresholds for

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species categorization: hind foot length, weight, width of head, and tail length (Hinton 2014); analysis of DNA samples collected during trapping efforts will help to assign captured canids to position along the species continuum post release. Age of individuals will be estimated based on physical characteristics, including weight and tooth replacement (Knick 1990, Hinton 2014, Gier 1968), and captured canids will be aged into one of three classes: > 2 years old as adults, < 2 but > 1 year old as juveniles, and > 6 months but < 12 months old as pups (Hinton 2014). Reproductive status will be determined based on estimated age class and presence of gonadal descent during the breeding season for males and the presence of nipple swelling or previous suckling for females (Hutson and Racey 2004, Magee 2008, Mengel 1971).

Captured individuals will be ear marked using a button tag (model 410, Ketchum Mfg. Co. [or equivalent], PO Box 10, 11 Town Shed Road, Lake Luzerne, NY 12846) placed along the middle of the ear where they are most protected from loss, with a pin-type applicator (485sa Pow-R-ceps plier, Ketchum Mfg. Co. [or equivalent]) (Silvy 2012). The puncture site will be treated with an antiseptic to deter infections. Each sympatric canid will also be marked with an individually-numbered, glass-encapsulated, passive integrated transponder (PIT model HPT12, 12.5 mm, 134.2 kHz, Biomark, Inc., 703 South Americana Blvd., Suite 150, Boise, ID; Gannon et al. 2007), using a syringe-type implanter and replaceable needle (model MK10 [implanter], model N125 [needle], Biomark, Inc.). Successful PIT placement will be verified with a mini portable reader (model GPR Plus, Biomark, Inc.). The implantation site will be prepared by swabbing with 70% alcohol (Mrozek et al. 1995) and a sterilized new needle will be used for each injection. The standard implantation site for transponders is subcutaneously on the dorsal midline of the back, cranial to the shoulder blades (Ingwersen 2000).

A skin biopsy will be taken from all captured target canids by puncturing the pinna of the ear with a biopsy punch in the same location where the ear tag will be placed (Palamar 2014). The biopsied area will be disinfected with alcohol after sampling. The skin biopsy will be placed in a labeled (ID, date, and sample type) cryogenic tube filled with 95% ethanol as buffer and then stored in a freezer until sent out to a lab for genetic analysis (Palamar 2014, Tom 2012). A selection of hairs with the root bulla attached will be pulled from the belly and placed in paper envelopes (Janecka et al. 2007). Hair samples will serve as back up to tissue samples

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for genetic testing. All samples will be sent to the Laboratory for Ecological, Evolutionary and Conservation Genetics, at University of Idaho (875 Perimeter Drive, MS 1136, Moscow, ID 83844) for genotyping to determine species as well as individual identification, hybridization presence, and parentage analysis following previously developed protocols (Adams et al. 2007, Hinton 2014, Miller et al. 2003). The appropriate genetic analyses that examine the coyote-hybrid-wolf species continuum will be performed.

Blood will be collected from all juvenile and adult target canids by venipuncture of the brachial or jugular veins using a 22-28-gauge needle (M. Palamar, NCWRC veterinarian, personal communication, 2016). As per NCWRC veterinarian recommendations, approximately 12 ml of blood will be collected for each animal for possible future testing for diseases of importance to sympatric canid species as well as the humans and domestic animals that they may come into contact with. A minimum of two 6 ml lavender top tube (for whole blood with EDTA) will be filled. Samples should be refrigerated at all times; a cooler with ice will suffice while in the field. Samples should be sent to the NCWRC within 48 hours or frozen for later shipping. Skin scrapes will be collected from animals presenting signs compatible with sarcoptic mange (lesions) for possible future diagnostic purposes. Lesions will be scraped until blood is drawn; the scrapings will be placed onto a slide and covered with a piece of clear tape for later visual confirmation.

Should overheating occur, processing will be performed in the following prioritization order and the first five items will need to be completed before releasing any individuals: 1) trap injury evaluation, 2) collaring, 3) DNA (skin biopsy) sample collection, 4) morphometrics, 5) aging, 6) PIT tagging, 7) weight, 8) ear tagging, 9) reproductive status, 10) ectoparasite evaluation, 11) blood collection, and 12) skin scrape collection.

Collaring

Vertex Plus GPS Collars will be attached to 25 sympatric canids captured on the study area, 10 of which will be equipped with proximity sensors (Vectronic Aerospace GmbH, Carl-Scheele-Str. 12, 12489 Berlin, Germany). Project staff will pilot test proximity sensor technology for utility in analysis of spatial and temporal community dynamics. Proximity sensors trigger increased GPS location acquisition during those time intervals when two collared individuals

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come within a set distance from each other (http://www.vectronic-aerospace.com/wildlife-monitoring/sensors/uhf-id-tags, accessed August 2016).

To avoid instances of collar induced strangulation, only adult (>2 years old) male and female individuals will receive collars (Hinton 2014). ASM guidelines recommends a collar weight of <5-10% of a canids bodyweight, we will observe these guidelines (Sikes et al. 2011). Sympatric canids not releasable at a capture site will not be collared and will not become study animals.

GPS radio-collars will have both VHF and GPS Iridium locational systems as well as store-on-board capabilities. Radio-collar units will be programmed to record GPS coordinates once every 1.75 hours producing approximately 13 locations per day while cycling through the 24-hour time cycle. These settings will allow for a GPS battery life of 300 to 552 days, averaging 431 days. The VHF beacon will be in operation from 0800 – 1600 hours daily. GPS locations will be sent via satellite once per day and each transmission with contain 12 locations. The use of an integrated drop off firing mechanism should allow the collars to drop off within a maximum of approximately 548 days after deployment. The drop off schedule once set cannot be changed. The drop off firing mechanism is wired to a battery unit independent of the collar battery, therefore should the collar battery become depleted, the drop off mechanism will not be affected (C. Akakpo, Vectronic Aerospace GmbH, personal communication, 2016). Unless a collared individual is recaptured before the collar battery dies, the drop off mechanism will fire at the scheduled time frame post collar deployment.

Observation of sympatric canid habitat use and movements will occur through GPS data obtained with combination GPS/VHF radio-collars. VHF relies on triangulation, the process of estimating the location of a transmitter by using two or more compass bearings obtained by using directional antennas at known locations remote from the transmitter's position (White and Garrott 1990), whereas GPS uses a satellite based system to obtain location coordinates. There have been many published studies where one or both of these methods were used, with mixed success for determining various aspects of carnivore ecology throughout the United States (Hinton et al. 2012, Schrecengost et al. 2009, Sparkman et al. 2012). While GPS technology has developed rapidly in recent history, the real time functional advantage of VHF

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cannot be disregarded. When GPS technology falters or malfunctions, VHF can serve as replacement for data collection in addition to its use in real time monitoring of study animals. Canids will be minimally monitored for mortality approximately every 30 days by using VHF aerial telemetry techniques (Whitehouse and Steven 1977) as there may be a delay in satellite transmission of GPS location data due to weather, season, and animal behavior. Transient canids and individuals from breeding pairs that have lost a mate, have been found to use much larger areas versus paired residents, potentially increasing the opportunity for losing track of these individuals when GPS technology reaches its functional capacity or experiences malfunction. VHF data may also provide locations of canids in cover too dense for GPS units to function. Use of VHF telemetry techniques for data collection may be expanded as necessary for project needs.

Spatial Data Analyses

Both minimum convex polygon (MCP) and adaptive kernel (AK) home ranges (95%) and core use areas (50% and 25%) (Seaman and Powell 1996, Seaman et al. 1999) will be calculated from GPS data by using BIOTAS (Ecological Software Solutions LLC, 2016) and Geospatial Modelling Environment (Spatial Ecology, LLC, 2016) for ArcGIS 10.2.2 (Environmental Systems Research Institute, 2016) (Benson et al. 2006, Riley 2006, Tucker et al. 2008, Hinton 2014) for comparison to older studies. These estimations can also be calculated using VHF data, provided data minimum requirements are met. Spatial distribution in relation to habitat will also be estimated by dynamic Brownian bridge movement models as described by Hinton (2014) with R statistical software (R Core Team 2016) using the moveud package with habitat covariates important to each species (Bryne et al. 2014, Collier 2013, Kranstauber and Smolla 2013, C. Proctor, personal communication, 2016). Additionally, recent research into how canids shift their ranges will also be investigated for populations on the AP (Morin and Kelly, in review). Spatial overlap and co-occurrence will be assessed using methods described by Shipley (2012). Habitat and cover types will be estimated from digitized maps created by the SEGAP (Hinton 2014) or ortho files, as available (Shipley 2012). Percent composition of habitat and cover types within home ranges and core areas as well as edge density will be quantified (Shipley 2012). Habitat selection and cover type use effects on spatial distribution will be estimated at both the population (2nd order) and individual (3rd order) spatial scales using resource selection functions

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(Johnson et al. 2006, Manly et al. 2002, Shipley 2012). Effects of seasonality and time of day activity will also be explored. The spatial and temporal patterns of space use by sympatric canids will be studied using data generated from the interaction GPS collar sensors, particularly distance between individuals and duration of proximity.

Den Monitoring

Project staff will attempt to locate den sites for sympatric canids to get pup counts, morphometric measurements, age estimates, and skin biopsies. Project staff will also attempt to monitor pup survival during the pup rearing season by using remote cameras placed around the den site (Harrison and Gilbert 1985, Parks 1979, Way et al. 2001). Pups will be weighed, measured, and PIT tagged during May and June of each year when they become active but are still den-obligated (Gier 1968). We will investigate the use of remote camera traps for monitoring den behavior with a two-camera array around the den (H. Garbe, personal communication, 2016, Kays and Slauson 2008). This method has been successfully used to monitor kit fox pup survival (Kluever et al. 2013). Because coyotes have been found to be sensitive to den site disturbance, there is a general lack of data in the literature regarding this approach for monitoring pup survival. Approaching an experimental methodology systematically will be important for determining which methods are effective and which are not. As a starting point for testing this methodology, remote cameras will be placed two to five meters from main den entrances and set to take photos using a passive infrared sensor trigger (a beam that when broken by movement through it, triggers the camera to take a series of photos) with a time restriction between photo intervals to limit the number of photos taken and maximize the space on the memory card for the time period between camera checks (Kluever et al. 2013). Cameras will be checked six days after deployment and will be redeployed (i.e. new batteries and memory card, if required); cameras will remain at each den site until radio-collar data indicates the den site has been moved (Kluever et al. 2013). Cameras will be not be redeployed to a new coyote den site during a season if that breeding pair has already moved the den once due to the disturbance of camera presence/deployment.

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Mortalities

If a collared animal dies during the project, the carcass will be sent to SCWDS for necropsy. Red wolves will be sent to the SCWDS laboratory for necropsy, unless it is determined to be a law enforcement case. In potential law enforcement cases, the NCWRC Division of Wildlife Management Chief and USFWS Ecological Services Raleigh Field Office Field Supervisor will be contacted and requested to contact the appropriate law enforcement personnel, immediately after determining the need for law enforcement involvement. The carcass and all relevant information will then be turned over to law enforcement; the GPS-collar will be removed and genetic samples will be taken from the individual prior to release to law enforcement.

E. Project Personnel

Andrea Shipley has worked for the North Carolina Wildlife Resources Commission as a Canid Biologist since February 2016. Prior to that, she worked as a Wildlife Biologist for a non-profit located in northeastern Nevada as well as in several different field biologist oriented positions. Andrea has a background in carnivore and spatial ecology, having earned her MS in Biological Sciences from Eastern Kentucky University and BS in Biological Sciences from Rutgers University; Andrea will act as project lead and coordinator.

Brandon Sherrill has worked for the North Carolina Wildlife Resources Commission as a Mammalogist since December 2013. Prior to that, he worked as an educator at the North Carolina Museum of Natural Sciences and as a regional wildlife biologist for the South Carolina Department of Natural Resources. Brandon earned a BS and MS in Fisheries, Wildlife, and Conservation Biology from North Carolina State University; Brandon will act as project supervisor.

Krishna Pacifici, Research Assistant Professor at NCSU, will be the quantitative analysis collaborator on the project. Krishna's background and experience in quantitative ecology makes him well suited to consult and assist with advanced statistical analyses of spatial data.

Lisette Waits, Department Head and Distinguished Professor at the University of Idaho, will be the DNA analysis collaborator for the project, responsible for all DNA related sample processing and subsequent analyses.

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F. Schedule and Estimated Costs

The project will run from soon after December 1, 2017 through June 30, 2020. The estimated timeline for major tasks is as follows:

Year 1: Initiate field work soon after December 1, 2017 with assistance from 1-2 field technicians; 1 technician will be required for trapping and den monitoring efforts. Data collection will begin immediately after collar deployment and data will be managed by Andrea Shipley throughout the life of the project. Data analysis will be initiated after den monitoring season concludes, with guidance and assistance from Krishna Pacifici at North Carolina State University (NCSU). Report, manuscript and presentation production will be initiated concurrently with data analysis.

Year 2: Continue field work and data collection with assistance from 1-2 field technicians. Continue data analysis with guidance and assistance from Krishna Pacifici at NCSU. Continue and finalize report and manuscript production, and presentation at professional working groups and/or meetings.

GPS technology allows researchers to collect locational data at fine spatial and temporal scales through the deployment of collar units on wildlife study subjects. In this project, we propose to study a sample of sympatric canid populations with GPS radio-collars, in order to investigate the population parameters outlined in previous sections as well as species interactions. The purchase and use of this technology is critical to meeting the research objectives set forth in this document as well as in the document included in Attachment 1.

While GPS technology has evolved over the past 20 years, the cost of technology has plateaued. Upfront cost per unit remains relatively high, however project savings occurs at the back end when compared to older telemetry technology such as very high frequency (VHF)

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which require intensive labor to collect data at similar spatial and temporal scales. Pilot testing the proximity sensor enabled GPS-collars will allow investigation of the utility of this relatively new tool for community dynamics analysis by providing an increased locational data acquisition when individuals come within a set distance, or closer, from each other. Additionally, these sensors record the identities of the interacting individuals and the duration of their interactions. Using a trigger to temporarily switch GPS fix schedules will enable us to collect very fine scale data while conserving battery life, achieving project objectives in an efficient manner. Exploring the efficaciousness of this technology has the potential to positively impact future research projects requiring use of GPS-collars for data collection.

Aerial tracking will provide regular study animal surveillance useful to investigate cases of mortality, collar malfunction, or satellite data transmission delays, which can vary seasonally. In some situations, ground tracking could prove less expensive than aerial tracking. However, ground telemetry techniques require more than one biologist working in tandem to acquire accurate location estimates. This often translates to increased labor to collect data, particularly in large study areas. Aerial tracking will provide a more efficient and cost-effective method for surveilling study subjects in this large study area, requiring only one biologist and a contracted pilot. NCWRC personnel will perform aerial tracking along with the NCWRC pilot at a minimum frequency of every 30 days.

Use of local trappers to assist with sampling efforts provides several benefits. Local trappers have established, long-term relationships with private land owners, thereby providing access to private lands that might be otherwise difficult to secure. This will enable project biologists to obtain a representative sample of sympatric canids in the study area, as well as to operate more trap lines concurrently. This is particularly important when using a SCR sample design, as it will have direct implications on the resulting analyses and inferences.

As part of collaboration efforts, the project will contract the services of Krishna Pacifici, Research Assistant Professor in the Applied Ecology department at NCSU. Krishna's expertise is in quantitative ecology; consultation and assistance services provided will allow project biologists to make appropriate statistically relevant inferences from collected data.

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DNA analysis will be contracted to Lisette Wait's lab at the University of Idaho. Lisette's team at The Laboratory for Ecological, Evolutionary and Conservation Genetics has previous experience in analyzing red wolf and coyote hybrid molecular samples and has the most comprehensive DNA methodology for this sympatric canid species continuum in the nation. This expertise will facilitate expedient species identification on collared study animals besides landscape level population dynamics analysis.

	Commission	In-kind	Total
a. Personnel	$ 7,200.00	$ -	$ 7,200.00
b. Fringe Benefits	$ -	$ -	$ -
c. Travel	$ 30,000.00	$ -	$ 30,000.00
d. Equipment	$ 54,000.00	$ -	$ 54,000.00
e. Supplies	$ 61,500.00	$ -	$ 61,500.00
f. Contractual	$ 315,590.00	$ -	$ 315,590.00
g. Construction	$ -	$ -	$ -
h. Other	$ 6,000.00	$ -	$ 6,000.00
i. Total Direct Charges (sum of a – h)	$ 474,290.00	$ -	$ 474,290.00
j. Indirect Charges	$ 4,800.00	$ -	$ 4,800.00
k. Totals (sum of i and j)	$ 479,090.00	$ -	$ 479,090.00
Federal (75%)			$ 359,317.50
State (25%)			$ 119,772.50

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G. Geographic Location

Three counties of the Albemarle Peninsula of North Carolina (Dare, Hyde, and Tyrrell counties).

H. Related Federal Projects

NC-W-F15AF00726 (W-72) NC-Division of Wildlife Management Cooperative Projects

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I. Glossary

Abundance: Species abundance is the number of individuals per species, and relative abundance refers to the evenness of distribution of individuals among species in a community.

Adaptive kernel (AK): A probabilistic home range estimator based on the distribution and density of locations that has been collected over a period of time.

Adverse reactions: In pharmacology, any unexpected or dangerous reaction to a drug.

Aerial: Existing, happening, or operating in the air.

Annually: Once a year; every year.

Anthropogenic: Caused or influenced by humans.

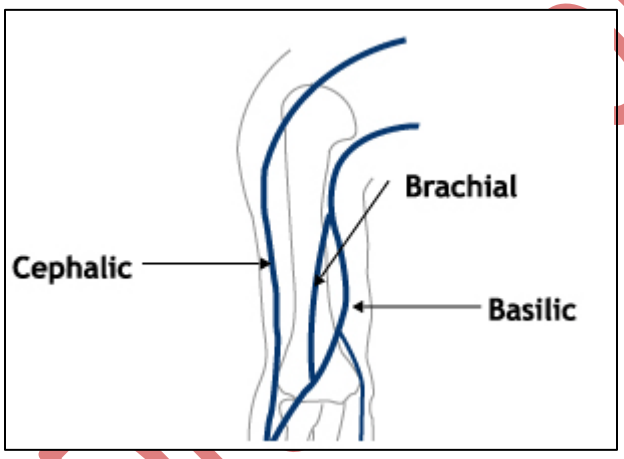
Apex: Having no natural predators in its ecosystem.

Ataxia: The loss of full control of bodily movements.

Beacon: A radio beacon whose purpose is the investigation of the propagation of radio signals.

Biopsy: The removal for diagnostic study of a piece of tissue from a living body.

Brachial vein: One of a pair of veins accompanying the brachial artery and uniting with each other and with the basilic vein to form the axillary vein.



Breeding pair: A pair of animals which cooperate over time to produce offspring with some form of a bond between the individuals.

Carrying capacity: The maximum population size of the species that the environment can sustain indefinitely, given the food, habitat, water, and other necessities available in the environment.

Compensatory immigration: Individuals emigrating from areas with lower mortality to those with higher mortality; filling a deficiency of individuals in a population experiencing higher mortality. The increase in size or activity of one part of an organism or organ that makes up for the loss or dysfunction of another.

Composition: The combining of distinct parts or elements to form a whole.

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Co-occurrence: Refers to observation of the spatial overlap between two (or more) different individuals over a period of time.

Coordinates: Any of the scales or magnitudes that serve to define the position of a point.

Core use areas: An area within a home range exhibited by a dense concentration of location points; commonly estimated at 50% of the location data points.

Covariates: A variable that is possibly predictive of the outcome under study.

Cranial: Pertaining to the cranium or to the anterior (in animals) or superior (in humans) end of the body.

Cryogenic: Very low temperatures, e.g. -80°C.

Den-obligated: Restricted to a particular condition of life, in this case restricted to a den site.

Density: A measure of the number of organisms that make up a population in a defined area.

Deployment: To organize and send out (people or things) to be used for a particular purpose.

Depredation: The act of preying upon.

Depressed respiration: A decrease in the ability to exhale and inhale; respiration that has a rate below 12 breaths per minute or that fails to provide full ventilation and perfusion of the lungs.

Diagnostic: The process of determining by examination the nature and circumstances of a diseased condition.

Disorientation: Loss of one's sense of direction, position, or relationship with one's surroundings.

Distribution: The manner in which a biological taxon is spatially arranged.

DNA: (deoxyribonucleic acid) is a type of macromolecule known as a nucleic acid. It is shaped like a twisted double helix and is composed of long strands of alternating sugars and phosphate groups, along with nitrogenous bases (adenine, thymine, guanine and cytosine).

Dorsal: Situated on or toward the upper side of the body, equivalent to the back, or posterior, in humans; situated on or toward the posterior plane in humans or toward the upper plane in quadrupeds.

Duration: A continuous period of time.

Dynamic Brownian bridge movement models: Incorporates temporal and behavioral characteristics of movement paths into estimation of home range.

Ectoparasite: a parasite that lives on the outside of its host rather than within the hosts body; e.g. fleas and lice.

Effective trap area: Calculated by buffering each trap site by half the mean maximum distance traveled, each of these boundaries are dissolved, creating a measurable area.

Efficacious: Producing or capable of producing a desired effect.

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Efficient: Accomplishment of or ability to accomplish a job with a minimum expenditure of time and effort.

Euthanize: The act of putting to death painlessly or allowing to die, as by withholding extreme medical measures, a person or animal suffering from an incurable, especially a painful, disease or condition.

Expedient: Suitable for achieving a particular end in a given circumstance.

Evaporative cooling: reduction in temperature resulting from the evaporation of a liquid, which removes latent heat from the surface from which evaporation takes place.

Facilitate: Make an action or process easy or easier.

Genotyping: Investigate the genetic constitution of (an individual organism).

Gonadal descent: The act or process of descending from a higher to a lower location; testicular descent occurs during the breeding season annually.

GPS: Global Positioning System, is a radio navigation system that allows land, sea, and airborne users to determine their exact location, velocity, and time 24 hours a day, in all weather conditions, anywhere in the world.

Home range: an area over which an animal or group of animals regularly travels in search of food or mates, and that may overlap with those of neighboring animals or groups of the same species.

Hybridization: The result of mixing, through sexual reproduction, two animals or plants of different breeds, varieties, species or genera.

Immobilization agent: An active force or substance capable of producing an effect.

Implantation: To put or fix firmly.

Inbreeding depression: The reduced biological fitness in a given population as a result of inbreeding, or breeding of related individuals.

Inception: The establishment or starting point of an institution or activity.

Interspecific: Existing or occurring between different species.

Iridium: A satellite constellation providing voice and data coverage to satellite phones, pagers and integrated transceivers over the Earth's entire surface.

Jugular vein: Any of several large veins in the neck, carrying blood from the head and face.

Lacerations: A deep cut or tear in skin or flesh.

Locational: A position or site occupied or available for occupancy or marked by some distinguishing feature.

Malfunction: Fail to operate in the normal or usual manner

Methodology: A system of methods used in a particular area of study or activity.

Midline: A median line or plane of bilateral symmetry, especially that of the body.

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Minimum convex polygon (MCP): Completely enclose all data points by connecting the outer locations in such a way as to create a convex polygon.

Molecular samples: Genetic samples that may be used for investigation of genetic constitution of an individual.

Morphometrics: The process of measuring the external shape and dimensions of landforms, living organisms, or other objects.

Mortality: The state of being subject to death.

Non-target bycatch: Animals caught by accident that are not the target species being sought.

Parameters: A numerical or other measurable factor forming one of a set that defines a system or sets the conditions of its operation.

Parentage: The origin of something; the state or relation of a parent.

Passive integrated transponder: A microchip implant is an identifying integrated circuit placed under the skin of an animal.

Pinna: The external part of the ear in humans and other mammals; the auricle.

Plateaued: A period or state of little or no growth or decline.

Population dynamics: The branch of life sciences that studies the size and age composition of populations as dynamic systems, and the biological and environmental processes driving them (such as birth and death rates, and by immigration and emigration).

Population growth: The increase in the number of individuals in a population.

Population size: A group of organisms of the same species that live in the same area.

Population status:

Population trend: Changes over time and can include changes in ranging behavior and distribution, biogeography and life-history.

Population viability: The process that determines the probability that a population will go extinct within a given number of years.

Proximity: Nearness in space, time, or relationship.

Quantified: Express or measure the quantity of.

Quantitative: Relating to, measuring, or measured by the quantity of something rather than its quality.

Radio-telemetry: The use of radio waves for transmitting information from a distant instrument to a device that indicates or records the measurements.

Recumbency: The state of leaning, resting, or reclining.

Reintegrate: Restore (elements regarded as disparate) to unity.

Draft - Confidential

Remnant: A small remaining quantity of something.

Reproductive status: Relating to or effecting reproduction.

Spatial: Relating to, occupying, or having the character of space.

Spatial capture-recapture: A method commonly used in ecology to estimate an animal population's size. A portion of the population is captured, marked, and released. Marked animals are either recaptured or are tracked, each tracking location being considered a recapture.

Species Continuum: An aggregate of species capable of interbreeding, resulting in fertile hybrid offspring whose genetic composition may represent a varying array of phenotypes and genotypes from the parental species, at which the extreme ends of the spectrum are distinct.

Standardize: Cause (something) to conform to a standard.

Statistically relevant inferences: the process of deducing properties of an underlying distribution by analysis of data. Inferential statistical analysis infers properties about a population: this includes testing hypotheses and deriving estimates.

Stochastic population models: Ecological population modeling is concerned with the changes in population size and age distribution within a population as a consequence of interactions of organisms with the physical environment, with individuals of their own species, and with organisms of other species; stochasticity possesses some inherent randomness. In stochastic population models, the same set of parameter values and initial conditions will lead to an ensemble of different out puts.

Strangulation: The condition in which circulation of blood to a part of the body is cut off by constriction.

Stratifying: Form or arrange into strata, one of a number of portions or divisions likened to layers or levels.

Surveillance: Continuous observation of a place, person, group, or ongoing activity in order to gather information.

Survival: A living or continuing longer than, or beyond the existence of, another person, thing, or event.

Sympatric: Occurring within the same geographical area; overlapping in distribution.

Tachycardia: A heart rate that exceeds the normal resting rate. In general, a resting heart rate over 100 beats per minute is accepted as tachycardia in human adults.

Telemetry: See radio-telemetry.

Temporal: Of or relating to time.

Tooth replacement: The process of development of two successive sets of teeth, initially the deciduous set and consecutively the permanent set.

Transmitter: A set of equipment used to generate and transmit electromagnetic waves carrying messages or signals, especially those of radio or television.

Transponder: A device for receiving a radio signal and automatically transmitting a different signal.

Draft - Confidential

Vaccinate: Treat with a vaccine to produce immunity against a disease; inoculate.

Venipuncture: The puncture of a vein as part of a medical procedure, typically to withdraw a blood sample or for an intravenous injection.

VHF: Very high frequency is the ITU designation for the range of radio frequency electromagnetic waves (radio waves) from 30 MHz to 300 MHz, with corresponding wavelengths of ten to one meters.

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Attachment 1: Intra-service Section 7 Biological Evaluation Form

Region 4
INTRA-SERVICE SECTION 7 BIOLOGICAL EVALUATION FORM

[Note: This form provides the outline of information needed for intra-Service consultation. If additional space is needed, attach additional sheets, or set up this form to accommodate your responses.]

Originating Person: Andrea Shipley
Telephone Number: 252.926.0266 **E-Mail:** andrea.shipley@ncwildlife.org
Date: November 8, 2016

PROJECT NAME (Grant Title/Number): NC – Division of Wildlife Management Cooperative Projects / (W-72)

I. Service Program:

_____Ecological Services
__X__Federal Aid
  _____Clean Vessel act
  _____Coastal Wetlands
  _____Endangered Species Section 6
  _____Partners for Fish and Wildlife
  _____Sport Fish Restoration
  __X__Wildlife Restoration
_____Fisheries
_____Refuges/Wildlife

II. State/Agency:

NORTH CAROLINA / NORTH CAROLINA WILDLIFE RESOURCES COMMISSION

III. Station Name:

FWS RALEIGH ECOLOGICAL SERVICES OFFICE

IV. Description of Proposed Action (attach additional pages as needed):

Conduct research project entitled "**Coyotes of the Albemarle: Spatial Ecology, Resource Selection, Demographics, and Interactions with a Sympatric Canid**"

The coyote (*Canis latrans*) is now abundant throughout the 100 counties in North Carolina (NC), where they are managed as nongame with no closed season or bag limit (NC Wildlife Resources Commission 2016). Previously restricted to the West and Midwest regions of the United States, by the early 1990s coyotes had expanded their range into the Albemarle Peninsula (AP), which is situated in the northeast coastal plains region of NC (Hinton et al. 2012, Murray et al. 2014).

Recently described as using "compensatory immigration," coyotes are able to opportunistically fill spatial resource gaps by periodic transiency (Hinton 2016). These periods of transiency can sometimes bring coyotes into conflict with humans and other canids, especially while taking advantage of anthropogenic resources. Though a rural area, human land uses predominate on the AP. The AP is comprised of approximately 30% agricultural fields, 50% forest and coastal marshes, and 20% "other" land cover types on federal, state and private lands (Dellinger 2011).

In 1968, individuals from a remnant population of red wolves were removed from Texas and Louisiana and a captive breeding program was initiated. The United States Fish and Wildlife Service (USFWS) released a non-essential, experimental population of red wolves (*Canis rufus*) on the Alligator River National Wildlife Refuge (ARNWR) in 1987 (Hinton et al. 2013). The red wolf population increased until 2008 and peaked at around 208 individuals (USFWS Red Wolf Recovery Program 2007), a few animals short of the recovery goal of 220 in the wild (USFWS Red Wolf Recovery Program 2013), with an estimated carrying capacity of 140-150 for the AP (Hinton et al. 2013, Kelly et al. 1999, USFWS Red Wolf Recovery Program 2007). Red wolves presently inhabit an approximately 6900 square kilometer recovery area within Beaufort, Dare, Hyde, Tyrrell, and Washington counties (Wildlife Management Institute 2014).
Accurate up-to-date estimates of the population are unavailable, but USFWS staff report a population size of 45-60 individuals with three mortalities in 2016 (https://www.fws.gov/redwolf/index.html July 2016). Hybridization with coyotes, inbreeding depression, and gunshot mortality have all been suspected issues that have affected the population growth and viability since the inception of the Red Wolf Recovery Program (RWRP) (Hinton et al. 2013). In 2013, NCWRC and USFWS established a committee to oversee the collaborative management and conservation of red wolves and other canids on the AP. A USFWS memorandum documented detailed action items for the joint management of canids on the AP, including specific research objectives which this proposal seeks to address (Attachment 1).

As coyotes on the AP increase in number, monitoring coyote movements, particularly in relation to red wolves, will provide important data to NCWRC and USFWS staff for science-based local and landscape-level decisions about coyote population management. Collection of finer temporal scale location data will help to manage interactions of both canid species with humans, as well as to support development of dynamic stochastic population models.

Coyote and red wolves will be live trapped by cooperating NCWRC and USFWS staff, and private trappers using double coil size 3 foothold traps, during the breeding season (Nov-Feb for coyote, Jan-Feb for red wolves) in the tri-county area of Dare, Hyde and Tyrrell. Morphological measurements, incidents of injury, occurrence of ectoparasites, age classification, and reproductive status will be determined; blood and tissue samples will be taken for genetic analysis. All captured individuals that meet the age classification and weight requirements will be collared with GPS collar units. All captured and collared individuals will be released at the capture site. The objectives listed below will be achieved by obtaining measurements, samples and information from the captured, collared, and tracked individuals over the course of three years using GPS location data.

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Objective 1: Use GPS collar and proximity sensor technology to test performance under various conditions and evaluate the frequency and accuracy of the scheduled fix rates.

Objective 2: Use fine scale GPS data collection for investigating annual and seasonal spatial dynamics of sympatric canids: home range and core area sizes, amount of overlap in home range and core areas, movement pathways and daily activity patterns, and cover type selection and preference.

Objective 3: Use fine scale GPS data collection for investigating the number and age structure of offspring for family groups of collared sympatric canids.

Objective 4: Use fine scale GPS data collection for investigating sources of mortality for sympatric canids.

Objective 5: Use fine scale GPS data collection for preventing and mitigating canid conflicts with landowners.

Objective 6: Determine genetic profiles of sympatric canids through DNA identification of all captured individuals, parentage, and presence of hybridization.

V. Pertinent Species and Habitat:

A. Include species/habitat: See section VI

B. Complete the following table:

SPECIES/CRITICAL HABITAT	STATUS[1]
Canis rufus	T

[1]STATUS: E = endangered, T = threatened, PE = proposed endangered, PT =proposed threatened, CH = critical habitat, PC = proposed critical habitat, C = candidate species

VI. Location:

A. Statewide

Albemarle Peninsula (see web address www.ncwildlife.org)

B. Section, township, and range (or latitude and longitude):

Dare, Hyde, Tyrrell counties

C. Distance (miles) and direction to nearest town:

As stated above

D. Species/habitat occurrence:

Canis rufus

VII. Determination of Effects:

A. Explanation of effects of the action on species and critical habitats in item V. B. (attach additional pages as needed):

SPECIES/CRITICAL HABITAT	IMPACTS TO SPECIES/CRITICAL HABITAT
Canis rufus	Trap induced injury is possible

B. Explanation of actions to be implemented to reduce adverse effects:

SPECIES/CRITICAL HABITAT	ACTIONS TO MITIGATE/MINIMIZE IMPACTS
Canis rufus	Use of appropriate trap types, daily trap checks, treatment of minor injuries, trapping season limitations and limitations on environmental conditions for trap operation

VIII. Effect Determination and Response Requested:

Species/ Critical Habitat	Determination[1]			Response[1] Requested
	NE	NA	AA	
Canis rufus		X		Concurrence

[1] Determination/Response Requested:

NE = No Effect. This determination is appropriate when the proposed action will not directly, indirectly, or cumulatively impact, either positively or negatively, any listed, proposed, candidate species or designated/proposed critical habitat. Response Requested is optional but a "Concurrence" is recommended for a complete Administrative Record.

NA = Not Likely To Adversely Affect. The determination is appropriate when the proposed action is not likely to adversely impact any listed, proposed, candidate species or designated/proposed critical habitat or there may be beneficial effects to these resources. Response Requested is a "Concurrence".

AA = Likely To Adversely Affect. This determination is appropriate when the proposed action is likely to adversely impact any listed, proposed, candidate species or designated/proposed critical habitat. Response Requested for listed species is "Formal Consultation". Response Requested for proposed or candidate species is "Conference".

Signature (originating station) **Date**

Title

IX. Reviewing Ecological Services Office Evaluation:

A. Concurrence _____ Non-Concurrence _____

B. Formal consultation required _____

C. Conference required _____

D. Formal conference required _____

E. Remarks (attach additional pages as needed):

_____ _____

Signature **Date**

_____ _____

Title **Office**

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Attachment 2: Joint Memorandum

MEMORANDUM

November 20, 2013

TO: All Interested Parties

FROM: "for" Cynthia K. Dohner, Director, Southeast Region, U.S. Fish and Wildlife Service
Gordon S. Myers, Executive Director, N.C. Wildlife Resources Commission

SUBJECT: Collaborative Conservation of Red Wolves and Other Canids on North Carolina's Albemarle Peninsula

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Recovery of the federally-listed red wolf has been a priority for the U.S. Fish and Wildlife Service (FWS) for more than 20 years and is focused in North Carolina on the Albemarle Peninsula (AP; i.e., Hyde, Tyrrell, Washington, Beaufort, and Dare counties). Comprehensive stakeholder involvement and collaboration with other management agencies is critical to successful recovery of any at-risk species. The North Carolina Wildlife Resources Commission (WRC) is a key collaborator in this regard, as it has jurisdiction over all state-trust wildlife resources in N.C.

Since 2009, the FWS and WRC have worked to broaden our collaboration in the conservation and management of all canid species (including red wolves) on the AP. As these efforts have solidified, specific actions have been jointly identified by our two agencies that will improve conservation outcomes. These actions are categorized into five areas; collaboration, research, outreach, regulatory, and enforcement. Specific action items are outlined and prioritized within each of these categories in Attachment A.

This memo establishes the FWS's and WRC's commitment to initiate, or to continue, the efforts outlined in Attachment A. The common goal in this effort is to establish clear expectations and accountability for collaboration regarding the action items on Attachment A, thus resulting in enhanced and seamless canid conservation and management on the AP. This approach provides the best opportunity to achieve recovery goals for red wolves, while at the same time managing other canids to balance biological variables with social expectations. The dynamics of these canid species are complex and offer unique opportunities for innovation. Appropriate staff from each agency is hereby tasked with immediately developing a timeline to implement these actions. Through this commitment, we will continue to advance our collective conservation goals.

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Attachment A

Action Items for Collaborative Conservation of Canids on North Carolina's Albemarle Peninsula (AP)
(*Note: Action Items are prioritized within category.*)

Collaboration

1. The N.C. Wildlife Resources Commission (WRC) and U.S. Fish and Wildlife Service (FWS) will formalize in writing the collaborative management of canids on the AP. This agreement should:
    a. include a clear mission statement, goals, objectives, and implementation strategies (ask and answer the "Why?");
    b. set a goal to define success regarding canid management on the AP;
    c. espouse a philosophy of canid management operating within the context of a three-legged stool (i.e., federal and state governments and stakeholders);
    d. as available, commit funding and staffing resources for field personnel to contribute to the conservation of the red wolf and management of coyotes;
    e. as available, commit funding to conduct research pertinent to canid management on the AP;
    f. establish polices and goals for developing a collaborative genetic archive for AP canids, a data sharing portal accessible by staff in both agencies, and reciprocal sharing of all historical data (including phenotypic and genotypic data and literature) of the red wolf;
    g. establish a foundation for developing and implementing an adaptive approach to canid management on private lands on the AP;
    h. initiate development of a collaborative canid research program;
    i. describe plans to conduct the next five year Red Wolf Program review;
    j. outline options for holding annual workshops with federal and state enforcement staff;
    k. outline plans to hold semi-annual coordination meetings regarding canid management on the AP; and
    l. develop milestones for future development of a management plan for all canids in the AP.

2. The FWS will initiate a review of the current Red Wolf Recovery Plan to determine if the state-of-our-knowledge or field conditions have changed such as to warrant its revision. Review and comments from the WRC will be considered in this evaluation.

3. The WRC, with support and participation of the FWS, will establish a "Canid Forum" (similar to that established for manatees in Florida) to facilitate communication and discussion regarding canid management and citizen science opportunities on the AP.

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Attachment A

Research

1. The FWS and WRC will provide funding and logistical support for research identified by the Red Wolf Recovery Implementation Team, Red Wolf Program staff, other FWS staff, or the WRC that promote the conservation and recovery of the red wolf and other canids on the AP. Studies could include:
    a. tests of the "placeholder theory" on the AP, including behavior of sympatric canids,
    b. determining carrying capacity of canids on the AP,
    c. determining genetic profiles of canid species on the AP,
    d. evaluating predator-prey dynamics,
    e. studies of canid habitat use,
    f. epidemiology of diseases impacting canids on the AP,
    g. development of stochastic simulation models of sympatric canid population dynamics and habitat use, and
    h. canid dispersal dynamics

2. The FWS and WRC will conduct jointly-supported research to determine the attitudes and opinions of N.C. private landowners and other citizens concerning canids on the AP (i.e., human dimensions studies).

Outreach

1. The FWS and WRC will collaborate with other partners to design and implement broad-based outreach and marketing programs with clear goals, objectives, strategies, and measurable outcomes, including development of consistent agency messages and educating the public about canids on the AP.

Regulatory

1. The FWS and WRC will initiate a review and, if needed, subsequent rule-making to clarify concepts or rectify conflicts in current federal or state rules (including the current 10(J) rule).

2. The WRC will review and evaluate statutory requirements for listing red wolves as state threatened in the five AP counties.

3. As data demonstrating a relationship between coyote hunting and red wolf mortality become available, the FWS and WRC will evaluate, and if appropriate implement, adaptive approaches to regulate of take of coyotes that may result in incidental take of red wolves.

4. The WRC will evaluate the status, management, and regulation of Controlled Fox Hunting Preserves.

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Attachment A

5. The WRC will develop BMPs (due care provisions) for coyote hunting, trapping, and live sale.

6. The WRC will compile, compare, and contrast canid hunting and trapping regulations and programs in other states, including, but not limited to, other states with other species of wolves.

Enforcement

1. The FWS and WRC will develop coordination strategies to improve enforcement of federal regulations protecting red wolves.

Attachment 3: Landowner Agreement Form

NC Wildlife Resources Commission
Wildlife Management Division
Wildlife Diversity Program
Landowner Agreement for Scientific Collection

_____ / _____ / _____
MM DD YYYY

Property Type
Private _____ Federal _____ State _____

NC Wildlife Resources Commission
Address: 1701 Mail Service Center, Raleigh, NC 27699-1701
Phone: 919-707-0010

Cooperator's Name: _____
Last First Middle

Cooperator's Address: _____
Street City, State, Zip

Where will the work be performed? _____

give address or directions if different from above _____

Business, Farm, Property Common Name _____

Owner's or Rep Name _____ _____
If different from Cooperator Telephone Number

Owner's Address: _____
If different from Cooperator Street City, State, Zip

WRC Employee & Work Location	Species
Employee Name	1)
	2)
Duty Area	3)
	4)

I, the cooperator or cooperator's representative, have been informed of the methods and the manner in which research devices will be used, and of the possible hazards associated with their use. I understand that NCWRC, (to include its officers, employees and agents) will: exercise reasonable precautions to safeguard all persons to prevent injury to target and non-target animals; guard against the mishandling of control devices and materials; and exercise due caution and proper judgment in all scientific collection operations. I understand that NCWRC may collect Global Positioning System (GPS) coordinates at the project site as part of component or activity tracking or as wildlife disease monitoring or research data. I, the undersigned cooperator, do hereby give my consent and concurrence to NCWRC, its employees, and its agents, to use, upon lands owned, leased, or otherwise controlled by me, and identified by this document, the following methods and devices (an attachment of additional devices and/or methods may be attached):

Statement of agreement: The landowner, cooperator, or representative, as listed above hereby give permission to NCWRC to perform trap and release of the species listed for scientific collection purposes. In consideration of these understandings, I, the cooperator or cooperator's representative, agree to: assume responsibility for injury to my property under my control, when said injury is not the result of negligence on the part of NCWRC (it's officers, employees, and agents); assist in maintaining such warning signs as NCWRC may place for the purpose of notifying persons entering onto such lands of the possible hazards associated with scientific measures in use thereon; and to give adequate warning of these possible hazards to persons I authorize to enter onto such lands. Further, I, the cooperator or cooperator's representative, agree not to concurrently use or allow to be used upon lands covered by this agreement, any canid depredation efforts during the scientific collection time period.

Landowner Signature/Date _____
Signature Date

WRC Employee Signature/Date _____
Signature Date

Attachment 4: Trapper Service Contract

Contract in development.

Draft - Confidential

From: Smethers, Lacey
To: Sheehan, Greg
Cc: Downey Magallanes; Todd Willens; Gulac, Catherine; Roslyn Sellars
Subject: Re:
Date: Thursday, May 17, 2018 1:21:08 PM

Downey is unavailable Monday. Tues-Thursday mornings after 9:30 seem to be the best

Lacey Smethers
Special Assistant, Office of the Secretary

On Thu, May 17, 2018 at 1:01 PM, Sheehan, Greg <greg_j_sheehan@fws.gov> wrote:

> I could you meet on Monday am. I have included my assistant for scheduling purposes.
>
> Thanks
>
> On Thu, May 17, 2018 at 12:56 PM, Smethers, Lacey <lacey_smethers@ios.doi.gov> wrote:
>
> > Would Tuesday or Wednesday morning work for everyone?
> >
> > Lacey Smethers
> > Special Assistant, Office of the Secretary
> >
> > On Thu, May 17, 2018 at 12:37 PM, Sheehan, Greg <greg_j_sheehan@fws.gov> wrote:
> >
> > > If you want a quick run down I could come up right now and do that. If more formal then early Monday morning or Wed-Friday.
> > >
> > > Let me know
> > >
> > > Thanks
> > > Greg
> > >
> > > On Thu, May 17, 2018 at 12:00 PM, Smethers, Lacey <lacey_smethers@ios.doi.gov> wrote:
> > >
> > > > Let me know what works best for everyone!
> > > >
> > > > Lacey Smethers
> > > > Special Assistant, Office of the Secretary
> > > >
> > > > On Thu, May 17, 2018 at 11:54 AM, Downey Magallanes <downey_magallanes@ios.doi.gov> wrote:
> > > >
> > > > > Could we schedule and update on red Wolf program
> > > > >
> > > > > Sent from my iPhone

> > --
> > Greg Sheehan
> > Principal Deputy Director
> > US Fish and Wildlife Service
> > 1849 C Street NW, Room 3358
> > Washington, DC 20240
> > Office 202-208-4545
> > Cell 202-676-7675

--
Greg Sheehan
Principal Deputy Director
US Fish and Wildlife Service
1849 C Street NW, Room 3358
Washington, DC 20240
Office 202-208-4545
Cell 202-676-7675

Research and Monitoring
Special Use Permit Application

Refuge Name:

Address:

Attn: (Refuge Official)

E-Mail:

Phone #:

For Official Use Only

Approved Permit #:

Station #:

Permit Term: from ____ to ____

Note: We do not require all information for each Research project. See instructions at the end of the notice and contact the refuge to determine applicability of a particular item. Attach additional sheets if the text spaces provided are inadequate.

1a) Identify the type of Permit you are applying for: **New** ◯ **Renewal** ◯ **Modification** ◯ **Other** ◯

1b) Have you applied, or do you intend to apply, to any other refuges for this same activity? ◯ **Yes** ◯ **No**

1c) If yes, which refuges?

Applicant Information

2) Principal investigator:

3) Is curriculum vitae or resume attached? **Yes** ◯ **No** ◯

4a) Affiliation/Sponsoring Organization:

4b) Relationship to affiliation/sponsoring organization (professor, staff, student, etc.):

5) Physical Address:

City/State/Zip:

6) Mailing Address: (if different than above)

City/State/Zip:

7) Phone #: 8) Fax #: 9) E-mail:

10) List **known** assistants/subcontractors/subpermittees: (Only required if the assistants/subcontractors/subpermittees will be operating on the refuge without the permittee being present.)

Name	Address	Phone #

Project Information

11) Title of project:

12) Is a full research proposal attached? Yes ◯ No ◯

Note: Depending on the research and monitoring project for which you are requesting a permit, we may ask you for the following project information (13 -25) if it is not included in your research proposal, or if you have not provided a full research proposal with this application. Please contact the specific refuge where the activity is being conducted to determine what information is required.

Attach additional sheets to the application if the text spaces provided are inadequate.

13) Describe project by specifically identifying timing, frequency, and how the project is expected to proceed:

14) Specifically identify location(s) and/or attach a map for the project: (GPS location(s) preferred)

15) Identify species or habitats being studied:

16) Purpose/hypothesis:

17) Expected benefits of research/monitoring:

18) Briefly describe project history and context of research/monitoring project:

19) Briefly describe project's relationship to other research/monitoring projects either known of or conducted by the applicant:

20) Identify the types of specimen collections to be taken **(see specimen collection clause in the instruction section #20)** or data to be collected during the proposed project:

21) List other cooperators and institutions involved in the project:

22) Generally identify the anticipated timeline for analysis, write-up and publication:

23) For research involving animals, attach an Assurance of Animal Care Form or an approval from an Institutional Animal Care and Use Committee? Is a form or approval attached? ◯ Yes ◯ No ◯ N/A

License/Insurance/Certifications/Permits

Note: Contact the specific refuge office where the research project is going to be conducted to determine if any type of license, insurance, certification(s), or permit(s) will be required. We may process this Special Use Permit while the applicant obtains them. Attach additional sheets to the application if the text spaces provided are inadequate.

24a) List and attach copies of any **licenses** you have for equipment operation (i.e., aviation or commercial boats), pesticide applications, transporters) or others if required:

License Type	Number	Expiration Date (if applicable)

24b) List and attach copies of any **insurance** you have (i.e general liability, flight/grounding, contaminants, medical evacuation, or others if required:

Insurance Type	Carrier	Expiration Date (if applicable)

24c) List and attach copies of any **certifications** you have, such as rat free, hull inspections, CPR/First Aid, or others if required:

Certificate Type	Expiration Date (if applicable)

24d) List and attach copies of any other Federal, State, or Tribal **permits** if required:

Permit Type	Permit Number	Expiration Date (if applicable)

Logistics and Transportation **Attach additional sheets if the text spaces provided are inadequate.**

25a) Does project require personnel to stay overnight on the refuge? **Yes** ◯ **No** ◯

25b) If yes, how many? ☐ And list known personnel involved in overnight stay below:

List Names	List Names	List Names	List Names

26) Specifically describe all major instrumentation/equipment/gear (i.e. use of drones) and materials used, if applicable or required:

27a) Provide details and schedule for the installation of instrumentation:

27b) Provide details and schedule for the removal of instrumentation:

27c) If instrumentation is permanent, describe need:

27d) If instrumentation requires a maintenance schedule, describe needs and schedule:

27e) Provide a data collection schedule:

28) Provide logistical arrangements for offsite transportation of samples:

29a) Provide detailed information on the logistics for onsite, intersite, and/or ship-to-shore transportation to or on the refuge, if required**:**

29b) Provide descriptions, license plate and/or identification numbers of vehicles used for onsite transportation, if required:

Vehicle Type	Plate/I.D./Registration #	Vehicle Type	Plate/I.D./Registration #

29c) Provide descriptions, license plate and/or identification numbers of vehicles used for intersite transportation, if required:

Vehicle Type	Plate/I.D./Registration #	Vehicle Type	Plate/I.D./Registration #

29d) Provide descriptions, license plate and/or identification numbers of vehicles used for ship-to-shore transportation, if required

Vehicle Type	Plate/I.D./Registration #	Vehicle Type	Plate/I.D./Registration #

30a) Is fuel cache needed? **Yes** ◯ **No** ◯ **N/A** ◯ 30b) Provide specific location(s) of fuel caches: (GPS coordinates preferred)

31) Attach Safety Plan if required. Is Safety Plan attached? **Yes** ◯ **No** ◯ **N/A** ◯

Work and Living Accommodations

32) Specifically describe onsite work and/or living accommodations, including spike camps:

33) Specifically describe on or offsite hazardous material storage or other on or offsite material storage space: (Including on and offsite fuel caches.)

Sign, date, and print this form and return it to the refuge for processing. By signing this application, I agree my operations will conform to the information I have provided in this application, and I understand that any deviations or changes to this information must receive prior written approval.

34) Signature of Applicant: _____Date of Application: _____

NOTICES

No Members of Congress or Resident Commissioner shall participate in any part of this contract or to any benefit that may arise from it, but this provision shall not pertain to this contract if made with a corporation for its general benefit.

The Permittee agrees to be bound by the equal opportunity "nondiscrimination in employment" clause of Executive Order 11246.

PRIVACY ACT STATEMENT

Authority: The information requested is authorized by the National Wildlife Refuge System Administration Act (16 U.S.C. 668dd-ee) and the Refuge Recreation Act (16 U.S.C. 460k-460k-4).

Purpose: To collect the applicant's information to process permits allowing for: research and monitoring activities by students, universities, or other non-FWS organizations.

Routine Uses: The information will be used by the refuge's administrative office for processing Research and Monitoring Special Use permits. More information about the routine uses maybe found in the Systems of Records Notice, FWS-5 National Wildlife Refuge Special Use Permits.

Disclosure: Providing the information is voluntary. However, submission of information is required to process and approve research and monitoring activity usage on the National Wildlife Refuge System.

PAPERWORK REDUCTION ACT STATEMENT

We are collecting this information subject to the Paperwork Reduction Act (44 U.S.C. 3501) to evaluate the qualifications, determine eligibility, and document permit applicants and to respond to requests made under the Freedom of Information Act and the Privacy Act of 1974. The information that you provide is required to obtain or retain a benefit; however, failure to provide all required information is sufficient cause for the U.S. Fish and Wildlife Service to deny a permit. False, fictitious, or fraudulent statements or representations made in the application may be grounds for revocation of the Special Use Permit and may be punishable by fine or imprisonment (18 U.S.C. 1001). According to the Paperwork Reduction Act of 1995, an agency may not conduct or sponsor and a person is not required to respond to a collection of information unless it displays a currently valid OMB control number. OMB has approved this information collection and assigned control number 1018-0102.

ESTIMATED BURDEN STATEMENT

The public reporting burden for this information collection varies based on the requested specific refuge use. We estimate the relevant public reporting burden for the Research and Monitoring Activity Special Use Permit Application form is to average 5 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to the Service Information Collection Clearance Officer, Division of Policy, Performance, and Management Programs, Fish and Wildlife Service, Mail Stop BPHC, 5275 Leesburg Pike, Falls Church, VA 22041-3803. Please do not send your completed form to this address.

GENERAL CONDITIONS AND REQUIREMENTS

1) Responsibility of Permittee: We shall consider the permittee, by operating on the premises, to have accepted these premises with all facilities, fixtures, or improvements in their existing condition as of the date of this permit. At the end of the period specified or upon earlier termination, the permittee shall give up the premises in as good order and condition as when received except for reasonable wear, tear, or damage occurring without fault or negligence. The permittee will fully repay the Service for any and all damage directly or indirectly resulting from negligence or failure on his/her part, and/or the part of anyone of his/her associates, to use reasonable care.
2) Operating Rules and Laws: The permittee shall keep the premises in a neat and orderly condition at all times, and shall comply with all municipal, county, and State laws applicable to the operations under the permit as well as all Federal laws, rules, and regulations governing national wildlife refuges and the area described in this permit. The permittee shall comply with all instructions applicable to this permit issued by the refuge official in charge. The permittee shall take all reasonable precautions to prevent the escape of fires and to suppress fires and shall render all reasonable assistance in the suppression of refuge fires.

3) Use Limitations: The permittee's use of the described premises is limited to the purposes herein specified and does not, unless provided for in this permit, allow him/her to restrict other authorized entry onto his/her area; and allows the U.S. Fish and Wildlife Service to carry on whatever activities are necessary for: (1) protection and maintenance of the premises and adjacent lands administered by the U.S. Fish and Wildlife Service; and (2) the management of wildlife and fish using the premises and other U.S. Fish and Wildlife Service lands.

4) Transfer of Privileges: This permit is not transferable, and no privileges herein mentioned may be sublet or made available to any person or interest not mentioned in this permit. No interest hereunder may accrue through lien or be transferred to a third party without the approval of the Regional Director of the U.S. Fish and Wildlife Service and the permit shall not be used for speculative purposes.

5) Compliance: The U.S. Fish and Wildlife Service's failure to require strict compliance with any of this permit's terms, conditions, and requirements shall not constitute a waiver or be considered as a giving up of the U.S. Fish and Wildlife Service's right to thereafter enforce any of the permit's terms or conditions.

6) Conditions of Permit not Fulfilled: If the permittee fails to fulfill any of the conditions and requirements set forth herein, the U.S. Fish and Wildlife Service shall retain all money paid under this permit to be used to satisfy as much of the permittee's obligation as possible.

7) Payments: All payment shall be made on or before the due date to the local representative of the U.S. Fish and Wildlife Service by a postal money order or check made payable to the U.S. Fish and Wildlife Service.

8) Termination Policy: At the termination of this permit the permittee shall immediately give up possession to the U.S. Fish and Wildlife Service representative, reserving, however, the rights specified in paragraph 11 below. If he/she fails to do so, he/she will pay the U.S. Fish and Wildlife Service, as liquidated damages, an amount double the rate specified in this permit for the entire time possession is withheld. Upon yielding possession, we will still allow the permittee to reenter as needed to remove his/her property as stated in paragraph 11 below. The acceptance of any fee for the liquidated damages or any other act of administration relating to the continued tenancy is not to be considered as an affirmation of the permittee's action nor shall it operate as a waiver of the U.S. Fish and Wildlife Service's right to terminate or cancel the permit for the breach of any specified condition or requirement.

9) Revocation Policy: The Regional Director of the U.S. Fish and Wildlife Service may revoke this permit without notice for noncompliance with the terms hereof, or for violation of general and/or specific laws or regulations governing national wildlife refuges, or for nonuse. It is at all times subject to discretionary revocation by the Director of the Service. Upon such revocation the U.S. Fish and Wildlife Service, by and through any authorized representative, may take possession of said premises for its own and sole use, and/or may enter and possess the premises as the agent of the permittee and for his/her account.

10) Damages: The U.S. Fish and Wildlife Service shall not be responsible for: any loss or damage to property including but not limited to crops, animals, and machinery; injury to the permittee or his/her relatives or to the officers, agents, employees, or any other(s) who are instructed to be on the premises; the sufferance from wildlife or employees or representatives of the U.S. Fish and Wildlife Service carrying out their official responsibilities. The permittee agrees to hold the U.S. Fish and Wildlife Service harmless from any and all claims for damages or losses that may arise to be incident to the flooding of the premises resulting from any associated Government river and harbor, flood control, reclamation, or Tennessee Valley Authority activity.

11) Removal of Permittee's Property: Upon the expiration or termination of this permit, if all rental charges and/or damage claims due to the U.S. Fish and Wildlife Service have been paid, the permittee may, within a reasonable period as stated in the permit or as determined by the U.S. Fish and Wildlife Service official in charge, but not to exceed 60 days, remove all structures, machinery, and/or equipment, etc., from the premises for which he/she is responsible. Within this period the permittee also must remove any other of his/her property including his/her acknowledged share of products or crops grown, cut, harvested, stored, or stacked on the premises. Upon failure to remove any of the above items within the aforesaid period, they shall become the property of the U.S. Fish and Wildlife Service. .

INSTRUTIONS FOR COMPLETING APPLICATION

You may complete the application portion verbally, in person, or electronically and submit to the refuge for review. Note: Please read instructions carefully as not all information is required for each activity. Contact the specific refuge where the activity will take place if you have questions regarding the applicability of a particular item. We may add special conditions or permit stipulations to permit prior to approval.

1a-1c) Identify if permit application is for new, renewal, or modification of an existing permit, whether or not you have or will be applying to another refuge for the same activity, and for which refuge(s). Permit renewals may not need all information requested. Contact the specific refuge headquarters office where the activity is going to be conducted to determine applicability of this requirement.

2-3) Provide principal investigator or applicant full name. Attach principal investigator's Curriculum Vitae or Resume, if required. Permit renewals generally do not require a Curriculum Vitae or Resume if the project is a continuation of a previously issued permit being conducted by the same investigator. Contact the specific refuge office to determine applicability of this requirement.

4-9) Provide investigator's physical and/or mailing address, phone, fax, e-mail, affiliation and/or sponsoring organization, and relationship to affiliation or organization (title, professor, student, etc.).

10) Provide the names and addresses of assistants, subcontractors, or subpermittees. We may require names and addresses if the assistants, subcontractors or subpermittees will be operating on the refuge without the permittee being present. Volunteers, assistants, subcontractors, or subpermittees accompanied by the permittee need not be identified.

11) Provide title of research or monitoring project.

12a-12b) Attach a full research or monitoring proposal, if required. Permit renewals generally do not require a project proposal if the project is a continuation of a previously issued permit being conducted by the same investigator. Contact the specific refuge office to determine applicability of this requirement.

13) Provide detailed information on the activity, including timing, frequency, how the project is expected to proceed, etc. Permit renewals may not need activity description, if the activity is unchanged from previous permit. Most repetitive research projects do not require an activity description for each visit to the refuge. Contact the specific refuge office to determine applicability of this requirement.

14) Identify specific location (GPS coordinates preferred) if not a named facility, and/or attach a map of the location. Permit renewals may not require a location if the project is essentially unchanged from the previous permit. Contact the specific refuge office to determine applicability of this requirement.

15) Identify species or habitats being studied.

16-17) Specifically identify purpose or hypothesis of the research or monitoring project and describe expected benefits. Permit renewals may not need to identify purpose or hypothesis if the project is a continuation of a previously issued permit being conducted by the same investigator. Contact the specific refuge office to determine applicability of this requirement.

18) Briefly describe project history and context. Permit renewals should describe previous research activities as part of a previously issued permit being conducted by the same investigator. Contact the specific refuge office to determine applicability of this requirement.

19) Briefly describe project's relationship to other research/monitoring projects either known of or conducted by the applicant, if applicable. Include a brief statement of how the research or monitoring permit being applied for will add to or supplement other ongoing research or monitoring on the same, or related, species or habitats. Contact the specific refuge office to determine applicability of this requirement.

20) Identify specimen collections to be taken or types of data to be collected. You may use specimens collected under this permit, any components of any specimens (including natural organisms, enzymes, genetic materials or seeds), and research results derived from collected specimens for scientific or educational purposes only, and not for commercial purposes unless you have entered into a Cooperative Research and Development Agreement (CRADA) with us. We prohibit the sale of collected research specimens or transfers to third parties for commercial purposes. Breach of any of the terms of this permit will be grounds for revocation of this permit and denial of future permits. Furthermore, if you sell or otherwise transfer for commercial purposes collected specimens, any components thereof, or any products or research results developed from such specimens or their components without a CRADA, you will pay us a royalty rate of 20 percent of gross revenue from such sales. In addition to such royalty, we may seek other damages and injunctive relief against you. Permit renewals may not need to identify samples taken if the project is a continuation of a previously issued permit being conducted by the same investigator. Contact the specific refuge office to determine applicability of this requirement.

21) List other cooperators and institutions involved in the project, if applicable. Contact the specific refuge office to determine applicability of this requirement.

22) Generally, identify the anticipated time line for analysis, write-up, and publication of project results. Include whether the project is a single, or multiple year project. Identification of an actual publication where the results are printed is not necessary. However, applicants should include the anticipated dissemination of project results. Contact the specific refuge office to determine applicability of this requirement.

23) Check box acknowledging a completed Assurance of Animal Care Form or an Institutional Animal Care and Use Committee (or equivalent) that has granted approval has been completed, and has been submitted to refuge station, if required. Contact the specific refuge office to determine applicability of this requirement.

24a-24d) Specifically identify types and numbers of licenses, insurance, certifications, and other State, Federal, or Tribal permits if required. Contact the specific refuge headquarters office where the project is going to be conducted to determine applicability of these requirements, and to coordinate the simultaneous applications of any of these requirements while this Special Use Permit is being processed.

25a-25b) Provide the number of and/or name(s) of any personnel required to stay overnight on the refuge, if applicable.

26) Identify all equipment (including drones) and materials that will be used, if required. Permit renewals may not require a list of equipment if the project is essentially unchanged from a previously issued permit. Contact the specific refuge office to determine applicability of this requirement.

27a-27e) Identify types and schedule(s) of installation of any instrumentation, data collection, and maintenance schedule of instrumentation, if required. Permit renewals may not require a list of equipment if the project is essentially unchanged from a previously issued permit. However, schedules of installation of any instrumentation, data collection, and maintenance schedule of instrumentation may still be required. Contact the specific refuge headquarters office where the project is going to be conducted to determine applicability of this requirement.

28) Identify logistical arrangements for offsite transportation of samples taken, if applicable.

29a-29d) Describe and provide vehicle descriptions and license plate or identification numbers of all vehicles, including boats and airplanes, if required. Motor vehicle descriptions are only required for permittee vehicle, and/or if the vehicle will be operated on the refuge without the permittee being present. Motor vehicles that are accompanied by the permittee as part of a group (convoy) activity need not be identified if cleared in advance by refuge supervisor. Specifically describe ship-to-shore, intersite (between islands, camps, or other sites) and onsite transportation mechanisms, and license plate or identification numbers, if required.

30a-30b) Identify specific location(s) of fuel cache(s) (GPS coordinates preferred), if required.

31a-31b) Attach safety plan, if required. Contact the specific refuge office to determine applicability of this requirement.

32) Specifically describe onsite work and/or living accommodations, if required. Include descriptions and locations (GPS coordinates preferred) of spike camps or other remote work and/or living accommodations that are not part of the base of operations. Contact the specific refuge office to determine applicability of this requirement.

33) Specifically describe onsite and offsite hazardous material storage, or other onsite material storage space (including on and offsite fuel caches), if required. Contact the specific refuge office to determine if descriptions of hazardous material storage or other onsite material storage are required.

34) Sign, date, and print the application. Click on the Print button to print the application (if using the fillable version). The refuge official will review and, if approved, fill out the remaining information, sign, and return a copy to you for signature and acceptance.

THIS APPLICATION FORM IS NOT VALID AS A PERMIT
BUT MAY BE USED AS A REFERENCE DOCUMENT ATTACHED TO THE OFFICIAL PERMIT.
ONLY OFFICIAL REFUGE PERSONNEL MAY ASSIGN A VALID PERMIT NUMBER AND PERMIT TERM
TO THIS APPLICATION FORM AFTER THE PERMIT HAS BEEN APPROVED.

North Carolina Coastal Refuge Complex Refuge Research Proposal Guidelines

A research proposal including a justification and description of the work to be done on the refuge is required before approval of a special use permit. Below are the necessary requirements for a proposal to be considered. In addition, refuge staff reserves the right to ask more detailed questions before approving a project. Proposals should be submitted electronically as a Microsoft Word document or hard copy to the refuge manager.

Cover Page
The cover page must contain the following information:

- Title of proposal
- Current date
- Investigator(s)—name, title, organizational affiliation, address, telephone and fax numbers and e-mail address of all investigators or cooperators
- Proposed starting date
- Estimated completion date
- List of all partners and funding sources of the project
- Signatures of principal investigator(s) and other appropriate institutional officials

Abstract
The abstract should contain a short summary description of the proposed study, including reference to major points in the sections "Statement of Issue," "Objectives," and "Methods and Procedures."

Statement of Issue
Provide a clear precise summary of the problem to be addressed and the need for its solution. This section should include statements of the importance, justification, relevance, timeliness, ability to be generalized, and contribution of the study. Describe how any products will be used, including any anticipated commercial use. What is the estimated probability of success of accomplishing the objective(s) within the proposed timeframe?

Objectives/Hypotheses
A very specific indication of the proposed outcomes of the project should be stated as objectives or hypotheses to be tested. Project objectives should be measurable. Provide a brief summary of what information will be provided at the end of the study and how it will be used in relation to the problem. These statements should flow logically from the statement of issue and directly address the management problem.

Establish data quality objectives in terms of precision, accuracy, representativeness, completeness, and comparability as a means of describing how good the data need to be to meet the project's objectives.

Study Area
Provide a detailed description of the geographic area(s) to be studied and include a clear map delineating the proposed study area(s) and showing specific locations where work will occur.

Methods and Procedures
This section should describe as precisely as possible, how the objectives will be met or how the hypotheses will be tested. Include detailed descriptions and justifications of the field and laboratory methodology, protocols, and instrumentation. Explain how each variable to be measured directly addresses the research objective/hypothesis. Describe the experimental design, population, sample size, and sampling approach (including procedures for sub-sampling). Summarize the statistical and other data analysis procedures to be used. List the response variables and tentative independent variables or covariates. Describe the experimental unit(s) for statistical analysis. Also include a detailed project time schedule that includes start, fieldwork, analysis, reporting, and completion dates.

Quality Assurance/Quality Control
Adequate quality assurance/quality control procedures help ensure that data and results are:

- Credible and not an artifact of sampling or recording errors.
- Of known quality.
- Able to stand up to external scientific scrutiny.
- Accompanied by detailed method documentation.

Describe the procedures to be used to ensure that data meet defined standards of quality and program requirements, errors are controlled in the field, laboratory, and office, and data are properly handled, documented, and archived. Describe the various steps (e.g., personnel training, calibration of equipment, data verification and validation) that will be used to identify and eliminate errors introduced during data collection (including observer bias), handling, and computer entry. Identify the percentage of data that will be checked at each step.

Specimen Collections
Clearly describe the kind (species), numbers, sizes, and locations of animals, plants, rocks, minerals, or other natural objects to be sampled, captured, or collected. Identify the reasons for collecting, the intended use of all the specimens to be collected, and the proposed disposition of collected specimens. For those specimens to be retained permanently as voucher specimens, identify the parties responsible for cataloging, preservation, and storage, as well as the proposed repository.

Special Requirements, Permits, and Concerns
Provide information on the following topics where applicable. Attach copies of any supporting documentation that will facilitate processing of your application.

Refuge Assistance
Describe any refuge assistance needed to complete the proposed study, such as use of equipment or facilities or assistance from refuge staff. It is important that all equipment, facilities, services, and logistical assistance expected to be provided by the Service be specifically identified in this section so all parties are in clear agreement before the study begins.

Ground Disturbance
Describe the type, location, area, depth, number, and distribution of expected ground-

disturbing activities, such as soil pits, cores, or stakes. Describe plans for site restoration of significantly affected areas.

Proposals that entail ground disturbance may require an archaeological survey and special clearance prior to approval of the study. You can help reduce the extra time that may be required to process such a proposal by including identification of each ground disturbance area on a U.S. Geological Survey 7.5-minute topographic map.

Site Marking and/or Animal Marking
Identify the type, amount, color, size, and placement of any flagging, tags, or other markers needed for site or individual resource (e.g., trees) identification and location. Identify the length of time it is needed and who will be responsible for removing it. Identify the type, color, and placement of any tags placed on animals (see special use permit for stipulations on marking and handling of animals).

Access to Study Sites
Describe the proposed method and frequency of travel to and within the study site(s). Explain any need to enter restricted areas. Describe the duration, location, and number of participants, and approximate dates of site visits.

Use of Mechanized and Other Equipment
Describe any vehicles, boats, field equipment, markers, or supply caches by type, number, and location. You should explain the need to use these materials and how long they are to be left in the field.

Safety
Describe any known potentially hazardous activities, such as electro-fishing, scuba diving, whitewater boating, aircraft use, wilderness travel, and wildlife capture, handling, or immobilization.

Chemical Use
Identify chemicals and hazardous materials that you propose using within the refuge.

Indicate the purpose, method of application, and amount to be used. Describe plans for storage, transfer, and disposal of these materials and describe steps to remediate accidental releases into the environment. Attach copies of Material Safety Data Sheets.

Animal Welfare
If the study involves animals, describe your protocol for any capture, holding, marking, tagging, tissue sampling, or other handling of these animals (including the training and qualifications of personnel relevant to animal handling and care). If it is required that your institutional animal welfare committee review your proposal, you must include a copy of their recommendations. Describe alternatives considered, and outline procedures to be used to alleviate pain or distress. Include contingency plans to be implemented in the event of accidental injury to or death of the animal. Include State and Federal permits. Where appropriate, coordinate with and inform State natural resource agencies.

Additional information or sections that may be requested for the proposal:

Literature Summary

This section should include a thorough but concise literature review of current and past research that pertains to the proposed research, especially any pertinent research conducted at refuges within the North Carolina Coastal Refuge Complex. A discussion of relevant legislation, policies, and refuge planning and management history, goals, and objectives should also be included.

Literature Cited

List all reports and publications cited in the proposal.

Peer Review

Provide the names, titles, addresses, and telephone numbers of individuals with subject-area expertise who have reviewed the research proposal. If the reviewers are associated with the investigator's research institution, or if the proposal was not reviewed, please provide the names, titles, addresses, and telephone numbers of three to five potential subject-area reviewers who are not associated with the investigator's institution. These individuals will be asked to provide reviews of the proposal, progress reports, and the draft final report.

Budget

The budget must reflect both funding and assistance that will be requested from the Service and the cooperator's contributions on an identified periodic (usually annual) basis.

Personnel Costs

Identify salary charges for principal investigator(s), research assistant(s), technician(s), clerical support, and others. Indicate period of involvement (hours or months) and pay rate charged for services. Be sure to include adequate time for data analysis and report writing and editing.

Fringe Benefits

Itemize fringe benefit rates and costs.

Travel

Provide separate estimates for fieldwork and meetings. Indicate number of trips, destinations, estimated miles of travel, mileage rate, air fares, days on travel, and daily lodging and meals charges. Vehicle mileage rate cannot exceed standard government mileage rates if Federal funds are to be used. Charges for lodging and meals are not to exceed the maximum daily rates set for the locality by the Federal government (contact North Carolina Coastal Refuge Complex for appropriate rates).

Equipment

Itemize all equipment to be purchased or rented and provide a brief justification for each item costing more than $1,000. Be sure to include any computer-related costs. For proposals funded under a Service agreement or contract, the refuge reserves the right to transfer the title of purchased equipment with unit cost of $1,000 or more to the Federal government following completion of the study. These items should be included as deliverables.

Supplies and Materials
Purchases and rentals under $1,000 should be itemized as much as is reasonable.

Subcontract or Consultant Charges
All such work must be supported by a subcontractor's proposal also in accordance with these guidelines.

Indirect Charges
Identify the indirect cost (overhead) rate and charges and the budget items to which the rate is applicable.

Cooperator's Contributions
Show any contributing share of direct or indirect costs, facilities, and equipment by the cooperating research institution.

Outside Funding
List any outside funding sources and amounts.

Personnel and Qualifications
List the personnel who will work on the project and indicate their qualifications, experience, and pertinent publications. Identify the responsibilities of each individual and the amount of time each will devote. A full vita or resume for each principal investigator and any consultants should be included here.

Deliverables:
All deliverables must be submitted to refuge staff no later than six months after the end of the project. Any extensions must be added as an amendment to the special use permit. Copies of publications that may extend outside of this six month period are still required as they become available. Interim deliverable timelines will be agreed on at the time of the issuing of the permit.

Deliverables that are required are as follows:

Reports and Publications
- Progress report(s) (usually quarterly, semiannually, or annually; may be required)
- Draft final and final report(s) (always required)
- The refuge manager appreciates opportunities to review manuscripts in advance of their publication.

Data Files
Provide any spatial (Geographic Information Systems [GIS]) and non-spatial data files that is generated and submitted as part of the research. Non-spatial data must be entered onto DVDs or an external data drive in Microsoft Access or Microsoft Excel. Spatial data, which includes Global Positioning System (GPS)-generated files, must be in a format compatible with the refuge's GIS system. A condition of the permit will be that the Service has access to and may utilize in future mapping and management all GIS information generated.

Metadata
For all non-spatial and spatial data sets or information products, documentation of information (metadata) describing the extent of data coverage and scale, the history of

where, when, and why the data were collected, who collected the data, the methods used to collect, process, or modify/ transform the data, and a complete data dictionary must also be provided as final deliverables. Spatial metadata must conform to Service (FGDC) metadata standards.

Specimens and Associated Project Documentation
A report on collection activities, specimen disposition, and the data derived from collections must be submitted to the refuge following refuge guidelines.

Other:
Researchers must provide the refuge manager with all of the following:

- Copies of field notes/notebooks/datasheets.
- Copies of raw data (in digital format), including GIS data, as well as analyzed data.
- Copies of all photos (digital photos preferred), slides, videos, and films.
- Copies of any reports, theses, dissertations, publications or other material (such as news articles) resulting from studies conducted on refuge.
- Detailed protocols used in study.
- Aerial photographs.
- Maps/GIS data.
- Interpretive brochures and exhibits.
- Training sessions (where appropriate).
- Survey forms.
- Value-added software, software developed, and models.

Additional deliverables may be required of specific studies.

STATE: North Carolina

GRANT TITLE: W79-Wildlife Management

PROJECT TITLE: Pilot Study – Using Fine Scale GPS Technology to Research Sympatric Canid Population Dynamics (Job 2.0?)

A. Problem and Need

The coyote (*Canis latrans*) is now abundant throughout the 100 counties in North Carolina (NC), and is managed as nongame with no closed season or bag limit (NC Wildlife Resources Commission 2016). Previously restricted to the West and Midwest regions of the United States, by the early 1990s coyotes had expanded their range into the Albemarle Peninsula (AP), which is situated in the northeast coastal plain region of NC (Hinton et al. 2012, Murray et al. 2014). In recent years as coyotes have increased their population, some have begun to make use of the Outer Banks region.

The United States Fish and Wildlife Service (USFWS) released a non-essential, experimental population of captive-bred red wolves (*Canis rufus*) on the Alligator River National Wildlife Refuge (ARNWR) in 1987 (Hinton et al. 2013). This population increased until 2008 and peaked at around 130 individuals (Group Solutions, Inc. 2016), short of the recovery goal of 220 in the wild (USFWS Red Wolf Recovery Program 2013). The AP has an estimated carrying capacity of 140-150 wolves (Hinton et al. 2013, Kelly et al. 1999, USFWS Red Wolf Recovery Program 2007). The exact number of red wolves is not known, but USFWS staff report a population estimate of 45-60 individuals with eight mortalities to date in 2016 (https://www.fws.gov/redwolf/index.html August 2016). Hybridization with coyotes and inbreeding depression are suspected factors that have affected red wolf population growth and viability since the inception of the Red Wolf Recovery Program (RWRP), while vehicular and gunshot mortality are known factors (Hinton et al. 2013). Because of hybridization between red wolves and coyotes, the AP supports a continuum of sympatric canids, hereafter referred to as "sympatric canids."

As part of a recent program review, the USFWS halted many aspects of the RWRP in 2015 and discontinued the coyote sterilization program, potentially affecting the spatial

Commented [JM1]: The 220 animals in the wild is the minimum population number in the Recovery Plan divided into 2-3 mainland sites.

Commented [JM2]: Currently population estimate is 25-40 and there has been 6 known red wolf mortalities in 2017.

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distribution and population dynamics of sympatric canids. Telemetry data from coyotes on the AP suggests that about 70% of coyotes are residents (i.e., those that defend set territories) while the other 30% are transients, with most being dispersing juveniles (Hinton et al. 2015). Transient coyotes do not defend set territories. Coyotes can travel long distances and become transient even as adults, especially when they lose their mate. Recently described as using "compensatory immigration," coyotes opportunistically fill spatial resource gaps by periodic transiency; when spots come open, individuals that do not yet have permanent territories and have been roaming in the area, are able to inhabit the new openings (Hinton 2016). These periods of transiency can sometimes bring coyotes into conflict with other canids and humans, especially when they are utilizing of anthropogenic resources.

Though a rural area, human land uses occupy a significant portion of space on the AP. The AP is comprised of approximately 30% agricultural fields, 50% forest and coastal marshes, and 20% "other" land cover types on federal, state and private lands (Dellinger 2011). Concerns about fear of attacks on humans and domestic pets, the effects of sympatric canids on white-tailed deer and other game populations, and homeowner property damage comprise many of the conflict calls regarding sympatric canids on the AP (Responsive Management, forthcoming data). Wildlife managers in this region frequently receive requests for information on canid management (C. Turner, personal communication, 2016).

The changes in state and federal canid management rules have resulted in confusion regarding residents' rights and options for management of property damage by sympatric canids. As a result, some citizens are unsure of the legal and most effective methods for canid conflict management. Adding to management complexity is the need to manage canids for conservation purposes, such as reducing predation on at-risk ground nesting species or reducing hybridization of sympatric canids.

In 2013, NCWRC and USFWS established a committee to oversee the collaborative management and conservation of sympatric canids on the AP. A USFWS and NCWRC joint memorandum documented detailed action items for the joint management of sympatric canids on the AP, including specific research objectives which this proposal seeks to address (Attachment 2). As sympatric canids on the AP increase in number, monitoring their

Commented [JM3]: Would like to know a bit more about calls Chris is receiving like volume of calls, how many potential involve red wolves, etc.

Commented [JM4]: What types of property damage is being referred to here? Red wolves have been confirmed in livestock depredation 7 times in the 30 years of the program in NC. Is this a product of the unfortunate lumping of coyotes, domestic dogs, hybrids and red wolves as sympatric canids?

Commented [JM5]: Would be interesting to analyze the direct predation by canids on ground nesting birds as compared to the potential benefits from canids (red wolves) preying on other known nest predators? Or if there has been documented cases of red wolves preying on ground nesting species.

Commented [JM6]: Does not acknowledge the dramatic decrease in the red wolf population because of the lumping as sympatric canids.

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movements, particularly in relation to individuals of differing ancestry, could provide important data to NCWRC and USFWS staff for science-based local and landscape-level decisions about sympatric canid populations and conflict management. Collection of finer temporal scale location data would help to manage interactions of sympatric canids with humans, as well as to support development of dynamic stochastic population models.

B. Objectives (after December 1, 2016-November 30, 2018)

Objective 1: Use GPS collar and proximity sensor technology to test performance under various conditions and evaluate the frequency and accuracy of the scheduled fix rates.

Objective 2: Use fine scale GPS data collection for investigating annual and seasonal spatial dynamics of sympatric canids: home range and core area sizes, amount of overlap in home range and core areas, movement pathways and daily activity patterns, and cover type selection and preference.

Objective 3: Use fine scale GPS data collection for investigating the number and age structure of offspring for family groups of collared sympatric canids.

Objective 4: Use fine scale GPS data collection for investigating sources of mortality for sympatric canids.

Objective 5: Use fine scale GPS data collection for preventing and mitigating canid conflicts with landowners.

Objective 6: Determine genetic profiles of sympatric canids through DNA identification of all captured individuals, parentage, and presence of hybridization.

At the end of this two-year pilot study, we will deliver an observational summary detailing the use of the GPS and sensor technology for spatial and population dynamics research on sympatric canids on the AP.

C. Expected Results and Benefits

As part of a pilot study, we will monitor the status of collared individuals by using a finer scale assessment of space and habitat use than previous studies. Earlier research focused on many of the same objectives we suggest investigating here, but during a time of intense, active

Commented [JM7]: Concern that the objectives are largely focused on testing GPS collars, which is more appropriately done on a more common species such as coyotes and not on a species with low population numbers such as red wolves. As discussed in the meeting, many of these types of objectives have been done for red wolves, particularly on the Refuge.

Commented [JM8]: FWS already conducts over 75 telemetry flights/year followed up by ground reconnaissance to assess collared red wolf and coyote causes of mortality.

Commented [JM9]: Potential concerns about what data is to be shared with private landowners.

Commented [JM10]: The attached Section 7 document states it is a three year project.

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management. Specific management techniques are no longer being carried out and dynamics between sympatric canids are expected to have changed substantially. The uncertainty regarding current dynamics presents a need for additional research in order to inform actions for the management of sympatric canids. Information gained from research may impact management rules and landowner's abilities to manage canids in some areas. Additionally, GPS technology has improved since earlier research was conducted allowing for more temporally detailed data collection and more nuanced analyses. Understanding how sympatric canids collectively use resources in areas of human-dominated landscapes will allow wildlife managers to tailor management options to local conditions. On the AP, row crop agriculture and hunting represent the primary and secondary land uses, respectively. Row crop agriculture is a significant nutrient resource on the landscape and, as opportunists, canids take advantage of such resources when they are available. Non-consumptive wildlife-driven tourism persists in all seasons and wildlife watching is a main draw for tourists in this area. For many tourists, the opportunity to see or hear large carnivores is the sole attraction for traveling to the AP. Information from this study will be provided to local constituents to establish a knowledge base regarding how sympatric canids use resources on private lands. Management and guidance could serve to prevent or minimize conflict while maximizing positive wildlife interaction opportunities for constituents. Development of a common understanding between wildlife managers and landowners based upon factual information is paramount for collaboratively achieving successful management of sympatric canids. The data collected in this pilot study is the foundation upon which this understanding and future management actions will be built.

The current level of hybridization between sympatric canids on the AP will be characterized using DNA gathered during this study. Body size exists as a continuum between coyotes and red wolves and has been documented as the most important factor for successful interspecific breeding pairs of these canids (Hinton 2014). Though both species have been found to use resources in similar manners, red wolves generally have more expansive home ranges and therefore may not use local resources as intensively as coyotes, depending on body size. Obtaining individual identification of study animals will allow managers, armed with spatial information, to infer how and why individuals in the canid species continuum exploit

Commented [JM11]: It is accurate that some of the management techniques are not currently being used, but it should be noted that FWS may begin to using some of them in the future and perhaps during the life of this project.

Commented [JM12]: Little has changed regarding management on the Refuge itself and particularly with the Milltail pack.

Commented [JM13]: Clarification on exactly what is being referred to here.

Commented [JM14]: Red wolves only, no other "large" carnivores, if coyotes would even be considered large. Or is this meant to refer to black bears as well? Could use clarification.

Commented [JM15]: Potential concern depending on what type of information is shared.

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anthropogenic resources considering their life history traits.

In conjunction with prior research, data collected will contribute to knowledge on sympatric canid population dynamics on the AP. Estimating population size will allow managers to monitor population trends of sympatric canids and to examine the long and short-term impacts of different management strategies on their populations. While it is unknown whether sample size will allow for population estimation, obtaining population estimates for coyotes would provide wildlife managers with baseline data, when paired with annual mortality estimates, for monitoring changes in population abundance over time. Information on changes in abundance, reproductive dynamics, and habitat use could impact management strategies to influence long-term conservation outcomes. Results of this pilot study will allow managers to determine if future work will be necessary, what amount of effort will be required to achieve each objective, and whether or not population estimates will be an attainable goal.

Commented [JM16]: Would likely be better suited for a coyote population size estimate in an area with no other sympatric canids.

D. Approach

The official Red Wolf Recovery Area (RWRA) covers approximately 6,900 square kilometers within Beaufort, Dare, Hyde, Tyrrell, and Washington counties (Wildlife Management Institute 2014). However, the USFWS has proposed the RWRA be constricted to the ARNWR and the Dare County Bombing Range in Dare county by the end of 2017. Due to these proposed RWRA changes, this study proposes to capture and radio-collar 25 sympatric canids within Dare, Hyde, and Tyrrell counties (hereafter referred to as "study area"); those counties being within and directly adjacent to the proposed new RWRA. The thematic subheadings below provide detailed descriptions of the approaches required for achieving the pilot study objectives.

Commented [JM17]: It is more accurate to refer to it as the Non-essential Experimental Population (NEP) boundary.

Commented [JM18]: Need to discuss the protocol if a red wolf is captured that is already wearing a radio-collar. Initial thought that FWS would be notified to determine the age of the collar and a decision to be made on whether to replace release the animal with the existing collar, replace it with a new VHF collar based on the age of the collar or replace it with a GPS collar. This should be part of the decision tree that was discussed at the meeting.

Commented [JM19]: As discussed in the meeting, this is not currently accurate as we are in the middle of the NEPA process to analyze a range of alternatives of which this is only one of the alternatives. No decisions have been made in this regard.

Sampling Efforts

Trained NCWRC personnel will conduct live trapping of sympatric canids, with assistance from the USFWS RWRP biologists, and trained, experienced local trappers. NCWRC and USFWS wildlife personnel will select local trappers based on their past performance in trapping sympatric canids, but may also select trappers from the NCWRC coyote trappers list. NCWRC staff will train contracted trappers on specific trapping procedures before every trapping

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season. The project lead will supervise and coordinate all trapping activities including locations for installation and the operation of trap lines and handling of captured animals. Simultaneous personal trapping activities by contracted trappers will not be permitted while performing contracted trapping services, as specified in the draft service contract (Attachment 4).

Trapping efforts will follow a spatial capture-recapture (SCR) framework with a systematic targeted sampling design, focusing on areas that contain resources previously found to be used by sympatric canids (e.g. edge, agricultural fields, secondary roads, etc.) (Harris et al. 2013, Ivan et al. 2013), while attempting to sample a diversity of habitat types. This effort will allow us to increase the probability of detection of sympatric canids on the landscape (Tom 2012). While it is important to sample a wide range of habitats, the most important requirement for SCR is the number of collared individuals; this requirement provides flexibility in the other requirements for field sampling as needed (K. Pacifici, personal communication, 2016). We will initially focus trapping in areas of known red wolf packs, as advised by RWRP.

Trapping will take place during the breeding season when the likelihood of capturing females in the later stages of gestation or whelping females will be low. Capture efforts will be conducted from soon after 1 December 2017 – February 2018 and December 2018 – February 2019. Captured sympatric canids will be surrendered to NCWRC or the USFWS at capture sites. Trapping should occur on both public and private lands to obtain sampling coverage of the study area. Ideally, all federal and state lands would be accessible for trap and release (hereafter referred to as "capture") of sympatric canids, but it is most important to be able to trap and release on Alligator River NWR and the Dare County Bombing Range as those encompass the newly proposed RWRP recovery area and comprise the majority of land area for Dare county. Unlike Dare ~~county~~County, there are ample private lands that surround Pocosin Lakes NWR and Lake Mattamuskeet NWR in both Tyrrell and Hyde counties that may be utilized to effectively sample individuals who may use those federal lands, should they be excluded from capture activities. Capture on federal lands may require USFWS take permits and proposed activities may be subject to a compatibility assessment (P. Benjamin, personal communication, 2016). Scientific collection activities that take place on private lands will require agreements outlining conditions mutually decided by NCWRC and landowners

Commented [JM20]: Concern over multiple captures of red wolves due to the ever present possibility of trap injuries or other issues, particularly with folks that may not be used to conducting this type of trapping and since the wild population numbers are currently so low.

Commented [JM21]: As discussed in the meeting, the focus would more appropriately be focused in areas where we are unsure of red wolf presence and would also be areas with a greater chance of having coyotes.

Commented [JM22]: Due to the low population numbers and potential risks to red wolves, we do not trap during the breeding season (e.g. February) in areas with red wolves. All trapping of red wolves should occur in January and potentially late December.

Commented [JM23]: As discussed in the meeting, if any trapping is to be conducted on Federal lands it will need to be done by FWS personnel due to the difficulty of the process for allowing non-federal personnel to conduct activities on the refuge. Additionally, the objectives focus largely on landowner conflicts and resources, which are not an issue on the Refuge and there also likely isn't a large enough coyote population in established wolf areas to address the objectives.

Commented [JM24]: As discussed in the meeting, it would require a Compatibility Determination and some level of NEPA. So it was decided the pilot study would focus on non-Federal lands.

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(Attachment 3).

To increase probability of detection of sympatric canids, the accessible study area will be partitioned by a grid, the cell size of which will based on the average annual home range size of resident coyotes previously reported for the AP, approximately 23 km^2 (Hinton et al. 2015). As a system of sampling, trap lines will be referred here as "traps," and the number of trap sets (i.e. the actual trapping device) and number of each trap set size may vary between traps as necessary. Sampling will be standardized within each grid cell by use of equal number of traps per cell, on average 3 per cell, each at an approximate length of 10 km (Andelt and Gipson 1979, Way et al. 2004).

Target canids will be captured by using Softcatch #3 Coyote 4x4 (Oneida Victor Inc. Ltd., P.O. Box 32398, Euclid, Ohio 44132, Hinton 2014, Schemnitz 1994), the EZ Grip #7 (Livestock Protection Company, P.O. Box 725, Alpine, Texas 79831, Frame and Meier 2007), or equivalent. Various lures and baits will be used to increase trapping efficiency (Frederick et al. 1989, Shipley 2012). Traps will be laid on the Monday of each week and will be opened at the time of deployment. Traps will be checked once daily at dawn, to reduce potential stress to trapped individuals and will not be operated on days where the temperature is expected to reach or exceed 80° F (R. Nordsven, personal communication, 2016) or during times of predicted inclement weather (e.g. snow, hail, high wind, etc., Sikes et al. 2011). To standardize effort and remain logistically realistic, traps should be open for three trap nights in a row before being removed. Trap sets that have been closed due to non-target bycatch or other circumstances may be reopened and all traps should be re-baited and lured as appropriate.

Trap set locations will be marked by NCWRC or USFWS personnel using handheld GPS units (Garmin GPSMAP 64S, 1200 E. 151st St., Olathe, KS 66062-3426) and given a sequential identification number. Traps will also be given an identification number and trap set points will be documented in ArcMap 10.4. Trappers will keep detailed records on trap set operation, non-target species trapped, and other relevant details. Non-target species will be released from traps after an in-field assessment of injuries, if any, and animals with life threatening injuries will be euthanized by the trap operator. Targeted recapture of collared canids will occur annually during the same months, to replace GPS collar batteries and drop-off collar release

Commented [JM25]: Please work with Ryan regarding the use of trap stakes and drags as both can cause injury or death if not used properly.

Commented [JM26]: Traps should be covered or rendered inoperable during a hard freeze. A leghold trap can cut of blood circulation to the foot and can lead to frozen tissue during a hard freeze. Concerns private trappers not use to methods used to limit trap injuries as they are not typically trapping for release.

Commented [JM27]: Concerns over repeated trapping of red wolves.

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units in field. Trapping effort will be quantified (trap nights), the effective sample area will be estimated, the encounter (detection) probability will be estimated using a Gaussian detection model (Amundson et al. 2014), and an estimate of density for coyotes will be calculated using a modified Huggins closed-capture estimator in program MARK, if sample size allows (Harris et al. 2013, Ivan et al. 2013).

Animal Handling

Handling of canids will follow American Society of Mammalogists (ASM) guidelines (Sikes et al. 2011) and will be performed at the capture site. Chemical immobilization agents may be used depending on the number of field staff during processing (i.e., three or more staff required during non-chemical immobilizations, Craft 2007, M. Morse, personal communication, 2016).

Chemical Immobilization

Unless adequate numbers of personnel are available to safely employ mechanical restraint techniques, target animals will be anesthetized with the chemical immobilization agent BAM (Wildlife Pharmaceuticals, Inc., Windsor, CO 80550). BAM, a combination of Butorphanol tartrate, Azaperone tartrate and Medetomidine HCl., will be delivered by intramuscular injection by syringe pole to the hip. Dosage for canids is based on field trails performed by Wildlife Pharmaceuticals (Wildlife Pharmaceuticals, Inc. 2016) and the recommended dose for coyotes is 0.2CC and red wolves is 0.3CC, with adjunct doses of 0.1-0.2CC delivered if initial dosages do not cause induction (S. Kirschner, personal communication, 2017). Induction times for coyotes and wolves ranged from 5 to 10 minutes after initial and/or adjunct dosages (Wildlife Pharmaceuticals, Inc. 2016). After field handling is concluded the anesthesia will be reversed using two reversal agents, Atipamezole and Naltrexone, at double the CC of Atipamezole to BAM that was delivered (including adjunct doses, if given) and 0.5CC of Naltrexone. Recovery time from the reversal agents ranged from 10 to 25 minutes during field trails (Wildlife Pharmaceuticals, Inc. 2016). Field personnel will observe animals for signs of adverse effects for up to 30 minutes after reversal agents are delivered.

Commented [JM28]: FWS personnel would like to be involved on the handling and collaring of all red wolves, whenever possible.

Commented [JM29]: Two biologists and one note taker, if available. We typically do not chemically immobilize red wolves during processing.

Commented [JM30]: We have a better, cleaner and safer chemical immobilization protocol developed specifically for red wolves by the NCSU Vet School. Butorphanol @ 0.4mg/kg w/ Dexmedetomide @ 0.04mg/kg
Antagonist: Naloxone @ 0.02mg/kg w/ atipamizole @ 0.2mg/kg

Commented [JM31]: We have had better luck restraining the head with a catch pole and hand injecting the animal instead of using a syringe pole.

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Mechanical Immobilization

Unlike other carnivore families, the submissive behavioral response of canids to perceived dominance reduces the need to use immobilization agents. Appropriate mechanical restraint techniques can reduce handling time of animals, allowing animals to reintegrate into social groups more quickly, subsequently reducing overall stress to the individual (Powell and Proulx 2003). Target canids will be mechanically restrained with a restraint pole, until two muzzles can be placed around the snout. While pinned with the restraint pole by one person, a second person will restrain the set of legs not in the trap against the ground and a third person will release the foot from the trap. This set of legs will then be restrained by the 3rd person as the restraint pole is removed. Once the restraint pole is removed the person restraining the front legs will also then restrain the head. The first person will then move forward with processing the captured animal.

Each animal will be placed on a towel or blanket to provide thermal protection from the ground, with eyes covered and lubricated with eye ointment; temperature will be monitored with a rectal thermometer. Overheating occurs at approximately 104-105°F for canids (AZA Canid TAG 2012) and the animal handling crew will monitor temperature at 5-minute intervals; if a temperature reading reaches 104°F, corrective actions will be taken and temperature will be monitored at 1-minute intervals. Should overheating occur, the individual will be removed from insulation to expedite the natural evaporative cooling process. During days that approach 80°F in temperature, measures will be taken to reduce heat stress, such as: wetting the animal with water, application of a cold pack to the groin area between the back legs, application of rubbing alcohol to foot pads, or immediate release (AZA Canid TAG 2012). If the injured individual is suspected to be a red wolf, based on morphometrics, USFWS staff will be contacted for a decision. In the event that trap caused injuries are determined to be life threatening through use of a trap injury score assessment (Frame and Meier 2007) the individual will be euthanized. In the event that NCWRC personnel cannot be present, trained USFWS personnel may collar and measure captured target animals and will provide data sheets to NCWRC staff. Target animals will not be vaccinated or otherwise treated for diseases, regardless of the presence of disease symptoms.

Commented [JM32]: Morphometrics should not be the sole indicator of species.

Commented [JM33]: As stated previously, FWS personnel should be notified whenever a red wolf or an animal that could possibly be a red wolf is captured and would like to be involved in the handling and immobilization of all red wolves, whenever possible. No red wolves or animals suspected as possibly being red wolves should be euthanized without direct FWS involvement and an FWS decision to do so.

Commented [JM34]: Due to the high value of each individual red wolf with such a low population, all red wolves should be treated with vaccinations and for other diseases, visible and non-visible. Capture operations are risky for these animals and if we are going to undertake that risk we need to do whatever we can while they are in hand to give them the highest chance of survival and successful reproduction.

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Non-target animals will be released on site. Captured domestic dogs will be immediately released from the trap set following an injury score assessment and only if no life-threatening injuries are present. If a domestic dog has sustained life threatening injuries and owner identification information is present on the dog, then the animal will be held in either a transportable kennel, or at a dog pen on a state game land that is equipped with such facilities, until the owner can retrieve the dog. The costs associated with injuries sustained to the dog will be the responsibility of the animals' owner. Law enforcement may be requested to help communicate with the animal's owner. If the animal does not have an identifiable owner and has incurred substantial life threatening injuries (i.e. compound fracture), the dog will be euthanized on site. Target animals showing signs of disease symptoms such as circling behavior, head tilt, muscle twitches, convulsions with jaw chewing movements and salivation ("chewing gum fits"), disorientation, incoordination, staggering caused by paralysis of the hind legs, seizures, and partial or complete paralysis will be euthanized and tested according to protocol set forth by the agency veterinarian, in order to determine if there may be a public health issue (M. Palamar, personal communication, 2016). USFWS will be contacted in cases of suspected red wolves. Staff involved in animal handling duties will have the pre-exposure rabies vaccination series completed prior to field work inception and will maintain rabies titer records through properly licensed medical services providers.

If staff is bitten and skin is broken by an animal while performing handling duties, they will be advised to immediately visit a local hospital or clinic for evaluation by healthcare professionals. The field coordinator will immediately notify supervisory staff and an injury report and workers' compensation claim will be opened for the incident. The animal will be euthanized and the head will be sent to the state lab for rabies testing; the body may be sent to the Southeastern Cooperative Wildlife Disease Study (SCWDS) laboratory for additional disease investigation.

Capture Processing and Marking

During canid handling, NCWRC personnel will record age class, sex, weight, total body length, head width, ear length, and tail length, visually assess ectoparasite load, look for and disinfect with betadine or iodine as needed any minor trap caused injuries, and affix GPS collars

Commented [JM35]: Problematic on Refuges

Commented [JM36]: FWS retains the decision making on euthanasia for red wolves.

Commented [JM37]: It should not be automatic that staff being bitten during a capture should result in a red wolf being euthanized, particularly if that animal is displaying no signs of disease. We can't afford to lose any individuals in such a low population without sufficient cause. And no euthanasia of a red wolf should occur without FWS involvement in the decision making process. If needed, animals can be quarantined at Sandy Ridge.

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(Knick 1990, Sikes et al. 2011). All captured canids will be fitted with appropriately-sized GPS collars in the field based on morphometrics previously indicated as reliable thresholds for species categorization: hind foot length, weight, width of head, and tail length (Hinton 2014); analysis of DNA samples collected during trapping efforts will help to assign captured canids to position along the species continuum post release. Age of individuals will be estimated based on physical characteristics, including weight and tooth replacement (Knick 1990, Hinton 2014, Gier 1968), and captured canids will be aged into one of three classes: > 2 years old as adults, < 2 but > 1 year old as juveniles, and > 6 months but < 12 months old as pups (Hinton 2014). Reproductive status will be determined based on estimated age class and presence of gonadal descent during the breeding season for males and the presence of nipple swelling or previous suckling for females (Hutson and Racey 2004, Magee 2008, Mengel 1971).

Captured individuals will be ear marked using a button tag (model 410, Ketchum Mfg. Co. [or equivalent], PO Box 10, 11 Town Shed Road, Lake Luzerne, NY 12846) placed along the middle of the ear where they are most protected from loss, with a pin-type applicator (485sa Pow-R-ceps plier, Ketchum Mfg. Co. [or equivalent]) (Silvy 2012). The puncture site will be treated with an antiseptic to deter infections. Each sympatric canid will also be marked with an individually-numbered, glass-encapsulated, passive integrated transponder (PIT model HPT12, 12.5 mm, 134.2 kHz, Biomark, Inc., 703 South Americana Blvd., Suite 150, Boise, ID; Gannon et al. 2007), using a syringe-type implanter and replaceable needle (model MK10 [implanter], model N125 [needle], Biomark, Inc.). Successful PIT placement will be verified with a mini portable reader (model GPR Plus, Biomark, Inc.). The implantation site will be prepared by swabbing with 70% alcohol (Mrozek et al. 1995) and a sterilized new needle will be used for each injection. The standard implantation site for transponders is subcutaneously on the dorsal midline of the back, cranial to the shoulder blades (Ingwersen 2000).

A skin biopsy will be taken from all captured target canids by puncturing the pinna of the ear with a biopsy punch in the same location where the ear tag will be placed (Palamar 2014). The biopsied area will be disinfected with alcohol after sampling. The skin biopsy will be placed in a labeled (ID, date, and sample type) cryogenic tube filled with 95% ethanol as buffer and then stored in a freezer until sent out to a lab for genetic analysis (Palamar 2014, Tom

Commented [JM38]: What is the purpose of the ear tags? They've been used in the past, but were a source of infection and irritation, and were routinely pulled out. With the use of PIT tags, ear tags are needed less.

Commented [JM39]: To be consistent with existing red wolves and coyotes that have been captured it would be beneficial to use PIT tags by Trovan or to at least make sure whatever is used can be read by both agencies.

Commented [JM40]: There is an existing protocol with the same lab you are using for obtaining genetic information from blood samples only, as we have always done, which makes it unnecessary to take a skin biopsy.

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2012). A selection of hairs with the root bulla attached will be pulled from the belly and placed in paper envelopes (Janecka et al. 2007). Hair samples will serve as back up to tissue samples for genetic testing. All samples will be sent to the Laboratory for Ecological, Evolutionary and Conservation Genetics, at University of Idaho (875 Perimeter Drive, MS 1136, Moscow, ID 83844) for genotyping to determine species as well as individual identification, hybridization presence, and parentage analysis following previously developed protocols (Adams et al. 2007, Hinton 2014, Miller et al. 2003). The appropriate genetic analyses that examine the coyote-hybrid-wolf species continuum will be performed.

Blood will be collected from all juvenile and adult target canids by venipuncture of the brachial or jugular veins using a 22-28-gauge needle (M. Palamar, NCWRC veterinarian, personal communication, 2016). As per NCWRC veterinarian recommendations, approximately 12 ml of blood will be collected for each animal for possible future testing for diseases of importance to sympatric canid species as well as the humans and domestic animals that they may come into contact with. A minimum of two 6 ml lavender top tube (for whole blood with EDTA) will be filled. Samples should be refrigerated at all times; a cooler with ice will suffice while in the field. Samples should be sent to the NCWRC within 48 hours or frozen for later shipping. Skin scrapes will be collected from animals presenting signs compatible with sarcoptic mange (lesions) for possible future diagnostic purposes. Lesions will be scraped until blood is drawn; the scrapings will be placed onto a slide and covered with a piece of clear tape for later visual confirmation.

Should overheating occur, processing will be performed in the following prioritization order and the first five items will need to be completed before releasing any individuals: 1) trap injury evaluation, 2) collaring, 3) DNA (skin biopsy) sample collection, 4) morphometrics, 5) aging, 6) PIT tagging, 7) weight, 8) ear tagging, 9) reproductive status, 10) ectoparasite evaluation, 11) blood collection, and 12) skin scrape collection.

Collaring

Vertex Plus GPS Collars will be attached to 25 sympatric canids captured on the study area, 10 of which will be equipped with proximity sensors (Vectronic Aerospace GmbH, Carl-Scheele-Str. 12, 12489 Berlin, Germany). Project staff will pilot test proximity sensor technology

Commented [JM41]: FWS maintains blood samples for all captured red wolves.

Commented [JM42]: Animals showing signs of mange should be held and treated before release to heal that individual and avoid spreading it to the surrounding canid population, particularly red wolves. Conservation of red wolves needs to be the a priority.

Commented [JM43]: Several people commented with concerns on the prioritization. 1) cool/assess injuries/ensure survival of the animal, 2) radio collar animal, 3) draw blood, then the rest only if you are able to do it safely.

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for utility in analysis of spatial and temporal community dynamics. Proximity sensors trigger increased GPS location acquisition during those time intervals when two collared individuals come within a set distance from each other (http://www.vectronic-aerospace.com/wildlife-monitoring/sensors/uhf-id-tags, accessed August 2016).

To avoid instances of collar induced strangulation, only adult (>2 years old) male and female individuals will receive collars (Hinton 2014). ASM guidelines recommends a collar weight of <5-10% of a canids bodyweight, we will observe these guidelines (Sikes et al. 2011). Sympatric canids not releasable at a capture site will not be collared and will not become study animals.

GPS radio-collars will have both VHF and GPS Iridium locational systems as well as store-on-board capabilities. Radio-collar units will be programmed to record GPS coordinates once every 1.75 hours producing approximately 13 locations per day while cycling through the 24-hour time cycle. These settings will allow for a GPS battery life of 300 to 552 days, averaging 431 days. The VHF beacon will be in operation from 0800 – 1600 hours daily. GPS locations will be sent via satellite once per day and each transmission with contain 12 locations. The use of an integrated drop off firing mechanism should allow the collars to drop off within a maximum of approximately 548 days after deployment. The drop off schedule once set cannot be changed. The drop off firing mechanism is wired to a battery unit independent of the collar battery, therefore should the collar battery become depleted, the drop off mechanism will not be affected (C. Akakpo, Vectronic Aerospace GmbH, personal communication, 2016). Unless a collared individual is recaptured before the collar battery dies, the drop off mechanism will fire at the scheduled time frame post collar deployment.

Observation of sympatric canid habitat use and movements will occur through GPS data obtained with combination GPS/VHF radio-collars. VHF relies on triangulation, the process of estimating the location of a transmitter by using two or more compass bearings obtained by using directional antennas at known locations remote from the transmitter's position (White and Garrott 1990), whereas GPS uses a satellite based system to obtain location coordinates. There have been many published studies where one or both of these methods were used, with mixed success for determining various aspects of carnivore ecology throughout the United

Commented [JM44]: As discussed in the meeting, FWS would like to collar all red wolves captured. If effort and the potential risk of injury has already occurred such as is the case with any capture, then we would like to take advantage of having the red wolf in hand to place a VHF collar on it regardless of whether or not it meets the criteria for this project.

Commented [JM45]: Needs clarification. Why would trapping be occurring for this project in an area where a canid could not be released?

Commented [JM46]: For ESA listed species, the VHF frequency range is 164-165 mHz. Not only is this in keeping with policy, but it is consistent with the existing collars and allows for real time tracking of canids by FWS personnel for suspected depredations/complaints, reports of injuries, den locations, telemetry flights, etc. Previous researchers utilizing GPS collars on canids within the NEP boundary have used VHF frequencies within the 164-165 mHz range.

Commented [JM47]: Our recommendation based on our monitoring of red wolves is to set the VHF beacon to 12 hour rotations, with it set on from 0700 to 1900 (0800 to 2000 during daylight savings) because we have run into situations where we needed to do real time tracking past 1600.

Commented [JM48]: Concern over the short life span of the collars and need to recapture.

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States (Hinton et al. 2012, Schrecengost et al. 2009, Sparkman et al. 2012). While GPS technology has developed rapidly in recent history, the real time functional advantage of VHF cannot be disregarded. When GPS technology falters or malfunctions, VHF can serve as replacement for data collection in addition to its use in real time monitoring of study animals. Canids will be minimally monitored for mortality approximately every 30 days by using VHF aerial telemetry techniques (Whitehouse and Steven 1977) as there may be a delay in satellite transmission of GPS location data due to weather, season, and animal behavior. Transient canids and individuals from breeding pairs that have lost a mate, have been found to use much larger areas versus paired residents, potentially increasing the opportunity for losing track of these individuals when GPS technology reaches its functional capacity or experiences malfunction. VHF data may also provide locations of canids in cover too dense for GPS units to function. Use of VHF telemetry techniques for data collection may be expanded as necessary for project needs.

Commented [JM49]: FWS currently flies to monitor collard canids 1 to 2 times a week, partially to detect mortalities in a timely manner to more likely be able to determine the cause of death. For any collared canids, we would like to add those frequencies to our flights so they can be monitored much more frequently. Which is another reason the frequencies should be in the same range as the existing collars. Does the VHF beacon on the GPS collars have a mortality mode?

Spatial Data Analyses

Both minimum convex polygon (MCP) and adaptive kernel (AK) home ranges (95%) and core use areas (50% and 25%) (Seaman and Powell 1996, Seaman et al. 1999) will be calculated from GPS data by using BIOTAS (Ecological Software Solutions LLC, 2016) and Geospatial Modelling Environment (Spatial Ecology, LLC, 2016) for ArcGIS 10.2.2 (Environmental Systems Research Institute, 2016) (Benson et al. 2006, Riley 2006, Tucker et al. 2008, Hinton 2014) for comparison to older studies. These estimations can also be calculated using VHF data, provided data minimum requirements are met. Spatial distribution in relation to habitat will also be estimated by dynamic Brownian bridge movement models as described by Hinton (2014) with R statistical software (R Core Team 2016) using the moveud package with habitat covariates important to each species (Bryne et al. 2014, Collier 2013, Kranstauber and Smolla 2013, C. Proctor, personal communication, 2016). Additionally, recent research into how canids shift their ranges will also be investigated for populations on the AP (Morin and Kelly, in review). Spatial overlap and co-occurrence will be assessed using methods described by Shipley (2012). Habitat and cover types will be estimated from digitized maps created by the SEGAP (Hinton 2014) or ortho files, as available (Shipley 2012). Percent composition of habitat and cover types within home ranges and core areas as well as edge density will be quantified (Shipley 2012).

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Habitat selection and cover type use effects on spatial distribution will be estimated at both the population (2nd order) and individual (3rd order) spatial scales using resource selection functions (Johnson et al. 2006, Manly et al. 2002, Shipley 2012). Effects of seasonality and time of day activity will also be explored. The spatial and temporal patterns of space use by sympatric canids will be studied using data generated from the interaction GPS collar sensors, particularly distance between individuals and duration of proximity.

Den Monitoring

Project staff will attempt to locate den sites for sympatric canids to get pup counts, morphometric measurements, age estimates, and skin biopsies. Project staff will also attempt to monitor pup survival during the pup rearing season by using remote cameras placed around the den site (Harrison and Gilbert 1985, Parks 1979, Way et al. 2001). Pups will be weighed, measured, and PIT tagged during May and June of each year when they become active but are still den-obligated (Gier 1968). We will investigate the use of remote camera traps for monitoring den behavior with a two-camera array around the den (H. Garbe, personal communication, 2016, Kays and Slauson 2008). This method has been successfully used to monitor kit fox pup survival (Kluever et al. 2013). Because coyotes have been found to be sensitive to den site disturbance, there is a general lack of data in the literature regarding this approach for monitoring pup survival. Approaching an experimental methodology systematically will be important for determining which methods are effective and which are not. As a starting point for testing this methodology, remote cameras will be placed two to five meters from main den entrances and set to take photos using a passive infrared sensor trigger (a beam that when broken by movement through it, triggers the camera to take a series of photos) with a time restriction between photo intervals to limit the number of photos taken and maximize the space on the memory card for the time period between camera checks (Kluever et al. 2013). Cameras will be checked six days after deployment and will be redeployed (i.e. new batteries and memory card, if required); cameras will remain at each den site until radio-collar data indicates the den site has been moved (Kluever et al. 2013). Cameras will be not be redeployed to a new coyote den site during a season if that breeding pair has already moved the den once due to the disturbance of camera presence/deployment.

Commented [JM50]: FWS personnel currently conduct red wolf den work and in order to eliminate the need for more than one disturbance to the den site, FWS personnel should be present for all red wolf den work.

Commented [JM51]: Concerns over the need for skin biopsies on pups when needed information can be obtained from the blood draw.

Commented [JM52]: As discussed at the meeting, there are a lot of concerns regarding den disturbance and placing cameras at a red wolf den site as it greatly increases the likelihood of den/litter abandonment, which we cannot afford in such a low population.

Commented [JM53]: If the desire is to experiment with cameras at den sites, they should be deployed at coyote den sites.

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Mortalities

If a collared animal dies during the project, the carcass will be sent to SCWDS for necropsy. Red wolves will be sent to the SCWDS laboratory for necropsy, unless it is determined to be a law enforcement case. In potential law enforcement cases, the NCWRC Division of Wildlife Management Chief and USFWS Ecological Services Raleigh Field Office Field Supervisor will be contacted and requested to contact the appropriate law enforcement personnel, immediately after determining the need for law enforcement involvement. The carcass and all relevant information will then be turned over to law enforcement; the GPS-collar will be removed and genetic samples will be taken from the individual prior to release to law enforcement.

Commented [JM54]: As discussed in the meeting, upon death of an ESA listed animal the carcass and parts must be retained in FWS custody until there has been a necropsy performed by the FWS Labs in either Madison, WI or Ashland, OR, if it is a law enforcement case.

Commented [JM55]: The FWS office in Manteo should be contacted. We contact LE for every red wolf mortality and they determine if it is an LE case or not and if they should take possession of the carcass. LE will not allow genetic samples to be taken from the carcass until after the case is complete.

E. Project Personnel

Andrea Shipley has worked for the North Carolina Wildlife Resources Commission as a Canid Biologist since February 2016. Prior to that, she worked as a Wildlife Biologist for a non-profit located in northeastern Nevada as well as in several different field biologist oriented positions. Andrea has a background in carnivore and spatial ecology, having earned her MS in Biological Sciences from Eastern Kentucky University and BS in Biological Sciences from Rutgers University; Andrea will act as project lead and coordinator.

Brandon Sherrill has worked for the North Carolina Wildlife Resources Commission as a Mammalogist since December 2013. Prior to that, he worked as an educator at the North Carolina Museum of Natural Sciences and as a regional wildlife biologist for the South Carolina Department of Natural Resources. Brandon earned a BS and MS in Fisheries, Wildlife, and Conservation Biology from North Carolina State University; Brandon will act as project supervisor.

Krishna Pacifici, Research Assistant Professor at NCSU, will be the quantitative analysis collaborator on the project. Krishna's background and experience in quantitative ecology makes him well suited to consult and assist with advanced statistical analyses of spatial data.

Lisette Waits, Department Head and Distinguished Professor at the University of Idaho, will be the DNA analysis collaborator for the project, responsible for all DNA related sample processing and subsequent analyses.

Commented [JM56]: Since trapping is a big part of the project, it would be beneficial in the project personnel descriptions to give an indication of experience conducting capture operations.

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F. Schedule and Estimated Costs

The project will run from soon after December 1, 2017 through June 30, 2020. The estimated timeline for major tasks is as follows:

Year 1: Initiate field work soon after December 1, 2017 with assistance from 1-2 field technicians; 1 technician will be required for trapping and den monitoring efforts. Data collection will begin immediately after collar deployment and data will be managed by Andrea Shipley throughout the life of the project. Data analysis will be initiated after den monitoring season concludes, with guidance and assistance from Krishna Pacifici at North Carolina State University (NCSU). Report, manuscript and presentation production will be initiated concurrently with data analysis.

Year 2: Continue field work and data collection with assistance from 1-2 field technicians. Continue data analysis with guidance and assistance from Krishna Pacifici at NCSU. Continue and finalize report and manuscript production, and presentation at professional working groups and/or meetings.

GPS technology allows researchers to collect locational data at fine spatial and temporal scales through the deployment of collar units on wildlife study subjects. In this project, we propose to study a sample of sympatric canid populations with GPS radio-collars, in order to investigate the population parameters outlined in previous sections as well as species interactions. The purchase and use of this technology is critical to meeting the research objectives set forth in this document as well as in the document included in Attachment 1.

While GPS technology has evolved over the past 20 years, the cost of technology has plateaued. Upfront cost per unit remains relatively high, however project savings occurs at the back end when compared to older telemetry technology such as very high frequency (VHF)

Commented [JM57]: Need to make sure appropriate data is made available to FWS to maintain existing databases (e.g. studbook, mortality database, etc.).

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which require intensive labor to collect data at similar spatial and temporal scales. Pilot testing the proximity sensor enabled GPS-collars will allow investigation of the utility of this relatively new tool for community dynamics analysis by providing an increased locational data acquisition when individuals come within a set distance, or closer, from each other. Additionally, these sensors record the identities of the interacting individuals and the duration of their interactions. Using a trigger to temporarily switch GPS fix schedules will enable us to collect very fine scale data while conserving battery life, achieving project objectives in an efficient manner. Exploring the efficaciousness of this technology has the potential to positively impact future research projects requiring use of GPS-collars for data collection.

Aerial tracking will provide regular study animal surveillance useful to investigate cases of mortality, collar malfunction, or satellite data transmission delays, which can vary seasonally. In some situations, ground tracking could prove less expensive than aerial tracking. However, ground telemetry techniques require more than one biologist working in tandem to acquire accurate location estimates. This often translates to increased labor to collect data, particularly in large study areas. Aerial tracking will provide a more efficient and cost-effective method for surveilling study subjects in this large study area, requiring only one biologist and a contracted pilot. NCWRC personnel will perform aerial tracking along with the NCWRC pilot at a minimum frequency of every 30 days.

Use of local trappers to assist with sampling efforts provides several benefits. Local trappers have established, long-term relationships with private land owners, thereby providing access to private lands that might be otherwise difficult to secure. This will enable project biologists to obtain a representative sample of sympatric canids in the study area, as well as to operate more trap lines concurrently. This is particularly important when using a SCR sample design, as it will have direct implications on the resulting analyses and inferences.

As part of collaboration efforts, the project will contract the services of Krishna Pacifici, Research Assistant Professor in the Applied Ecology department at NCSU. Krishna's expertise is in quantitative ecology; consultation and assistance services provided will allow project biologists to make appropriate statistically relevant inferences from collected data.

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DNA analysis will be contracted to Lisette Wait's lab at the University of Idaho. Lisette's team at The Laboratory for Ecological, Evolutionary and Conservation Genetics has previous experience in analyzing red wolf and coyote hybrid molecular samples and has the most comprehensive DNA methodology for this sympatric canid species continuum in the nation. This expertise will facilitate expedient species identification on collared study animals besides landscape level population dynamics analysis.

	Commission	In-kind	Total
a. Personnel	$ 7,200.00	$ -	$ 7,200.00
b. Fringe Benefits	$ -	$ -	$ -
c. Travel	$ 30,000.00	$ -	$ 30,000.00
d. Equipment	$ 54,000.00	$ -	$ 54,000.00
e. Supplies	$ 61,500.00	$ -	$ 61,500.00
f. Contractual	$315,590.00	$ -	$315,590.00
g. Construction	$ -	$ -	$ -
h. Other	$ 6,000.00	$ -	$ 6,000.00
i. Total Direct Charges (sum of a – h)	$474,290.00	$ -	$474,290.00
j. Indirect Charges	$ 4,800.00	$ -	$ 4,800.00
k. Totals (sum of i and j)	$479,090.00	$ -	$479,090.00
Federal (75%)			$359,317.50
State (25%)			$119,772.50

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G. Geographic Location

Three counties of the Albemarle Peninsula of North Carolina (Dare, Hyde, and Tyrrell counties).

Commented [JM58]: Should be expanded to include Beaufort and Washington Counties since they are part of the NEP, if the only reason for excluding them is the assumption that the decision was already made to pull all red wolves back to Federal land in Dare and Hyde County.

H. Related Federal Projects

NC-W-F15AF00726 (W-72) NC-Division of Wildlife Management Cooperative Projects

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I. Glossary

Abundance: Species abundance is the number of individuals per species, and relative abundance refers to the evenness of distribution of individuals among species in a community.

Adaptive kernel (AK): A probabilistic home range estimator based on the distribution and density of locations that has been collected over a period of time.

Adverse reactions: In pharmacology, any unexpected or dangerous reaction to a drug.

Aerial: Existing, happening, or operating in the air.

Annually: Once a year; every year.

Anthropogenic: Caused or influenced by humans.

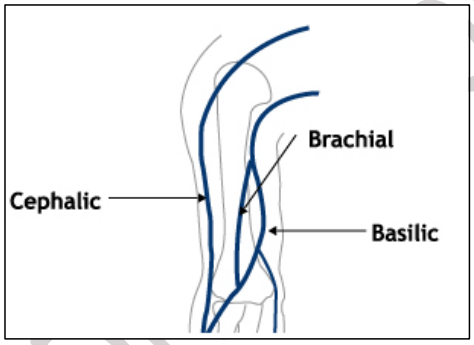
Apex: Having no natural predators in its ecosystem.

Ataxia: The loss of full control of bodily movements.

Beacon: A radio beacon whose purpose is the investigation of the propagation of radio signals.

Biopsy: The removal for diagnostic study of a piece of tissue from a living body.

Brachial vein: One of a pair of veins accompanying the brachial artery and uniting with each other and with the basilic vein to form the axillary vein.



Breeding pair: A pair of animals which cooperate over time to produce offspring with some form of a bond between the individuals.

Carrying capacity: The maximum population size of the species that the environment can sustain indefinitely, given the food, habitat, water, and other necessities available in the environment.

Compensatory immigration: Individuals emigrating from areas with lower mortality to those with higher mortality; filling a deficiency of individuals in a population experiencing higher mortality. The increase in size or activity of one part of an organism or organ that makes up for the loss or dysfunction of another.

Composition: The combining of distinct parts or elements to form a whole.

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Co-occurrence: Refers to observation of the spatial overlap between two (or more) different individuals over a period of time.

Coordinates: Any of the scales or magnitudes that serve to define the position of a point.

Core use areas: An area within a home range exhibited by a dense concentration of location points; commonly estimated at 50% of the location data points.

Covariates: A variable that is possibly predictive of the outcome under study.

Cranial: Pertaining to the cranium or to the anterior (in animals) or superior (in humans) end of the body.

Cryogenic: Very low temperatures, e.g. -80ºC.

Den-obligated: Restricted to a particular condition of life, in this case restricted to a den site.

Density: A measure of the number of organisms that make up a population in a defined area.

Deployment: To organize and send out (people or things) to be used for a particular purpose.

Depredation: The act of preying upon.

Depressed respiration: A decrease in the ability to exhale and inhale; respiration that has a rate below 12 breaths per minute or that fails to provide full ventilation and perfusion of the lungs.

Diagnostic: The process of determining by examination the nature and circumstances of a diseased condition.

Disorientation: Loss of one's sense of direction, position, or relationship with one's surroundings.

Distribution: The manner in which a biological taxon is spatially arranged.

DNA: (deoxyribonucleic acid) is a type of macromolecule known as a nucleic acid. It is shaped like a twisted double helix and is composed of long strands of alternating sugars and phosphate groups, along with nitrogenous bases (adenine, thymine, guanine and cytosine).

Dorsal: Situated on or toward the upper side of the body, equivalent to the back, or posterior, in humans; situated on or toward the posterior plane in humans or toward the upper plane in quadrupeds.

Duration: A continuous period of time.

Dynamic Brownian bridge movement models: Incorporates temporal and behavioral characteristics of movement paths into estimation of home range.

Ectoparasite: a parasite that lives on the outside of its host rather than within the hosts body; e.g. fleas and lice.

Effective trap area: Calculated by buffering each trap site by half the mean maximum distance traveled, each of these boundaries are dissolved, creating a measurable area.

Efficacious: Producing or capable of producing a desired effect.

Draft - Confidential

Efficient: Accomplishment of or ability to accomplish a job with a minimum expenditure of time and effort.

Euthanize: The act of putting to death painlessly or allowing to die, as by withholding extreme medical measures, a person or animal suffering from an incurable, especially a painful, disease or condition.

Expedient: Suitable for achieving a particular end in a given circumstance.

Evaporative cooling: reduction in temperature resulting from the evaporation of a liquid, which removes latent heat from the surface from which evaporation takes place.

Facilitate: Make an action or process easy or easier.

Genotyping: Investigate the genetic constitution of (an individual organism).

Gonadal descent: The act or process of descending from a higher to a lower location; testicular descent occurs during the breeding season annually.

GPS: Global Positioning System, is a radio navigation system that allows land, sea, and airborne users to determine their exact location, velocity, and time 24 hours a day, in all weather conditions, anywhere in the world.

Home range: an area over which an animal or group of animals regularly travels in search of food or mates, and that may overlap with those of neighboring animals or groups of the same species.

Hybridization: The result of mixing, through sexual reproduction, two animals or plants of different breeds, varieties, species or genera.

Immobilization agent: An active force or substance capable of producing an effect.

Implantation: To put or fix firmly.

Inbreeding depression: The reduced biological fitness in a given population as a result of inbreeding, or breeding of related individuals.

Inception: The establishment or starting point of an institution or activity.

Interspecific: Existing or occurring between different species.

Iridium: A satellite constellation providing voice and data coverage to satellite phones, pagers and integrated transceivers over the Earth's entire surface.

Jugular vein: Any of several large veins in the neck, carrying blood from the head and face.

Lacerations: A deep cut or tear in skin or flesh.

Locational: A position or site occupied or available for occupancy or marked by some distinguishing feature.

Malfunction: Fail to operate in the normal or usual manner

Methodology: A system of methods used in a particular area of study or activity.

Midline: A median line or plane of bilateral symmetry, especially that of the body.

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Minimum convex polygon (MCP): Completely enclose all data points by connecting the outer locations in such a way as to create a convex polygon.

Molecular samples: Genetic samples that may be used for investigation of genetic constitution of an individual.

Morphometrics: The process of measuring the external shape and dimensions of landforms, living organisms, or other objects.

Mortality: The state of being subject to death.

Non-target bycatch: Animals caught by accident that are not the target species being sought.

Parameters: A numerical or other measurable factor forming one of a set that defines a system or sets the conditions of its operation.

Parentage: The origin of something; the state or relation of a parent.

Passive integrated transponder: A microchip implant is an identifying integrated circuit placed under the skin of an animal.

Pinna: The external part of the ear in humans and other mammals; the auricle.

Plateaued: A period or state of little or no growth or decline.

Population dynamics: The branch of life sciences that studies the size and age composition of populations as dynamic systems, and the biological and environmental processes driving them (such as birth and death rates, and by immigration and emigration).

Population growth: The increase in the number of individuals in a population.

Population size: A group of organisms of the same species that live in the same area.

Population status:

Population trend: Changes over time and can include changes in ranging behavior and distribution, biogeography and life-history.

Population viability: The process that determines the probability that a population will go extinct within a given number of years.

Proximity: Nearness in space, time, or relationship.

Quantified: Express or measure the quantity of.

Quantitative: Relating to, measuring, or measured by the quantity of something rather than its quality.

Radio-telemetry: The use of radio waves for transmitting information from a distant instrument to a device that indicates or records the measurements.

Recumbency: The state of leaning, resting, or reclining.

Reintegrate: Restore (elements regarded as disparate) to unity.

Draft - Confidential

Remnant: A small remaining quantity of something.

Reproductive status: Relating to or effecting reproduction.

Spatial: Relating to, occupying, or having the character of space.

Spatial capture-recapture: A method commonly used in ecology to estimate an animal population's size. A portion of the population is captured, marked, and released. Marked animals are either recaptured or are tracked, each tracking location being considered a recapture.

Species Continuum: An aggregate of species capable of interbreeding, resulting in fertile hybrid offspring whose genetic composition may represent a varying array of phenotypes and genotypes from the parental species, at which the extreme ends of the spectrum are distinct.

Standardize: Cause (something) to conform to a standard.

Statistically relevant inferences: the process of deducing properties of an underlying distribution by analysis of data. Inferential statistical analysis infers properties about a population: this includes testing hypotheses and deriving estimates.

Stochastic population models: Ecological population modeling is concerned with the changes in population size and age distribution within a population as a consequence of interactions of organisms with the physical environment, with individuals of their own species, and with organisms of other species; stochasticity possesses some inherent randomness. In stochastic population models, the same set of parameter values and initial conditions will lead to an ensemble of different out puts.

Strangulation: The condition in which circulation of blood to a part of the body is cut off by constriction.

Stratifying: Form or arrange into strata, one of a number of portions or divisions likened to layers or levels.

Surveillance: Continuous observation of a place, person, group, or ongoing activity in order to gather information.

Survival: A living or continuing longer than, or beyond the existence of, another person, thing, or event.

Sympatric: Occurring within the same geographical area; overlapping in distribution.

Tachycardia: A heart rate that exceeds the normal resting rate. In general, a resting heart rate over 100 beats per minute is accepted as tachycardia in human adults.

Telemetry: See radio-telemetry.

Temporal: Of or relating to time.

Tooth replacement: The process of development of two successive sets of teeth, initially the deciduous set and consecutively the permanent set.

Transmitter: A set of equipment used to generate and transmit electromagnetic waves carrying messages or signals, especially those of radio or television.

Transponder: A device for receiving a radio signal and automatically transmitting a different signal.

Draft - Confidential

Vaccinate: Treat with a vaccine to produce immunity against a disease; inoculate.

Venipuncture: The puncture of a vein as part of a medical procedure, typically to withdraw a blood sample or for an intravenous injection.

VHF: Very high frequency is the ITU designation for the range of radio frequency electromagnetic waves (radio waves) from 30 MHz to 300 MHz, with corresponding wavelengths of ten to one meters.

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Attachment 1: Intra-service Section 7 Biological Evaluation Form

Region 4

INTRA-SERVICE SECTION 7 BIOLOGICAL EVALUATION FORM

[Note: This form provides the outline of information needed for intra-Service consultation. If additional space is needed, attach additional sheets, or set up this form to accommodate your responses.]

Originating Person: Andrea Shipley

Telephone Number: 252.926.0266 **E-Mail:** andrea.shipley@ncwildlife.org

Date: November 8, 2016

PROJECT NAME (Grant Title/Number): NC – Division of Wildlife Management Cooperative Projects / (W-72)

I. Service Program:

_____**Ecological Services**
__X__**Federal Aid**
- _____**Clean Vessel act**
- _____**Coastal Wetlands**
- _____**Endangered Species Section 6**
- _____**Partners for Fish and Wildlife**
- _____**Sport Fish Restoration**
- __X__**Wildlife Restoration**

_____**Fisheries**
_____**Refuges/Wildlife**

II. State/Agency:

NORTH CAROLINA / NORTH CAROLINA WILDLIFE RESOURCES COMMISSION

III. Station Name:

FWS RALEIGH ECOLOGICAL SERVICES OFFICE

IV. Description of Proposed Action (attach additional pages as needed):

Conduct research project entitled "**Coyotes of the Albemarle: Spatial Ecology, Resource Selection, Demographics, and Interactions with a Sympatric Canid"**

The coyote (*Canis latrans*) is now abundant throughout the 100 counties in North Carolina (NC), where they are managed as nongame with no closed season or bag limit (NC Wildlife Resources Commission 2016). Previously restricted to the West and Midwest regions of the United States, by the early 1990s coyotes had expanded their range into the Albemarle Peninsula (AP), which is situated in the northeast coastal plains region of NC (Hinton et al. 2012, Murray et al. 2014).

Recently described as using "compensatory immigration," coyotes are able to opportunistically fill spatial resource gaps by periodic transiency (Hinton 2016). These periods of transiency can sometimes bring coyotes into conflict with humans and other canids, especially while taking advantage of anthropogenic resources. Though a rural area, human land uses predominate on the AP. The AP is comprised of approximately 30% agricultural fields, 50% forest and coastal marshes, and 20% "other" land cover types on federal, state and private lands (Dellinger 2011).

In 1968, individuals from a remnant population of red wolves were removed from Texas and Louisiana and a captive breeding program was initiated. The United States Fish and Wildlife Service (USFWS) released a non-essential, experimental population of red wolves (*Canis rufus*) on the Alligator River National Wildlife Refuge (ARNWR) in 1987 (Hinton et al. 2013). The red wolf population increased until 2008 and peaked at around 208 individuals (USFWS Red Wolf Recovery Program 2007), a few animals short of the recovery goal of 220 in the wild (USFWS Red Wolf Recovery Program 2013), with an estimated carrying capacity of 140-150 for the AP (Hinton et al. 2013, Kelly et al. 1999, USFWS Red Wolf Recovery Program 2007). Red wolves presently inhabit an approximately 6900 square kilometer recovery area within Beaufort, Dare, Hyde, Tyrrell, and Washington counties (Wildlife Management Institute 2014).
Accurate up-to-date estimates of the population are unavailable, but USFWS staff report a population size of 45-60 individuals with three mortalities in 2016 (https://www.fws.gov/redwolf/index.html July 2016). Hybridization with coyotes, inbreeding depression, and gunshot mortality have all been suspected issues that have affected the population growth and viability since the inception of the Red Wolf Recovery Program (RWRP) (Hinton et al. 2013). In 2013, NCWRC and USFWS established a committee to oversee the collaborative management and conservation of red wolves and other canids on the AP. A USFWS memorandum documented detailed action items for the joint management of canids on the AP, including specific research objectives which this proposal seeks to address (Attachment 1).

As coyotes on the AP increase in number, monitoring coyote movements, particularly in relation to red wolves, will provide important data to NCWRC and USFWS staff for science-based local and landscape-level decisions about coyote population management. Collection of finer temporal scale location data will help to manage interactions of both canid species with humans, as well as to support development of dynamic stochastic population models.

Coyote and red wolves will be live trapped by cooperating NCWRC and USFWS staff, and private trappers using double coil size 3 foothold traps, during the breeding season (Nov-Feb for coyote, Jan-Feb for red wolves) in the tri-county area of Dare, Hyde and Tyrrell. Morphological measurements, incidents of injury, occurrence of ectoparasites, age classification, and reproductive status will be determined; blood and tissue samples will be taken for genetic analysis. All captured individuals that meet the age classification and weight requirements will be collared with GPS collar units. All captured and collared individuals will be released at the capture site. The objectives listed below will be achieved by obtaining measurements, samples and information from the captured, collared, and tracked individuals over the course of three years using GPS location data.

Commented [JM59]: Some of the information needs to be updated. The estimated population is 25-40 individuals. There were 11 known mortalities in 2016. There have been 6 known mortalities in 2017 so far. No trapping of red wolves in February as to not disrupt them during breeding season. Some of the other language should be changed to reflect changes in the project proposal.

Objective 1: Use GPS collar and proximity sensor technology to test performance under various conditions and evaluate the frequency and accuracy of the scheduled fix rates.

Objective 2: Use fine scale GPS data collection for investigating annual and seasonal spatial dynamics of sympatric canids: home range and core area sizes, amount of overlap in home range and core areas, movement pathways and daily activity patterns, and cover type selection and preference.

Objective 3: Use fine scale GPS data collection for investigating the number and age structure of offspring for family groups of collared sympatric canids.

Objective 4: Use fine scale GPS data collection for investigating sources of mortality for sympatric canids.

Objective 5: Use fine scale GPS data collection for preventing and mitigating canid conflicts with landowners.

Objective 6: Determine genetic profiles of sympatric canids through DNA identification of all captured individuals, parentage, and presence of hybridization.

V. Pertinent Species and Habitat:

A. Include species/habitat: See section VI

B. Complete the following table:

SPECIES/CRITICAL HABITAT	STATUS[1]
Canis rufus	T

[1]STATUS: E = endangered, T = threatened, PE = proposed endangered, PT =proposed threatened, CH = critical habitat, PC = proposed critical habitat, C = candidate species

VI. Location:

A. Statewide
Albemarle Peninsula (see web address www.ncwildlife.org)

B. Section, township, and range (or latitude and longitude):

Dare, Hyde, Tyrrell counties

C. Distance (miles) and direction to nearest town:

As stated above

D. Species/habitat occurrence:

Canis rufus

VII. Determination of Effects:

A. Explanation of effects of the action on species and critical habitats in item V. B. (attach additional pages as needed):

SPECIES/CRITICAL HABITAT	IMPACTS TO SPECIES/CRITICAL HABITAT
Canis rufus	Trap induced injury is possible

B. Explanation of actions to be implemented to reduce adverse effects:

SPECIES/CRITICAL HABITAT	ACTIONS TO MITIGATE/MINIMIZE IMPACTS
Canis rufus	Use of appropriate trap types, daily trap checks, treatment of minor injuries, trapping season limitations and limitations on environmental conditions for trap operation

Commented [JM60]: Same comment as previously regarding including Beaufort and Washington Counties.

Section VII. B. Actions to Mitigate/Minimize Impacts – Early morning daily trap checks, no trapping during freezing conditions, etc.

VIII. Effect Determination and Response Requested:

Species/ Critical Habitat	Determination[1]			Response[1] Requested
	NE	NA	AA	
Canis rufus		X		Concurrence

[1] Determination/Response Requested:

NE = No Effect. This determination is appropriate when the proposed action will not directly, indirectly, or cumulatively impact, either positively or negatively, any listed, proposed, candidate species or designated/proposed critical habitat. Response Requested is optional but a "Concurrence" is recommended for a complete Administrative Record.

NA = Not Likely To Adversely Affect. The determination is appropriate when the proposed action is not likely to adversely impact any listed, proposed, candidate species or designated/proposed critical habitat or there may be beneficial effects to these resources. Response Requested is a "Concurrence".

AA = Likely To Adversely Affect. This determination is appropriate when the proposed action is likely to adversely impact any listed, proposed, candidate species or designated/proposed critical habitat. Response Requested for listed species is "Formal Consultation". Response Requested for proposed or candidate species is "Conference".

Signature (originating station) **Date**

Title

IX. Reviewing Ecological Services Office Evaluation:

A. Concurrence _____ Non-Concurrence _____

B. Formal consultation required _____

C. Conference required _____

D. Formal conference required _____

E. Remarks (attach additional pages as needed):

_____ _____
Signature **Date**

_____ _____
Title **Office**

873 Attachment 2: Joint Memorandum

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MEMORANDUM

November 20, 2013

TO: All Interested Parties

FROM: "for"
Cynthia K. Dohner, Director, Southeast Region, U.S. Fish and Wildlife Service
Gordon S. Myers, Executive Director, N.C. Wildlife Resources Commission

SUBJECT: Collaborative Conservation of Red Wolves and Other Canids on North Carolina's Albemarle Peninsula

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Recovery of the federally-listed red wolf has been a priority for the U.S. Fish and Wildlife Service (FWS) for more than 20 years and is focused in North Carolina on the Albemarle Peninsula (AP; i.e., Hyde, Tyrrell, Washington, Beaufort, and Dare counties). Comprehensive stakeholder involvement and collaboration with other management agencies is critical to successful recovery of any at-risk species. The North Carolina Wildlife Resources Commission (WRC) is a key collaborator in this regard, as it has jurisdiction over all state-trust wildlife resources in N.C.

Since 2009, the FWS and WRC have worked to broaden our collaboration in the conservation and management of all canid species (including red wolves) on the AP. As these efforts have solidified, specific actions have been jointly identified by our two agencies that will improve conservation outcomes. These actions are categorized into five areas; collaboration, research, outreach, regulatory, and enforcement. Specific action items are outlined and prioritized within each of these categories in Attachment A.

This memo establishes the FWS's and WRC's commitment to initiate, or to continue, the efforts outlined in Attachment A. The common goal in this effort is to establish clear expectations and accountability for collaboration regarding the action items on Attachment A, thus resulting in enhanced and seamless canid conservation and management on the AP. This approach provides the best opportunity to achieve recovery goals for red wolves, while at the same time managing other canids to balance biological variables with social expectations. The dynamics of these canid species are complex and offer unique opportunities for innovation. Appropriate staff from each agency is hereby tasked with immediately developing a timeline to implement these actions. Through this commitment, we will continue to advance our collective conservation goals.

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Attachment A

Action Items for Collaborative Conservation of Canids on North Carolina's Albemarle Peninsula (AP)
(*Note: Action Items are prioritized within category.*)

Collaboration

1. The N.C. Wildlife Resources Commission (WRC) and U.S. Fish and Wildlife Service (FWS) will formalize in writing the collaborative management of canids on the AP. This agreement should:
    a. include a clear mission statement, goals, objectives, and implementation strategies (ask and answer the "Why?");
    b. set a goal to define success regarding canid management on the AP;
    c. espouse a philosophy of canid management operating within the context of a three-legged stool (i.e., federal and state governments and stakeholders);
    d. as available, commit funding and staffing resources for field personnel to contribute to the conservation of the red wolf and management of coyotes;
    e. as available, commit funding to conduct research pertinent to canid management on the AP;
    f. establish polices and goals for developing a collaborative genetic archive for AP canids, a data sharing portal accessible by staff in both agencies, and reciprocal sharing of all historical data (including phenotypic and genotypic data and literature) of the red wolf;
    g. establish a foundation for developing and implementing an adaptive approach to canid management on private lands on the AP;
    h. initiate development of a collaborative canid research program;
    i. describe plans to conduct the next five year Red Wolf Program review;
    j. outline options for holding annual workshops with federal and state enforcement staff;
    k. outline plans to hold semi-annual coordination meetings regarding canid management on the AP; and
    l. develop milestones for future development of a management plan for all canids in the AP.

2. The FWS will initiate a review of the current Red Wolf Recovery Plan to determine if the state-of-our-knowledge or field conditions have changed such as to warrant its revision. Review and comments from the WRC will be considered in this evaluation.

3. The WRC, with support and participation of the FWS, will establish a "Canid Forum" (similar to that established for manatees in Florida) to facilitate communication and discussion regarding canid management and citizen science opportunities on the AP.

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Attachment A

Research

1. The FWS and WRC will provide funding and logistical support for research identified by the Red Wolf Recovery Implementation Team, Red Wolf Program staff, other FWS staff, or the WRC that promote the conservation and recovery of the red wolf and other canids on the AP. Studies could include:
    a. tests of the "placeholder theory" on the AP, including behavior of sympatric canids,
    b. determining carrying capacity of canids on the AP,
    c. determining genetic profiles of canid species on the AP,
    d. evaluating predator-prey dynamics,
    e. studies of canid habitat use,
    f. epidemiology of diseases impacting canids on the AP,
    g. development of stochastic simulation models of sympatric canid population dynamics and habitat use, and
    h. canid dispersal dynamics

2. The FWS and WRC will conduct jointly-supported research to determine the attitudes and opinions of N.C. private landowners and other citizens concerning canids on the AP (i.e., human dimensions studies).

Outreach

1. The FWS and WRC will collaborate with other partners to design and implement broad-based outreach and marketing programs with clear goals, objectives, strategies, and measurable outcomes, including development of consistent agency messages and educating the public about canids on the AP.

Regulatory

1. The FWS and WRC will initiate a review and, if needed, subsequent rule-making to clarify concepts or rectify conflicts in current federal or state rules (including the current 10(J) rule).

2. The WRC will review and evaluate statutory requirements for listing red wolves as state threatened in the five AP counties.

3. As data demonstrating a relationship between coyote hunting and red wolf mortality become available, the FWS and WRC will evaluate, and if appropriate implement, adaptive approaches to regulate of take of coyotes that may result in incidental take of red wolves.

4. The WRC will evaluate the status, management, and regulation of Controlled Fox Hunting Preserves.

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Attachment A

5. The WRC will develop BMPs (due care provisions) for coyote hunting, trapping, and live sale.

6. The WRC will compile, compare, and contrast canid hunting and trapping regulations and programs in other states, including, but not limited to, other states with other species of wolves.

Enforcement

1. The FWS and WRC will develop coordination strategies to improve enforcement of federal regulations protecting red wolves.

Attachment 3: Landowner Agreement Form

NC Wildlife Resources Commission
Wildlife Management Division
Wildlife Diversity Program
Landowner Agreement for Scientific Collection

_____ / _____ / _____
MM DD YYYY

Property Type
Private _____ Federal _____ State _____

NC Wildlife Resources Commission
Address: 1701 Mail Service Center, Raleigh, NC 27699-1701
Phone: 919-707-0010

Cooperator's Name: _____
Last First Middle

Cooperator's Address: _____
Street City, State, Zip

Where will the work be performed? _____

give address or directions if different from above _____

Business, Farm, Property Common Name _____

Owner's or Rep Name _____ _____
If different from Cooperator Telephone Number

Owner's Address: _____
If different from Cooperator Street City, State, Zip

WRC Employee & Work Location	Species
	1)
Employee Name	2)
	3)
Duty Area	4)

I, the cooperator or cooperator's representative, have been informed of the methods and the manner in which research devices will be used, and of the possible hazards associated with their use. I understand that NCWRC, (to include its officers, employees and agents) will: exercise reasonable precautions to safeguard all persons to prevent injury to target and non-target animals; guard against the mishandling of control devices and materials; and exercise due caution and proper judgment in all scientific collection operations. I understand that NCWRC may collect Global Positioning System (GPS) coordinates at the project site as part of component or activity tracking or as wildlife disease monitoring or research data. I, the undersigned cooperator, do hereby give my consent and concurrence to NCWRC, its employees, and its agents, to use, upon lands owned, leased, or otherwise controlled by me, and identified by this document, the following methods and devices (an attachment of additional devices and/or methods may be attached):

Statement of agreement: The landowner, cooperator, or representative, as listed above hereby give permission to NCWRC to perform trap and release of the species listed for scientific collection purposes. In consideration of these understandings, I, the cooperator or cooperator's representative, agree to: assume responsibility for injury to my property under my control, when said injury is not the result of negligence on the part of NCWRC (it's officers, employees, and agents); assist in maintaining such warning signs as NCWRC may place for the purpose of notifying persons entering onto such lands of the possible hazards associated with scientific measures in use thereon; and to give adequate warning of these possible hazards to persons I authorize to enter onto such lands. Further, I, the cooperator or cooperator's representative, agree not to concurrently use or allow to be used upon lands covered by this agreement, any canid depredation efforts during the scientific collection time period.

Landowner Signature/Date _____
Signature Date

WRC Employee Signature/Date _____
Signature Date

Attachment 4: Trapper Service Contract

Contract in development.

Draft - Confidential

From: Google Calendar on behalf of Todd Willens
To: greg_j_sheehan@fws.gov
Subject: Tentatively Accepted: Phone call: (Greg and Senator Tillis) re: advance notice ... @ Tue Jun 26, 2018 9:30am - 9:45am (EDT) (greg_j_sheehan@fws.gov)
Attachments: invite.ics

Todd Willens has replied "Maybe" to this invitation.
Phone call: (Greg and Senator Tillis) re: advance notice of the red wolf proposal - Rm 3358
Below is the schedule so far. There are still a few details being ironed out and I hope to send you a final clean schedule shortly. When you get a chance, can you please let me know what number Senator Burr should use to call Greg?
9:30 a m - Senator Tillis
Call may include Todd Willens, TBD shortly
Senator's conference line: (b) (5) CIP(b) (5) CIP(b) (5) CIP
10:00 a.m. - Congressman Rouzer
Call details TBD
10:45 a.m. - Senator Burr
Senator to call Greg at (b) (5) CIP
Thank you,
Alyssa

When Tue Jun 26, 2018 9:30am – 9:45am Eastern Time
Where Rm 3358 (map <https://maps.google.com/maps?q=Rm+3358&hl=en>)
Video call https://hangouts.google.com/hangouts/_/doi.gov/alyssa-hausman <https://hangouts.google com/hangouts/_/doi.gov/alyssa-hausman?hceid=Z3JlZ19qX3NoZWVoYW5AZndzLmdvdg.62fdddudqs4aclr4vt2b8rfnr4>
Calendar greg_j_sheehan@fws.gov
Who • greg_j_sheehan@fws.gov - organizer
• thomas_irwin@fws.gov - creator
• alyssa_hausman@fws.gov
• martin_kodis@fws.gov
• todd_willens@ios.doi.gov
• barbara_wainman@fws.gov - optional
• matthew_huggler@fws.gov - optional
• angela_gustavson@fws.gov - optional
• gareth_rees@ios.doi.gov - optional

Invitation from Google Calendar <https://www.google.com/calendar/>
You are receiving this email at the account greg_j_sheehan@fws.gov because you are subscribed for invitation replies on calendar greg_j_sheehan@fws.gov.
To stop receiving these emails, please log in to https://www.google.com/calendar/ and change your notification settings for this calendar.
Forwarding this invitation could allow any recipient to modify your RSVP response. Learn More <https://support.google.com/calendar/answer/37135#forwarding> .

USDA Feral Swine Control Initiative
Saint Vincent Island National Wildlife Refuge
Camera Stations and Track Plots



From:	Willens, Todd
To:	Casey Stemler
Subject:	Fwd: Senate Capability Statements
Date:	Tuesday, September 26, 2017 6:10:19 PM
Attachments:	S- FWS - 18 - ES Gray Wolves in Wyoming_Final.docx S-FWS - 22 - ES Governor Approval of listing_Final bcj comments 9.26.17.docx S-FWS - 8 - ES Red Wolves Report Language_Final 9.26.17.docx S-FWS - 25 - ES Red Wolves Bill Language_Final (1).docx

---

Can you look at these.

Todd Willens
Assistant Deputy Secretary
Acting Assistant Secretary for Fish and Wildlife and Parks
U.S. Department of the Interior
1849 C Street, NW -- MIB Room 6116
Washington, DC 20240
office: 202-208-6291

NOTE: *Every email I send or receive is subject to release under the Freedom of Information Act.*

---------- Forwarded message ----------
From: **Fink, Wendy** <wendy_r_fink@ios.doi.gov>
Date: Tue, Sep 26, 2017 at 3:43 PM
Subject: Fwd: Senate Capability Statements
To: Todd Willens <todd_willens@ios.doi.gov>

Attached below are four capability statements in which the Department's budget office is seeking ASFWP clearance.

Wendy
---------- Forwarded message ----------
From: **Chris Nolin** <chris_nolin@fws.gov>
Date: Tue, Sep 26, 2017 at 12:31 PM
Subject: Fwd: Senate Capability Statements
To: maureen_foster@ios.doi.gov, wendy_r_fink@ios.doi.gov

Here are the capability statements that need to be cleared. Thanks for your help!

Sent from my iPad

Begin forwarded message:

> **From:** "Nolin, Chris" <chris_nolin@fws.gov>
> **Date:** September 13, 2017 at 11:37:14 AM EDT
> **To:** Charisa Morris <Charisa_Morris@fws.gov>, Stephen Guertin <stephen_guertin@fws.gov>
> **Subject: Senate Capability Statements**

Hi -

The Department Budget Office is asking once again that we try to clear the attached capability statements with FWP.

Can you see if we can get them cleared?

Thanks!

--
Chris Nolin
Budget Officer
US Fish & Wildlife Service
703-358-2343 desk
240-305-0490 cell
U.S. Fish and Wildlife Service Headquarters
MS: BPHC
5275 Leesburg Pike
Falls Church, VA 22041-3803

--

Wendy R. Fink

Counselor to the Assistant Secretary for Fish and Wildlife and Parks
U.S. Department of the Interior
1849 C St NW | MS 3145 | Washington D.C. 20240
P|202.208.4615

Capability Number: S-FWS-18

Department of the Interior
FY 2018—Capability Statement

Bureau: Fish and Wildlife Service
Appropriation: Resource Management
Activity/Subactivity: Ecological Services/Recovery

Proposed Bill Language:

The final rule published on September 10, 2012 (77 Fed. Reg. 55530) that was upheld by the U.S. Court of Appeals for the District of Columbia (1: 12-cv-01833) and reaffirmed by the final rule published on May 1, 2017 (82 Fed. Reg. 20284) that reinstated removal of Federal protections for the gray wolf in Wyoming under the Endangered Species Act of 1973, as amended, without regard to any other provision of statute or regulation that applies to issuance of such rule, shall not be subject to judicial review.

Proposed By: Senate Appropriations

Amount Enacted for Project/Program for FY 2017: $0 / 0 FTE
Amount Budgeted for Project/Program for FY 2018: $0 / 0 FTE

Effect of Proposed Amendment:

1. What would the funding in the proposed amendment be used for?

No funding is proposed. On September 21, 2014 the U.S. District Court for the District of Columbia vacated the Service's rule to delist the gray wolf in the State of Wyoming. On March 3, 2017, the U.S. Court of Appeals issued an opinion reversing the U.S. District Court's vacature of the Service's 2012 final rule. Consistent with the March court ruling, on April 26, 2017, the Service delivered a final rule that reinstated the removal of federal protections for the gray wolf in Wyoming under the Endangered Species Act. The Service will continue to monitor the population for the next five years to ensure recovery criteria are met.

2. Feasibility/capability of the proposed funding level or language this fiscal year?

The proposed bill language would affirm the Service's delisting of gray wolves in Wyoming, which has already gone into effect.

3. Is the program/project ranked on existing priority setting systems?

Funding for the Ecological Services program is subject to a careful priority setting process.

Outlay Effect:

FY 2018:	$0
FY 2019:	$0

Note: *Submission of this capability statement does not reflect Departmental support for the proposed amendment. The Department does not support the addition of funds for any program or project that would result in the reduction of funding for other programs or projects in the President's Budget.*

Capability Number: S-FWS-22

Department of the Interior
FY 2018—Capability Statement

Bureau: Fish and Wildlife Service
Appropriation: Resource Management
Activity/Subactivity: Ecological Services/Listing

Proposed Bill Language:

Provided that no funds be used for "endangered" or "threatened" listings under the Endangered Species Act of any species, unless the Governor of a State impacted by such a decision approves of a listing.

Proposed By: Senate Appropriations

Amount Enacted for Project/Program for FY 2017 (Listing only):

Amount Budgeted for Project/Program for FY 2018 (Listing only):

Effect of Proposed Amendment:

1. What would the funding in the proposed amendment be used for?

No funding is provided. Under the Endangered Species Act (ESA), the listing of species is a science-based determination reserved for the Secretary of the Interior or the Secretary of Commerce for species within their respective jurisdictions. By requiring approval of the Governor of any affected State, this proposed amendment would create a conflict with the ESA's deadlines for action on listing petitions or proposed listing rules, which would be unaffected by the proposed amendment. ~~open the Service to litigation since the statutory obligation to list species would still remain.~~ Therefore, the Service could be sued, under the c~~C~~itizen~~ S~~suit provision of the ESA, for not complying with a statutory duty. The Ninth Circuit has held that when the Service is legally prohibited from spending funds to take a listing action, the Service's failure to take action is still a violation of the ESA, even though a court may not order that the Service take action until after funds are available. ~~[~~Even if future courts follow the holding of the Ninth Circuit, however, this amendment could provide additional litigation and uncertainty as to how much time a court would grant to complete a listing decision after gubernatorial approval.~~]~~

The Service and the National Marine Fisheries Service (NMFS) published the "Revised Interagency Cooperative Policy Regarding the Role of State Agencies in Endangered Species Act Activities" (81 FR 8663) in the Federal Register on February 22, 2016. Through this policy, the Services recognize that, in the exercise of their general governmental powers, States possess broad trustee and police powers over fish, wildlife, and plants and their habitats within their borders. State agencies often possess scientific data and valuable expertise on the status and distribution of endangered, threatened, and candidate species of wildlife and plants. State

agencies, because of their authorities and their close working relationships with local governments and landowners, are in a unique position to assist the Services in implementing all aspects of the ESA. In this regard, section 6 of the ESA provides that the Services shall cooperate to the maximum extent practicable with the States in carrying out programs authorized by the ESA. Section 4(i) of the ESA requires that the Service provide a written justification to a State agency for taking action that is in conflict with comments received from the State agency or that fails to adopt a regulation pursuant to an action petitioned by the State agency.

2. Feasibility/capability of the proposed funding level or language this fiscal year?

The Service already has efforts underway to incorporate states more closely into listing decisions.

3. Is the program/project ranked on existing priority setting systems?

Funding for the Service's programs is subject to a careful priority-setting process.

Outlay Effect:

FY 2018: $0
FY 2019: $0

Note: *Submission of this capability statement does not reflect Departmental support for the proposed amendment. The Department does not support the addition of funds for any program or project that would result in the reduction of funding for other programs or projects in the President's Budget.*

Capability Number: S-FWS-25

Department of the Interior
FY 2018—Capability Statement

Bureau: Fish and Wildlife Service
Appropriation: Resource Management
Activity/Subactivity: Ecological Services/Recovery

Proposed Bill Language:

None of the funds appropriated or otherwise made available by the Act may be used by the Department of the Interior of the United States Fish and Wildlife Service to implement 50 CFR 17.84(c).

Proposed By: Senate Appropriations

Amount Enacted for Project/Program for FY 2017:
Amount Budgeted for Project/Program for FY 2018:

Effect of Proposed Amendment:
1. What would the funding in the proposed amendment be used for?

No funding is provided. This provision would prohibit the Service from enforcing the non-essential experimental population rule for the red wolf. Among other things, this rule allows incidental take of red wolves, and provides other regulatory relief in certain circumstance.

Once common throughout the eastern and southcentral United States, red wolf (*Canis rufus*) populations were decimated by the early part of the 20th Century as a result of intensive predator control programs and the degradation and alteration of the species' habitat. The red wolf was designated an endangered species in 1967, and shortly thereafter the U.S. Fish and Wildlife Service (Service) initiated efforts to conserve the species. The non-essential experimental population determination was finalized in November 1991.

This language would bar the Service from carrying out any of the responsibilities associated with implementing the provisions of the non-essential experimental red wolf population rule, which provides management flexibility and authorizes take for management purposes, depredation, and nuisance behaviors. This language would prohibit the Service from providing landowners in eastern North Carolina regulatory relief as intended by the rule. The Service would be prohibited from removing red wolves from private lands where they are not wanted or authorize take in any form. It would also prohibit continued implementation of scientifically proven management techniques used by the Service to manage interactions with coyotes. It would not preclude third parties from suing private citizens for take violations under section 9 of the ESA, likely to occur in the absence of Federal management.

2. Feasibility/capability of the proposed funding level or language this fiscal year?

This language would potentially cause an increase in litigation regarding the Government's responsibility to implement the statutory requirements of the ESA, and undercut the Service's ability to work collaboratively with States, local communities, and landowners to conserve this imperiled species.

3. Is the program/project ranked on existing priority setting systems?

Funding for the Service's programs is subject to a careful priority setting process.

Outlay Effect:

FY 2018: $0
FY 2019: $0

Note: *Submission of this capability statement does not reflect Departmental support for the proposed amendment. The Department does not support the addition of funds for any program or project that would result in the reduction of funding for other programs or projects in the President's Budget.*

Capability Number: S-FWS-8

Department of the Interior
FY 2018—Capability Statement

Bureau: Fish and Wildlife Service
Appropriation: Resource Management
Activity/Subactivity: Ecological Services/Recovery

Proposed Report Language:

The Committee acknowledges the North Carolina Wildlife Resources Commission request that the United States Fish and Wildlife Service end the Red Wolf Recovery Program and declare the red wolf extinct. Furthermore, the Committee agrees that the Red Wolf Recovery Program, since its establishment, has failed to meet the population recovery goals for the red wolf and that the program has negatively affected North Carolina landowners and the populations of several other native species. The Committee expects the United States Fish and Wildlife Service to end this failed program during fiscal year 2018.

Proposed By: Senate Appropriations

Amount Enacted for Project/Program for FY 2017:
Amount Budgeted for Project/Program for FY 2018:

Effect of Proposed Amendment:
1. What would the funding in the proposed amendment be used for?

No funding is provided. The red wolf was originally listed as a species threatened with extinction under the Endangered Species Preservation Act of 1966 (32 FR 4001; March 11, 1967). This species is currently listed as an endangered species under the Endangered Species Act of 1973, as amended (Act) (16 U.S.C. 1531 *et seq.*).

Historically, the red wolf range included Texas and Louisiana to the Ohio River Valley and up the Atlantic Coast into northern Pennsylvania or southern New York, and perhaps further north. However, by the mid-1970s, the only remaining population occurred in southeastern Texas and southwestern Louisiana (Wildlife Management Institute 2014).

In 1975, the decision was made to capture as many wild animals as possible and place them in a secured captive-breeding program. This decision was based on the critically low numbers of animals left in the wild, poor physical condition of those animals due to disease and internal and external parasites, the threat posed by an expanding coyote (*Canis latrans*) population, and consequent inbreeding problems.

In 1986, a final rule to introduce red wolves into Alligator River National Wildlife Refuge (Alligator River), Dare County, North Carolina, was published in the Federal Register (51 FR 41790, November 19, 1986). In 1991, a revision to the rule added Beaufort County to the counties where the experimental population designation would apply (56 FR 56325, November

4, 1991). Today, the only population of red wolves in the wild is the NEP established around Alligator River in North Carolina. All other individuals of this species are found in captive facilities around the country.

In 2013, acknowledging growing concerns from private landowners regarding management of the NEP, the Service and North Carolina Resources Commission entered into a broad canid management agreement, recognizing steps were needed to improve management of the population. Subsequently, the Service contracted an independent evaluation of the NEP project in 2014 and of the entire red wolf recovery program in 2015. From these evaluations, it became clear that the current direction and management of the NEP project is unacceptable to the Service and all stakeholders.

As a result of the findings from the evaluations, the Service is considering a potential revision of the 1995 NEP final rule. Scoping for this proposal took place in the summer of 2017.

2. Feasibility/capability of the proposed funding level or language this fiscal year?

The Service has a process underway to revise the program for red wolvefs. This provision would halt that process and other efforts to recovery red wolves.

3. Is the program/project ranked on existing priority setting systems?

Funding for the Service's programs is subject to a careful priority setting process.

Outlay Effect:

FY 2018:	$0
FY 2019:	$0

Note: *Submission of this capability statement does not reflect Departmental support for the proposed amendment. The Department does not support the addition of funds for any program or project that would result in the reduction of funding for other programs or projects in the President's Budget.*

From: gary_frazer@fws.gov
To: casey_hammond@ios.doi.gov; charisa_morris@fws.gov; matthew_huggler@fws.gov; virginia_lohnson@ios.doi.gov; stephen_guertin@fws.gov; cynthia_dohner@fws.gov; jim_kurth@fws.gov; james_schindler@ios.doi.gov; maureen_foster@ios.doi.gov; downey_magallanes@ios.doi.gov; micah_chambers@ios.doi.gov
Cc: roslyn_sellars@fws.gov; thomas_irwin@fws.gov; acquanetta_reese@fws.gov
Subject: Invitation: Red Wolf Briefing @ Thu Mar 2, 2017 2:30pm - 3:30pm (downey_magallanes@ios.doi.gov)
Attachments: invite.ics

---

more details » <https://www.google.com/calendar/event?
action=VIEW&eid=ajk0MzdpYzJoZjgyMzloM3M1dnFtdDhidjAgZG93bmV5X21hZ2FsbGFuZXNAaW9zLmRvaS5nb3Y&tok=MTkjZ2FyeV9mcmF6ZXJAZndzLmdvdjQ4Y2I3ZDY5MDcwN2ZjN2QzZmVjMDU0Y2RiMjM1MjZkMWY2NTQwOTQ&ctz=America/New_York&hl=en>

Red Wolf Briefing
When Thu Mar 2, 2017 2:30pm – 3:30pm Eastern Time
Where TBD (map <https://maps.google.com/maps?q=TBD&hl=en>)
Video call https://plus.google.com/hangouts/_/doi.gov/gary-frazer <https://plus.google.com/hangouts/_/doi.gov/gary-frazer?hceid=Z2FyeV9mcmF6ZXJAZndzLmdvdg.j94371c2hf8239h3s5vqmt8bv0>
Calendar downey_magallanes@ios.doi.gov
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Cc: angela_gustavson@fws.gov; barbara_wainman@fws.gov; matthew_huggler@fws.gov; gareth_rees@ios.doi.gov
Subject: Invitat on: Phone call: (Greg and Senator Tillis) re: advance notice ... @ Tue Jun 26, 2018 9:30am - 9:45am (EDT) (todd_willens@ os.doi.gov)
Attachments: invite.ics

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Phone call: (Greg and Senator Tillis) re: advance notice of the red wolf proposal - Rm 3358
Below is the schedule so far. There are still a few details being ironed out and I hope to send you a final clean schedule shortly. When you get a chance, can you please let me know what number Senator Burr should use to call Greg?
9:30 a.m - Senator Tillis
Call may include Todd Willens, TBD shortly
Senator's conference line [redacted]
10:00 a.m. - Congressman Rouzer
Call details TBD
10:45 a.m. - Senator Burr
Senator to call Greg a[redacted]
Thank you,
Alyssa

When Tue Jun 26, 2018 9:30am – 9:45am Eastern Time
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Meeting Agenda

06 Nov 2018
1:30PM EST at Pocosin Lakes NWR Offices in Columbia, NC

Meeting called by: Andrea Shipley

FWS/WRC Collaborative Management of AP Canids	Sara Schweitzer, WRC Wildlife Diversity Program Coordinator Andrea Shipley, WRC Mammalogist
Sympatric Canid Project Summary (Dec. 2017 – Nov. 2018)	Andrea Shipley, WRC Mammalogist Worth McAlister, WRC Wildlife Diversity Biologist
Next Steps	Worth McAlister, WRC Wildlife Diversity Biologist

- Implementation of Stationary GPS study
- Hiring seasonal staff (3-Month Temporary)
- Second field season collar deployment
- Continued monitoring of collared canids

Group Discussion	All

Project Summary:

In 2013, NCWRC and USFWS established a committee to oversee the collaborative management and conservation of sympatric canids on the AP. A USFWS and NCWRC joint memorandum documented detailed action items, including specific research objectives which this proposal seeks to address. As sympatric canids on the AP increase in number, monitoring their movements in relation to individuals of differing ancestry will provide important data to NCWRC and USFWS staff for science-based local and landscape-level decisions about sympatric canid populations and conflict management. Collection of finer temporal scale location data will help to manage interactions of sympatric canids with humans, as well as to support development of dynamic stochastic population models. At the end of this two-year pilot study, we will deliver a summary report detailing the use of the GPS and sensor technology for spatial and population dynamics research on sympatric canids on the AP.

From: maureen_foster@ios.doi.gov
To: casey_hammond@ios.doi.gov; jim_kurth@fws.gov; gary_frazer@fws.gov; charisa_morris@fws.gov; virginia_johnson@ios.doi.gov; tasha_robbins@ios.doi.gov; russell_roddy@ios.doi.gov; james_cason@ios.doi.gov
Cc: roslyn_sellars@fws.gov; jean_parrish@ios.doi.gov; thomas_irwin@fws.gov
Subject: Invitation: NOTE: New title and agenda items added -- Briefing on Pen... @ Thu Feb 9, 2017 4pm - 5pm (casey_hammond@ios.doi.gov)
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NOTE: New title and agenda items added -- Briefing on Pending ESA-Related Actions
Agenda:
-Notice of application for ESA sec 10 permit -- Hoopeston wind farm draft HCP
-ANPR and scoping notice -- revision to red wolf experimental population rule
-Comments on draft GAO report on ESA deadline lawsuits
-Invitation to speak at National Mitigation Banking Association meeting in March
-Heads up on separate upcoming briefings on litigation RE: Our recent habitat rules and an overview of the ESA
-Clearance of report to Congress on pesticide consultations
When Thu Feb 9, 2017 4pm – 5pm Eastern Time
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PLOS BIOLOGY

PERSPECTIVE

Carnivore conservation needs evidence-based livestock protection

Lily M. van Eeden[1☯]*, Ann Eklund[2☯]*, Jennifer R. B. Miller[3,4☯]*, José Vicente López-Bao[5], Guillaume Chapron[2], Mikael R. Cejtin[6,7], Mathew S. Crowther[1], Christopher R. Dickman[1], Jens Frank[2], Miha Krofel[8], David W. Macdonald[9], Jeannine McManus[10,11], Tara K. Meyer[12], Arthur D. Middleton[3], Thomas M. Newsome[1,13,14], William J. Ripple[14], Euan G. Ritchie[15], Oswald J. Schmitz[12], Kelly J. Stoner[16], Mahdieh Tourani[17], Adrian Treves[18☯]*

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Abstract

Carnivore predation on livestock often leads people to retaliate. Persecution by humans has contributed strongly to global endangerment of carnivores. Preventing livestock losses would help to achieve three goals common to many human societies: preserve nature, protect animal welfare, and safeguard human livelihoods. Between 2016 and 2018, four independent reviews evaluated >40 years of research on lethal and nonlethal interventions for reducing predation on livestock. From 114 studies, we find a striking conclusion: scarce quantitative comparisons of interventions and scarce comparisons against experimental controls preclude strong inference about the effectiveness of methods. For wise investment of public resources in protecting livestock and carnivores, evidence of effectiveness should be a prerequisite to policy making or large-scale funding of any method or, at a minimum, should be measured during implementation. An appropriate evidence base is needed, and

preparation of the manuscript. Carnegie Corporation of New York associated to the Global Change Institute to the University of Witwatersrand, Development Bank South Africa, Green Fund, United Nations Environment Program, and the Global Environment Facility. Received by JSM. The funder had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript. Swedish Research Council Formas. Received by AE, GC, JF, JVLB. The funder had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing interests: The authors have declared that no competing interests exist.

Provenance: Not commissioned; externally peer reviewed.

we recommend a coalition of scientists and managers be formed to establish and encourage use of consistent standards in future experimental evaluations.

Carnivores, such as lions and wolves, are killed in many regions over real or perceived threats to human interests. Combined with habitat loss and fragmentation, human-induced mortality has contributed to widespread carnivore population declines, along with declines of their important ecosystem functions [1]. Balancing the goals of nature preservation, livelihood protection, and welfare of carnivores and domestic animals depends on policies that foster coexistence between humans and carnivores in multiuse landscapes [2, 3]. Central to this aim is a need for rigorous scientific evidence that interventions are effective in preventing predation on livestock. Such policies should be based on strong inference [4, 5], otherwise, we risk wasting resources on ineffective interventions that might harm all involved.

Between 2016 and 2018, we independently published four reviews examining evidence for the effectiveness of interventions to reduce livestock predation by carnivores [6–9]. Here, we focus on the results for livestock losses or carnivore incursions into livestock enclosures (hereafter, "functional effectiveness" [8]). Since each review offered a unique perspective, we reconcile differences to synthesize three messages common to the reviews. First, despite the immense resources spent globally to protect livestock from carnivores, few peer-reviewed studies have produced strong inference about the functional effectiveness of interventions. Second, there was scant consistency of standards of evidence in our four reviews, hindering scientific consensus, and hence clear recommendations to policy-makers, about the relative functional effectiveness of different interventions. Finally, we identified several interventions that were found consistently effective, which deserve promotion in policy, even if only in the general conditions under which they have already been tested, as well as prioritization for further research under conditions in which evidence is lacking.

We suspect that the striking paucity of rigorous evaluation is due to the tendency for decisions about predator control to depend on factors other than evidence-based evaluation of whether a given intervention effectively protects livestock. These other factors—including ethics (should one implement the intervention?), feasibility (can one implement the intervention?), and perception (does one believe the intervention will work?)—might be important subsequent considerations in the implementation and decision-making processes. However, objective scientific evidence of an intervention's functional effectiveness must remain a foundational prerequisite on which subjective inquiries later build. The lack of scientific synthesis and consensus about functional effectiveness has allowed more subjective factors to dominate decision-making about predator control and likely wasted time and money on interventions that do not optimally protect livestock. Furthermore, shifting ethics and public values in some communities are enabling the return of carnivores to landscapes worldwide or leading to the increased use of nonlethal predator control interventions. We support these initiatives from the perspective of conserving carnivores but insist that scientific evidence for functional effectiveness be considered first to ensure that interventions intended to protect livestock accomplish that goal. This will prevent the inefficient—or worse yet, counterproductive—use of limited resources to protect animals long term.

Additionally, although our reviews collectively reveal a need for more evidence, scientists alone cannot fill this gap. Livestock owners, natural resource managers, and decision-makers each have an important role to play in research partnerships to collaboratively guide the testing of predator control interventions. Here, we appeal to these groups by summarizing the

advantages of evidence-based effective interventions, the best practices of scientific inference, and the role of policy in promoting effective predator control strategies. We start by synthesizing the results of our four independent reviews to provide scientific consensus on the evaluations of predator control interventions. We urge managers and policy decision-makers to use this discussion as a basis for creating policy that promotes evidence-based, effective strategies for protecting domestic animals from carnivore predation.

Synthesis of the science on functional effectiveness

Our four reviews [6–9] jointly screened >27,000 candidate studies. The four sets of inclusion criteria differed in geographic coverage, carnivore species, and standards of evidence and research design (see S1 Table), which limited overlap in the studies that passed screening (only 19% of studies were included in two or more of the four reviews; no study was included in all four, S1 Fig). The differing inclusion criteria also meant that it was not possible to conduct a quantitative comparison (meta-analysis) combining the data from our four reviews, but we suggest that such an analysis should be conducted in the future as evidence increases. Nonetheless, our reviews came to remarkably similar conclusions, irrespective of methods, suggesting that our conclusions are robust.

Among the 114 studies that passed screening in one or more reviews (S2 Table), representing >40 years of research, we found few that yielded strong inference about functional effectiveness. Surprisingly, many widely used methods have not been evaluated using controlled experiments. Also, few interventions have been compared side by side or tested singly under diverse conditions. These deficiencies in the literature are further compounded by disagreement among scientists, managers, and peer-reviewed journals about standards of evidence, such as which study designs produce strong inference [8]. We acknowledge the challenges of regional experiments amid dynamic, complex ecologies, publics, and jurisdictions. However, a handful of random-assignment experimental studies without bias ("gold standard") have proven that the obstacles are surmountable [8, 10, 11, 12].

We summarize our four sets of results by category of intervention in Fig 1. Our reviews agree that several methods have been tested numerous times with high standards of evidence and have been found effective: livestock guardian animals, enclosures for livestock, and a visual deterrent called fladry. Importantly, we should recognize that the effectiveness of different methods will vary under different contexts, and there is currently a bias among research toward certain geographic regions and predator types (Fig 2). Further, we agree that standards of evidence have been higher for nonlethal methods, and there remains a need to ensure data on all interventions are collected appropriately and consistently. As such, building on existing criticism of the lack of appropriate data collection in environmental management [13–16], our reviews collectively highlight the need to improve standards of evidence used in evaluating interventions. We need to develop a comprehensive evidence base that allows us to compare the effectiveness of interventions for reducing carnivore predation on livestock and inform consistent policy in any jurisdiction.

Importance of rigorous experimental design and evaluation

Societal values and, accordingly, policies for human–carnivore coexistence have changed over the millennia. The almost exclusive use of lethal interventions has given way to nonlethal interventions as important supplements to or replacements for prior lethal methods. Immense logistical and financial resources are invested in protecting livestock and carnivores, so the scarcity of rigorous scientific evidence for effectiveness should be a concern. We encourage governments to adopt proven methods from similar systems of carnivores and human

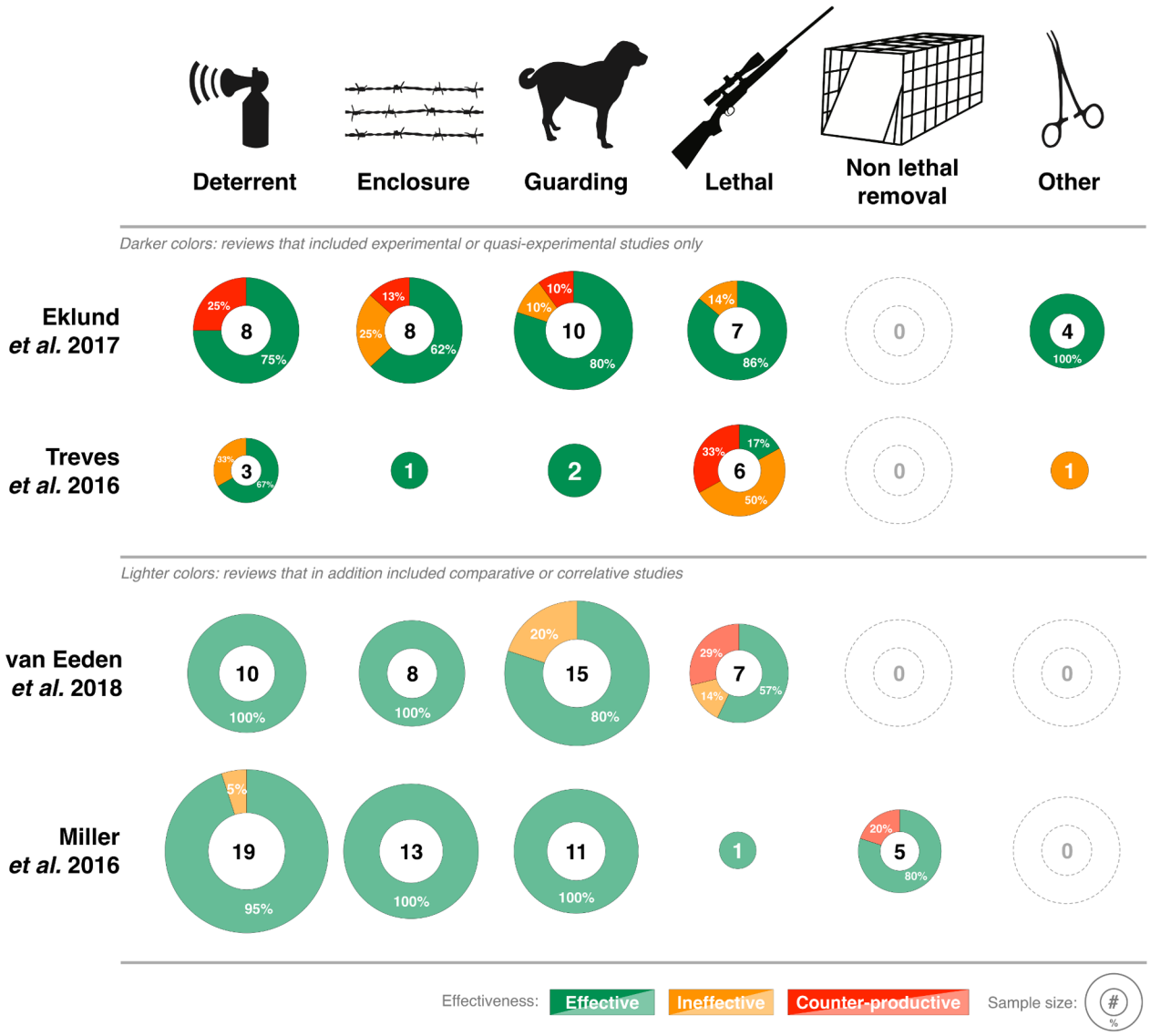


Fig 1. Percent of studies that measured interventions as "Effective," "Ineffective," or "Counter-productive" in reducing livestock loss to large carnivores, as measured by four independent reviews in 2016–2018. The sample sizes inside disks represent the number of studies or tests, as some studies reported more than one test of the same or different interventions. Darker colors represent reviews that included experimental or quasiexperimental controls; lighter colors represent reviews that also included comparative or correlative studies (see S1 Table for details). "Deterrents" include nonlethal interventions such as audio or visual deterrents, fladry, and livestock protection collars. "Enclosure/barrier" includes electrified and nonelectrified fencing and corralling. "Guarding" includes human shepherding and livestock guardian animals. "Lethal removal" includes hunting, poison baiting, and other lethal methods. "Non-lethal removal" refers to translocation of carnivores. "Other" includes carnivore sterilization and diversionary feeding. Eklund and colleagues measured effectiveness using RR and classified Effective as RR < 0.90, Ineffective = 0.90–1.10, and Counterproductive RR > 1.10. Treves and colleagues measured effectiveness as significant change in livestock loss. Note that Treves and colleagues initially contained 12 studies with 14 separate tests using gold or silver standards, but one test was subsequently removed after review of the methods found it impossible to draw strong inference [17]. van Eeden and colleagues measured effectiveness as Hedges' d and classified Effective as $d < -0.05$, Ineffective $-0.05 > d < 0.05$, and Counterproductive $d > 0.05$. Miller and colleagues measured effectiveness as percentage change in livestock loss (or carnivore behavior change) and classified Effective as $d > 0\%$ change, Ineffective = 0%, and Counterproductive $< 0\%$. RR, relative risk.

https://doi.org/10.1371/journal.pbio.2005577.g001

interests, with systems in place to review and adapt management actions as new evidence becomes available. When governments contemplate large-scale implementation or funding for interventions, scientific evidence of functional effectiveness deserves priority to avoid wasting

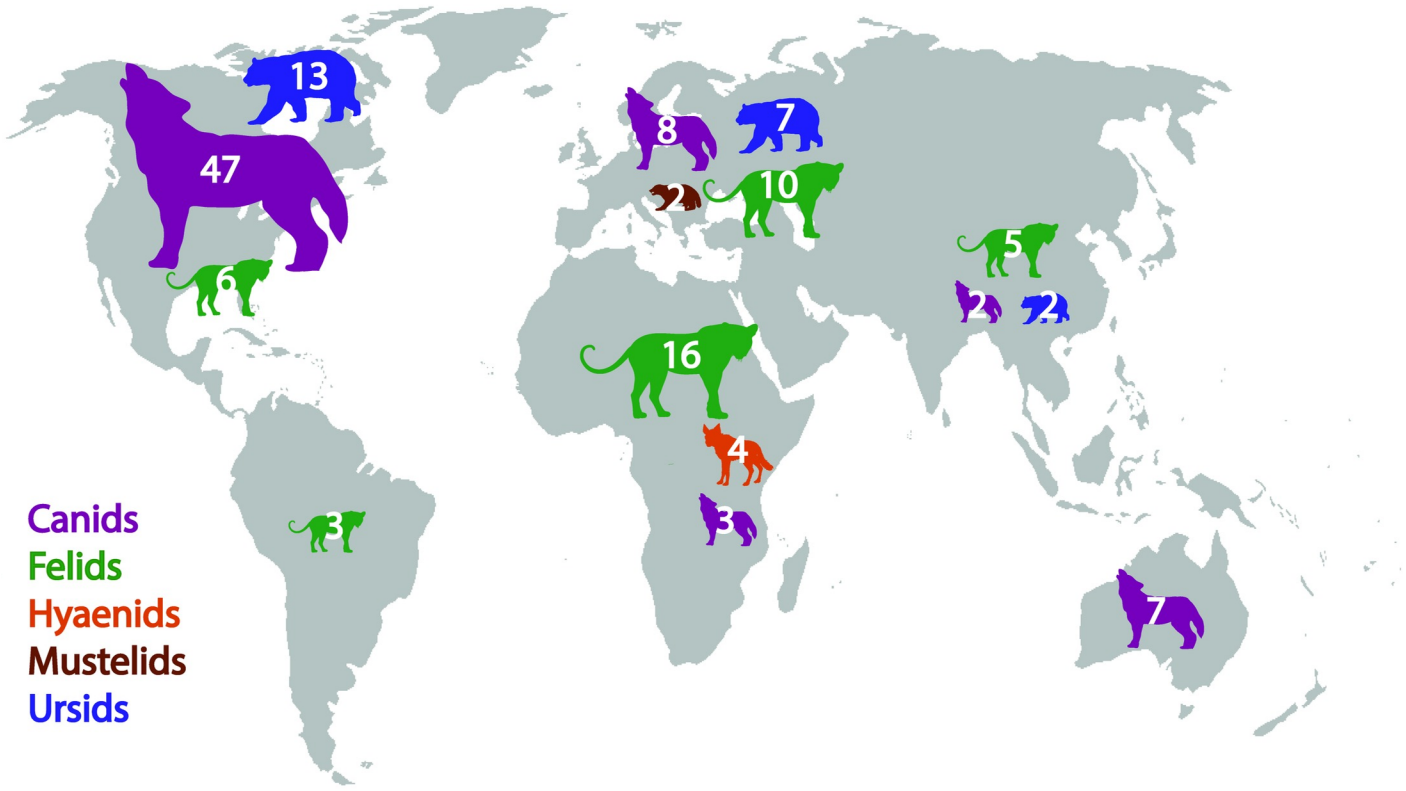


Fig 2. Number of studies included in four independent reviews published in 2016–2018, presented by carnivore family and continent. Canids include gray wolves and subspecies (*Canis lupus*), coyotes (*C. latrans*), dingoes (*C. dingo*), black-backed jackals (*C. mesomelas*), African wild dogs (*Lycaon pictus*), red foxes (*Vulpes vulpes*), and domestic dogs (*C. familiaris*). Felids include Eurasian lynx (*Lynx lynx*), cougars (*Puma concolor*), lions (*Panthera leo*), jaguars (*P. onca*), leopards (*P. pardus*), snow leopards (*P. uncia*), caracals (*Caracal caracal*), and cheetahs (*Acinonyx jubatus*). Hyaenids include spotted hyenas (*Crocuta crocuta*). Mustelids feature wolverines (*Gulo gulo*). Ursids include American black bears (*Ursus americanus*), Asiatic black bears (*U. thibetanus*), brown or grizzly bears (*U. arctos*), and polar bears (*U. maritimus*). Smaller carnivores (e.g., red foxes, hyenas, and caracals) are included in studies that investigated multiple carnivore species of varying sizes.

https://doi.org/10.1371/journal.pbio.2005577.g002

resources on ineffective methods, no matter if the latter are ethical or easy to implement. When no proven method is available, scientific evaluation of functional effectiveness should coincide with implementation.

Strong inference in any scientific field demands control over potentially confounding variables and testable claims about functional effectiveness of interventions [8]. In our context, all methods present opposable hypotheses, i.e., method X works or does not work. Several experimental design components are essential to strong inference about that hypothesis, and we focus here on the three of topmost priority for yielding strong inference about livestock protection interventions: controls, randomization, and replication.

The strongest inference results from experiments that achieve the "gold standard" through "random assignment to control and treatment groups without bias (systematic error) in sampling, treatment, measurement, or reporting" [8]. This requires that an intervention be used to protect a livestock herd (treatment) and that its effectiveness is compared against a livestock herd that is not exposed to the intervention (placebo control). Both treatment and control should be replicated using multiple independent herds of livestock that are distributed so that the effects of treatment on one herd do not confound the effects on another herd, which would eliminate independence. Random assignment of treatments avoids sampling or selection bias that is common in our field [8], as in others [18]. Implementing random assignment for actual

livestock herds can be challenging, but several studies have succeeded, such as those conducted by Davidson-Nelson and Gehring [10] and Gehring and colleagues [11]. In the Chilean altiplano, 11 owners of alpacas (*Vicugna pacos*) and llamas (*Lama glama*) joined a randomized reverse treatment (crossover) experiment to evaluate light devices in deterring carnivores [12]. Moreover, if large numbers of replicates are infeasible or replicates are unavoidably heterogeneous, then crossover, reverse treatment designs should help to increase the strength of inference about interventions [8, 12, S2 Table].

"Silver standard" designs provide weaker inference because of nonrandom assignment to treatment and then repeated measures of the replicate at two or more time points (before-and-after comparison of impact or quasiexperimental designs, also called case control). Both time passing and the treatment might explain changes in replicates, in addition to the extraneous "nuisance" variables present in agro-ecosystems at the outset [8].

The weakest standard of evidence is the correlative study, which compares livestock predation among herds that varied haphazardly in past protection or varied systematically if people intervened only where livestock had died. In correlational studies, confounding variables inevitably create selection or sampling bias. Although correlative studies may be useful as an initial exploratory step and help direct further research, confidence in their findings should be low, especially if there is large variation in the results. Correlative studies cannot substitute for the silver or gold standards described above.

Implementation of interventions must be consistent to avoid treatment bias. For example, the functional effectiveness of livestock-guarding dogs might vary with breed, individual, training, and maintenance of the dog. Likewise, tests of lethal methods have never controlled the simultaneous use of several methods of intervention (e.g., pooling shooting and trapping as one treatment), which is inadvisable for strong inference. Consistent maintenance of interventions throughout a study should also minimize treatment bias [18].

Well-designed experiments should incorporate evaluation along multiple dimensions. Was the intervention implemented as planned? Did attacks on livestock diminish? Measurement bias arises from systematic error in documenting implementation or losses in treatment or response variables. As in biomedical research, which sometimes uses patient self-reports as a subjective measure of effectiveness alongside objective measures of health outcomes, there are valid reasons to measure owners' perceptions of effectiveness of interventions. In human–wildlife interactions, people's attitudes can influence the adoption or rejection of interventions independently of scientific evidence [14,19]. Several of the reviews included metrics of perceived effectiveness among livestock owners, yet perception alone is not a reliable measure of functional effectiveness because of widespread placebo effects, whereby patients feel better simply because they have participated. Studies should therefore either "blind" their participants or use an independent, verifiable measure of effectiveness (i.e., livestock loss).

We recognize that gold or silver standards may be difficult to achieve. Systematic errors can be difficult to eliminate entirely, so we urge careful consideration of methods during the design process, including peer review prior to initiation. Ethical considerations about exposing animals to lethal risks may limit experimental designs. This inherent difficulty for controlled experiments may explain why some published experiments were completed in artificial settings (e.g., using captive carnivores or measuring bait consumption rather than livestock loss). Although most of our reviews omitted experiments for protecting property other than livestock, strong inference from such studies merit tests for livestock protection. Nonetheless, given that several examples of gold standard experiments overcame the complexities of people and wild ecosystems [5, 10, 11, 12], we urge greater effort and recommend government support and accolades for the highest standards of experimentation.

Incorporating science into conflict mitigation and conservation

Many governments have institutionalized support for livestock protection from predators and implemented various interventions at landscape scales. The European Council Directive 98/58/EC, concerning protection of animals kept for farming purposes, states that "animals not kept in buildings shall where necessary and possible be given protection from adverse weather conditions, predators and risks to their health." The Swedish Animal Welfare Act of 1988 mandates care should be given to injured animals as soon as possible. This obligation is in practice relevant subsequent to carnivore attacks. When trained field observers confirm livestock attacks by large carnivores, they also implement rapid response interventions, such as fladry and portable electric fences, to prevent recurrent attacks [20]. In the United States, in 2013 alone, the US Department of Agriculture killed >75,000 coyotes, 320 gray wolves (*Canis lupus*), and 345 cougars (*Puma concolor*) [21]. Similarly, in some Australian states, landowners and managers are required by law to actively control dingoes (*C. dingo*) on their property.

Given the weak state of current evidence about effectiveness, decisions to use interventions are most likely based on subjective factors (e.g., ethics, opinions, or perceptions) or nonscientific (and thus possibly biased) evidence. For example, many people have deeply rooted perceptions that an intervention is effective or not [19]. Therefore, research, promoted by policy, is needed to validate that perceptions align with measurable and scientifically defensible outcomes [14]. This is especially crucial in cases of lethal interventions, which entail multiple drawbacks, including ethical criticisms and the potential to hasten carnivore declines and impede population recoveries.

However, scientists alone cannot transform policies for implementation. The pursuit of science-based management must be truly interdisciplinary and involve carnivore ecologists, animal husbandry scientists, social scientists, natural resource managers, ethicists, and other scholars and practitioners. Political leaders can also play a role to prioritize, coordinate, and fund partnerships across government agencies and nongovernment organizations. Because we anticipate continued debate over the standards of effectiveness, we recommend a coalition be formed to clearly distinguish standards for evaluation and experimental protocols, which would be distinct from coalitions convened to consider local factors that affect decisions. Through collaboration, scientists, managers, and policy leaders can help to protect livestock within healthy ecosystems that include carnivores. Constituents worldwide increasingly support the restoration of carnivore populations and accordingly are calling for human–carnivore coexistence and minimizing conflicts [2]. Enabling coexistence through evidence-based solutions will give the public strong confidence in methods promoted by scientists and governments, particularly when implementation is difficult or the ethics are controversial.

Supporting information

S1 Table. Methods used by authors' reviews. Methods have been simplified for comparison. Refer to the original articles for a full account of methods used and justification for the use of these methods.
(DOCX)

S2 Table. Studies included in the four reviews.
(DOCX)

S1 Fig. Overlap of studies included in each of the four independent reviews that evaluated evidence of functional effectiveness of interventions in reducing carnivore attacks on livestock.
(TIF)

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From: Todd Willens
To: greg_j_sheehan@fws.gov; Maureen D. Foster
Subject: Predator document
Date: Tuesday, September 5, 2017 10:51:34 PM

I read the document. Does Downey want foreign species? I thought the topic was to be focused on domestic only. If so, we can scale back.

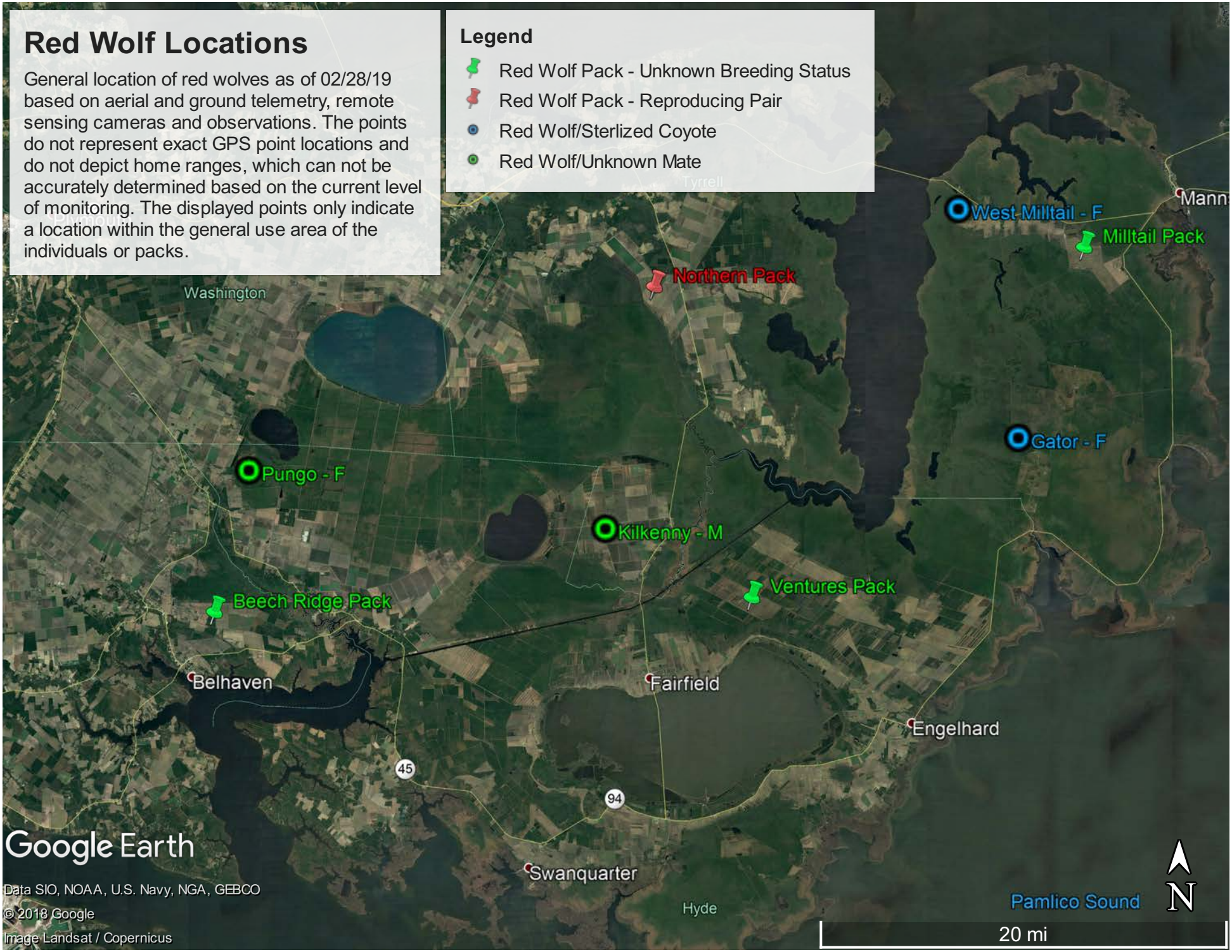
On Mexican wolf and red wolf, (b) (5) DPP(b) (5) DPP(b) (5) DPP (b) (5) DPP(b) (5) DPP(b) (5) DPP(b) (5) DPP. New Mexico has sued to stop reintroductions, and does not participate in the recovery team. Earlier this year, FWS agreed to terms limited reintroduction.

North Carolina has sued on red's and opposed reintroduction, correct?

What about Florida Panther and reintroduction.

Are there other prospective predator reintroductions planned?

Todd Willens
Assistant Deputy Secretary
Acting Assistant Secretary for Fish and Wildlife and Parks
U.S. Department of the Interior
1849 C Street, NW - MIB Room 6116
Washington, DC 20240


Red Wolf Locations
General location of red wolves as of 02/28/19 based on aerial and ground telemetry, remote sensing cameras and observations. The points do not represent exact GPS point locations and do not depict home ranges, which can not be accurately determined based on the current level of monitoring. The displayed points only indicate a location within the general use area of the individuals or packs.
Legend
Red Wolf Pack - Unknown Breeding Status
Red Wolf Pack - Reproducing Pair
Red Wolf/Sterlized Coyote
Red Wolf/Unknown Mate
Tyrrell
Mann
West Milltail - F
Milltail Pack
Northern Pack
Washington
Gator - F
Pungo - F
Kilkenny - M
Ventures Pack
Beech Ridge Pack
Belhaven
Fairfield
Engelhard
45
94
Swanquarter
Hyde
Pamlico Sound
N
20 mi
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2018 Google
Image Landsat / Copernicus

From: Willens, Todd
To: Greg Sheehan; Olivia Ferriter
Subject: Fwd: FWS ESA Capability Statements
Date: Thursday, October 12, 2017 6:07:59 PM
Attachments: S-FWS - 8 - ES Red Wolves Report Language_Final.docx
S-FWS - 25 - ES Red Wolves Bill Language_Final.docx

Greg,

I read this as not being consistent with our policy on red wolves. Can you please edit and resubmit to Olivia to reflect where we are on this issue. Thank you

"This language would bar the Service from carrying out any of the responsibilities associated with implementing the provisions of the non-essential experimental red wolf population rule, which provides management flexibility and authorizes take for management purposes, depredation, and nuisance behaviors. Under the ESA an experimental population designation provides more management flexibility to accommodate landowners than does a normal listing. Thus, this language would prohibit the Service from providing landowners in eastern North Carolina regulatory relief as intended by the rule. "

Todd Willens
Assistant Deputy Secretary
Acting Assistant Secretary for Fish and Wildlife and Parks
U.S. Department of the Interior
1849 C Street, NW -- MIB Room 6116
Washington, DC 20240
office: 202-208-6291

NOTE: *Every email I send or receive is subject to release under the Freedom of Information Act.*

Capability Number: S-FWS-8

Department of the Interior
FY 2018—Capability Statement

Bureau: Fish and Wildlife Service
Appropriation: Resource Management
Activity/Subactivity: Ecological Services/Recovery

Proposed Report Language:

The Committee acknowledges the North Carolina Wildlife Resources Commission request that the United States Fish and Wildlife Service end the Red Wolf Recovery Program and declare the red wolf extinct. Furthermore, the Committee agrees that the Red Wolf Recovery Program, since its establishment, has failed to meet the population recovery goals for the red wolf and that the program has negatively affected North Carolina landowners and the populations of several other native species. The Committee expects the United States Fish and Wildlife Service to end this failed program during fiscal year 2018.

Proposed By: Senate Appropriations

Amount Enacted for Project/Program for FY 2017:
Amount Budgeted for Project/Program for FY 2018:

Effect of Proposed Amendment:
1. What would the funding in the proposed amendment be used for?

No funding is provided. The red wolf was originally listed as a species threatened with extinction under the Endangered Species Preservation Act of 1966 (32 FR 4001; March 11, 1967). This species is currently listed as an endangered species under the Endangered Species Act of 1973, as amended (Act) (16 U.S.C. 1531 *et seq.*).

Historically, the red wolf range included Texas and Louisiana to the Ohio River Valley and up the Atlantic Coast into northern Pennsylvania or southern New York, and perhaps further north. However, by the mid-1970s, the only remaining population occurred in southeastern Texas and southwestern Louisiana (Wildlife Management Institute 2014).

In 1975, the decision was made to capture as many wild animals as possible and place them in a secured captive-breeding program. This decision was based on the critically low numbers of animals left in the wild, poor physical condition of those animals due to disease and internal and external parasites, the threat posed by an expanding coyote (*Canis latrans*) population, and consequent inbreeding problems.

In 1986, a final rule to introduce red wolves into Alligator River National Wildlife Refuge (Alligator River), Dare County, North Carolina, was published in the Federal Register (51 FR 41790, November 19, 1986). In 1991, a revision to the rule added Beaufort County to the counties where the experimental population designation would apply (56 FR 56325, November

4, 1991). Today, the only population of red wolves in the wild is the NEP established around Alligator River in North Carolina. All other individuals of this species are found in captive facilities around the country.

In 2013, acknowledging growing concerns from private landowners regarding management of the NEP, the Service and North Carolina Resources Commission entered into a broad canid management agreement, recognizing steps were needed to improve management of the population. Subsequently, the Service contracted an independent evaluation of the NEP project in 2014 and of the entire red wolf recovery program in 2015. From these evaluations, it became clear that the current direction and management of the NEP project is unacceptable to the Service and all stakeholders. Risks of continued hybridization, human-related mortality, continued loss of habitat due to sea level rise, and continued population decline are high and have led to poor prospects for the NEP.

As a result of the findings from the evaluations, the Service is considering a potential revision of the 1995 NEP final rule. Scoping for this proposal took place in the summer of 2017.

2. Feasibility/capability of the proposed funding level or language this fiscal year?

The Service has a process underway to revise the program for red wolves. This provision would halt that process and other efforts to recover red wolves.

3. Is the program/project ranked on existing priority setting systems?

Funding for the Service's programs is subject to a careful priority setting process.

Outlay Effect:

FY 2018:	$0
FY 2019:	$0

Note: *Submission of this capability statement does not reflect Departmental support for the proposed amendment. The Department does not support the addition of funds for any program or project that would result in the reduction of funding for other programs or projects in the President's Budget.*

Capability Number: S-FWS-25

Department of the Interior
FY 2018—Capability Statement

Bureau: Fish and Wildlife Service
Appropriation: Resource Management
Activity/Subactivity: Ecological Services/Recovery

Proposed Bill Language:

None of the funds appropriated or otherwise made available by the Act may be used by the Department of the Interior of the United States Fish and Wildlife Service to implement 50 CFR 17.84(c).

Proposed By: Senate Appropriations

Amount Enacted for Project/Program for FY 2017:
Amount Budgeted for Project/Program for FY 2018:

Effect of Proposed Amendment:

1. What would the funding in the proposed amendment be used for?

No funding is provided. The red wolf was originally listed as a species threatened with extinction under the Endangered Species Preservation Act of 1966 (32 FR 4001; March 11, 1967). This species is currently listed as an endangered species under the Endangered Species Act of 1973, as amended (Act) (16 U.S.C. 1531 *et seq.*).

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As a result of the findings from the evaluations, the Service is considering a potential revision of the 1995 NEP final rule. Scoping for this proposal took place in the summer of 2017.

This language would bar the Service from carrying out any of the responsibilities associated with implementing the provisions of the non-essential experimental red wolf population rule, which provides management flexibility and authorizes take for management purposes, depredation, and nuisance behaviors. Under the ESA an experimental population designation provides more management flexibility to accommodate landowners than does a normal listing. Thus, this language would prohibit the Service from providing landowners in eastern North Carolina regulatory relief as intended by the rule.

2. Feasibility/capability of the proposed funding level or language this fiscal year?

The Service has a process underway to revise the program for red wolves. This provision would halt that process and other efforts to recover red wolves.

3. Is the program/project ranked on existing priority setting systems?

Funding for the Service's programs is subject to a careful priority setting process.

Outlay Effect:

FY 2018:	$0
FY 2019:	$0

Note: *Submission of this capability statement does not reflect Departmental support for the proposed amendment. The Department does not support the addition of funds for any program or project that would result in the reduction of funding for other programs or projects in the President's Budget.*

From: Gustavson, Angela
To: Angela Gustavson
Subject: Congressional Affairs Update
Date: Friday, June 15, 2018 4:53:19 PM
Attachments: 6.15.18.docx

Good afternoon,

The Congressional Affairs Update for this week is attached.

- This week, the Service testified at a House Natural Resources field hearing in Michigan on management of cormorants in the Great Lakes region.
- The Senate continued debate on the NDAA and is scheduled to vote on final passage of the bill next week.
- The Senate Agriculture Committee approved the Farm bill this week.
- The House Natural Resources Committee approved legislation that would adopt nearly all of the Coastal Barrier Resources System digital pilot project maps.
- The Senate Appropriations Committee approved the FY 2019 Interior appropriations bill.
- Next week, the Service will testify at a Senate Indian Affairs oversight hearing on subsistence activities.

Have a good weekend,

Angela

Angela Gustavson
Deputy Chief
Division of Congressional and Legislative Affairs
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CONGRESSIONAL AFFAIRS UPDATE

Division of Congressional and Legislative Affairs
U.S. Fish and Wildlife Service

June 15, 2018

2018 Congressional Recess Schedule

Senate	*Holidays & Special Days*	*House*
State Work Period July 2-July 6	**Independence Day** July 4	**District Work Period** July 2-July 6
State Work Period Aug. 6-Aug. 10	**Labor Day** Sep. 3	**District Work Period** July 30-Sep. 3
Sep. 10-Sep. 11	**Rosh Hashanah**	Sep. 10-Sep. 11
Sep. 19	**Yom Kippur**	**District Work Period** Sep. 17-Sep. 21
Oct. 8	**Columbus Day**	Oct. 8
State Work Period Oct. 29-Nov. 12	**Veterans Day** Nov. 12 (observed)	**District Work Period** Oct. 15-Nov. 9
State Work Period Nov. 19-Nov. 23	**Thanksgiving Day** Nov. 22	**District Work Period** Nov. 19-Nov. 23
	Targeted Adjournment Date Dec. 14	

UPDATES ON LEGISLATION OF INTEREST

Senate Continues Debate on NDAA

This week, the Senate continued floor debate on H.R. 5515, the National Defense Authorization Act (NDAA) for FY 2019. The Senate passed a substitute amendment that contains the text of the Senate version of the NDAA, S. 2987, the John S. McCain NDAA for FY 2019, plus more than forty amendments. Neither S. 2987, nor any of the adopted amendments contain provisions of interest to the Service. The Senate is scheduled to vote on final passage on the legislation on Monday, June 18. It will then be conferenced with the House version, which contains several provisions of interest to the Service.

For more information, please visit:
https://www.senate.gov/legislative/LIS/floor_activity/floor_activity.htm

HEARINGS AND MARKUPS OF INTEREST

FWS Testifies at Field Hearing on Cormorant Depredation

On Monday, June 11, the House Committee on Natural Resources held an oversight field hearing in Alpena, Michigan titled "Examining Effects of Mismanagement of the Cormorant in the Great Lakes Region." Tom Cooper, Chief of the Migratory Bird Program for the Midwest Region, testified on behalf of the Service.

For more information, please visit:
https://naturalresources.house.gov/calendar/eventsingle.aspx?EventID=404825

Senate Appropriations Committee Approves Interior Budget for FY 19

On Thursday, June 14, the Senate Appropriations Committee held a full committee markup of legislation to fund the Department of the Interior for Fiscal Year 2019. The bill passed out of Committee by unanimous consent. The bill would fund the Service at $1.6 billion. Important program increases include funding for the State and Tribal Wildlife Grants and the North American Wetlands Conservation Act. The bill also provides funds to support FWS implementation of the RESTORE Act and to maintain continued operation of fish hatcheries. The bill continues the prohibition on listing the greater sage-grouse as an endangered species.

For more information, please visit:
https://www.appropriations.senate.gov/news/senate-appropriations-schedule-for-the-week-of-june-11-2018

Senate Committee Approves 2018 Farm Bill

On Wednesday, June 13, the Senate Committee on Agriculture marked up S. 3042, the Agriculture Improvement Act of 2018, aka, the Farm Bill. The bill was approved by a vote of 20-1, and included a substitute amendment and package of over 60 amendments as part of a manager's package. Other amendments of interest to the Service considered during the markup included:

- An amendment offered by **Senator Steve Daines (R-MT)** identical to his bill, S. 605, the Litigation Relief for Forest Management Projects Act, was withdrawn.
- An amendment offered by **Senator Amy Klobuchar (D-MN)** that allows governors to opt into the Sodsaver initiative was agreed to by voice vote.
- An amendment offered by **Senator Patrick Leahy (D-VT)** that provides more time for livestock and dairy farmers to complete their whole farm plans for the Environmental Quality Incentives Program passed by voice vote.
- An amendment offered by **Senator John Thune (R-SD)** that changes the Conservation Reserve Program to increase acreage and allow for more haying and grazing flexibility was withdrawn.

For more information, please visit:
https://www.agriculture.senate.gov/hearings/business-meeting-6-13-18

House Committee Approves Coastal Barrier Resources System Legislation

On Wednesday, June 13, the House Committee on Natural Resources held a markup of five bills, one of which is of interest to the Service. H.R. 5787, sponsored by **Representative Neal Dunn (R-FL-2)**, adopts nearly all of the Coastal Barrier Resources System digital pilot project maps. **Representatives Doug Lamborn (R-CO-5)** and **Alan Lowenthal (D-CA-47)** both spoke favorably of the bill and the CBRS in general. They also cited the collaborative effort with the Service and affected members of Congress. The bill passed out of Committee with a technical amendment by voice vote.

For more information, please visit:
https://naturalresources.house.gov/calendar/eventsingle.aspx?EventID=404920

UPCOMING HEARINGS AND MARKUPS

FWS to Testify at Subsistence Hearing in Senate Indian Affairs Committee
On Wednesday, June 20, the Senate Committee on Indian Affairs will hold an oversight hearing to discuss traditional subsistence activities in Native communities entitled "Keep What You Catch: Promoting Traditional Subsistence Activities in Native Communities." Jennifer Hardin, Subsistence Policy Coordinator at the Office of Subsistence Management, will testify on behalf of the Service. The hearing is scheduled for 2:30 p.m. in 628 Dirksen Senate Office Building.

For more information, please visit:
https://www.indian.senate.gov/hearing/oversight-hearing-keep-what-you-catch-promoting-traditional-subsistence-activities-native

Subcommittee to Examine Trade and Commerce at U.S. Ports
On Wednesday, June 20, the Senate Finance Subcommittee on International Trade, Customs, and Global Competitiveness will hold an oversight hearing titled, "Trade and Commerce at U.S. Ports of Entry". The hearing is scheduled for 2:30 p.m. in 215 Dirksen Senate Office Building.

For more information, please visit:
https://www.finance.senate.gov/hearings/trade-and-commerce-at-us-ports-of-entry

Subcommittee to Examine Federal Regulations and U.S. Agriculture
On Thursday, June 21, the House Small Business Subcommittee on Agriculture, Energy, and Trade will hold an oversight hearing titled, "Accelerating Agriculture: How Federal Regulations Impact America's Small Farmers". The hearing is scheduled for 10:30 a.m. in 2360 Rayburn House Office Building.

For more information, please visit:
https://smallbusiness.house.gov/calendar/eventsingle.aspx?EventID=400964

INTRODUCED LEGISLATION OF INTEREST

H.R.6119 — To remove the red wolf from the list of endangered and threatened wildlife for North Carolina, and for other purposes.
Sponsor: Rep. Rouzer, David [R-NC-7] (Introduced 06/14/2018) Cosponsors: (0)
Committees: House - Natural Resources
Latest Action: House - 06/14/2018 Referred to the House Committee on Natural Resources

H.R.6106 —To amend the Energy Policy Act of 2005 to clarify the authorized categorical exclusions and authorize additional categorical exclusions to streamline the oil and gas permitting process, and for other purposes.
Sponsor: Rep. Pearce, Stevan [R-NM-2] (Introduced 06/14/2018) Cosponsors: (5)

Committees: House - Natural Resources
Latest Action: House - 06/14/2018 Referred to the House Committee on Natural Resources

H.R.6103 — To establish a national commission on the Federal response to the 2017 natural disasters in Puerto Rico, and for other purposes.
Sponsor: Rep. Velazquez, Nydia M. [D-NY-7] (Introduced 06/14/2018) Cosponsors: (15)
Committees: House - Transportation and Infrastructure
Latest Action: House - 06/14/2018 Referred to the House Committee on Transportation and Infrastructure

S.3076 — A bill to establish a national commission on the Federal response to the 2017 natural disasters in Puerto Rico, and for other purposes.
Sponsor: Sen. Gillibrand, Kirsten E. [D-NY] (Introduced 06/14/2018) Cosponsors: (6)
Committees: Senate - Homeland Security and Governmental Affairs
Latest Action: Senate - 06/14/2018 Read twice and referred to the Committee on Homeland Security and Governmental Affairs.

S.3073 — Department of the Interior, Environment, and Related Agencies Appropriations Act, 2019
Sponsor: Sen. Murkowski, Lisa [R-AK] (Introduced 06/14/2018) Cosponsors: (0)
Committees: Senate - Appropriations
Committee Reports: S. Rept. 115-276
Latest Action: Senate - 06/14/2018 Placed on Senate Legislative Calendar under General Orders. Calendar No. 452.

H.R.6087 —To authorize the Secretary of the Interior to recover the cost of processing administrative protests for oil and gas lease sales, applications for permits to drill, and right of way applications, and for other purposes.
Sponsor: Rep. Cheney, Liz [R-WY-At Large] (Introduced 06/13/2018) Cosponsors: (4)
Committees: House - Natural Resources
Latest Action: House - 06/13/2018 Referred to the House Committee on Natural Resources.

S.Res.544 —A resolution celebrating June 11, 2018, as the 20th anniversary of the establishment of the United States Coral Reef Task Force.
Sponsor: Sen. Hirono, Mazie K. [D-HI] (Introduced 06/12/2018) Cosponsors: (5)
Latest Action: Senate - 06/12/2018 Submitted in the Senate, considered, and agreed to without amendment and with a preamble by Unanimous Consent

H.Res.929 —Recognizing World Oceans Day and the necessity to protect, conserve, maintain, and rebuild the ocean and its resources.
Sponsor: Rep. Bonamici, Suzanne [D-OR-1] (Introduced 06/08/2018) Cosponsors: (20)
Committees: House - Natural Resources, Science, Space, and Technology
Latest Action: House - 06/08/2018 Referred to the Committee on Natural Resources, and in addition to the Committee on Science, Space, and Technology

H.R.6064 —To rename the Oyster Bay National Wildlife Refuge as the Congressman Lester Wolff National Wildlife Refuge.
Sponsor: Rep. Suozzi, Thomas R. [D-NY-3] (Introduced 06/08/2018) Cosponsors: (0)
Committees: House - Natural Resources
Latest Action: House - 06/08/2018 Referred to the House Committee on Natural Resources.

From: Gustavson, Angela
To: Angela Gustavson
Subject: Congressional Meeting Memo
Date: Monday, February 27, 2017 4:55:19 PM
Attachments: MM February 27.docx

Good afternoon,

The Congressional Meeting Memo for this week is attached.

Angela

Angela Gustavson
Deputy Chief
Division of Congressional and Legislative Affairs
U.S. Fish and Wildlife Service
Office: 703-358-2253
Mobile: 202-909-5105
angela_gustavson@fws.gov

U.S. FISH AND WILDLIFE SERVICE
MEETING MEMO

Week of February 27, 2017

BRIEFINGS/MEETINGS

Monday, February 27

Mitch Ellis (Refuge Chief, Alaska Region), **Sara Boario** (Assistant Regional Director for External Affairs), **Ryan Noel** (Special Agent, Alaska Region), and **Amee Howard** (CLA, Alaska Region) will meet with *Mike DeFilippis, staff for Representative Don Young (R-AK),* as a courtesy. The meeting is scheduled for 1:00 p.m. in 2314 Rayburn House Office Building.

Sara Boario (Assistant Regional Director for External Affairs) and **Amee Howard** (CLA, Alaska Region) will meet with *Isaac Edwards, majority staff of the Senate Committee on Energy and Natural Resources,* as a courtesy and to discuss partnerships in Alaska. The meeting is scheduled for 2:00 p.m. in 204 Dirksen Senate Office Building.

Scott Kahan (Refuge Chief, Northeast Region), **Sharon Marino** (Deputy Regional Refuge Chief), and **Merra Howe** (CLA) will meet with *Matt Moran, staff for Representative Frank LoBiondo (R-NJ),* as a courtesy and to provide updates on Edwin B. Forsythe National Wildlife Refuge. The meeting is scheduled for 3:00 p.m. in 2427 Rayburn House Office Building.

Kevin Foerster (Refuge Chief, Pacific Region) and **Devin Helfrich** (CLA) will meet with *Brent Blevins, House Natural Resources Committee majority staff,* to discuss Midway Atoll National Wildlife Refuge. The meeting is scheduled for 3:00 p.m. in 1324 Longworth House Office Building.

Mitch Ellis (Refuge Chief, Alaska Region), **Sara Boario** (Assistant Regional Director for External Affairs), **Ryan Noel** (Special Agent, Alaska Region), and **Amee Howard** (CLA, Alaska Region) will meet with *Erik Elam, staff for Senator Dan Sullivan (R-AK),* as a courtesy. The meeting is scheduled for 4:00 p.m. in 702 Hart Senate Office Building.

Scott Kahan (Refuge Chief, Northeast Region), **Sharon Marino** (Deputy Regional Refuge Chief), and **Merra Howe** (CLA) will meet with *Julia Angelotti, staff for Representative Rob Wittman (R-VA),* as a courtesy and to provide updates on Rappahannock National Wildlife Refuge and Plum Tree Island National Wildlife Refuge. The meeting is scheduled for 3:45 p.m. in 2055 Rayburn House Office Building.

Scott Kahan (Refuge Chief, Northeast Region) and **Sharon Marino** (Deputy Refuge Chief, Northeast Region) will meet with *Kevin Dowling, staff for Representative Lee Zeldin (R-NY),* as a courtesy and to discuss issues at the Long Island National Wildlife Refuge Complex. The meeting is scheduled for 4:30 p.m. in 1517 Longworth House Office Building.

Kevin Foerster (Refuge Chief, Pacific Region) and **Devin Helfrich** (CLA) will meet with *Matt Strickler, House Natural Resources Committee minority staff,* to discuss Midway Atoll National Wildlife Refuge. The meeting is scheduled for 5:00 p.m. in 186 Ford House Office Building.

Tuesday, February 28

Cindy Dohner (Regional Director, Southeast Region) and **Kristen Peters** (CLA, Southeast Region) will meet with *Chris Jones, staff for Representative Rick Crawford (R-AR),* as a courtesy and to discuss at-risk species conservation. The meeting is scheduled for 1:00 p.m. in 2422 Rayburn House Office Building.

Wednesday, March 1

Cindy Dohner (Regional Director, Southeast Region) and **Kristen Peters** (CLA, Southeast Region) will meet with *Jordan Heyman and Riley Ploch, staff for Representative Vern Buchanan (R-FL),* as a courtesy. The meeting is scheduled for 1:00 p.m. in 2104 Rayburn House Office Building.

Cindy Dohner (Regional Director, Southeast Region), **Kristen Peters** (CLA, Southeast Region), and **Alyssa Hausman** (CLA) will meet with *Representative David Rouzer (R-NC)* as a courtesy and to discuss red wolf recovery. The meeting is scheduled for 2:30 p.m. in 424 Cannon House Office Building.

Thursday, March 2

Cindy Dohner (Regional Director, Southeast Region) and **Kristen Peters** (CLA, Southeast Region) will meet with *Kayla Dolan, staff for Senator Thom Tillis (R-NC),* as a courtesy and to discuss red wolf recovery. The meeting is scheduled for 9:30 a.m. in 185 Dirksen Senate Office Building.

Cindy Dohner (Regional Director, Southeast Region), **Kristen Peters** (CLA, Southeast Region), and **Alyssa Hausman** (CLA) will meet with *Lauren Reamy and Eleni Valanos, staff for Senator Marco Rubio (R-FL),* as a courtesy. The meeting is scheduled for 10:30 a.m. in 284 Russell Senate Office Building.

Cindy Dohner (Regional Director, Southeast Region) and **Kristen Peters** (External Affairs, Southeast Region) will meet with *Senator John Boozman (R-AR) and his staff* as a courtesy and to discuss at-risk species conservation. The meeting is scheduled for 4:30 p.m. in 141 Hart Senate Office Building.

Friday, March 3

Scott Kahan (Refuge Chief, Northeast Region), **Sharon Marino** (Deputy Regional Refuge Chief), and **Alex Kasdin** (CLA) will meet with *Adam Zipkin, staff for Senator Cory Booker (D-NJ)* as a courtesy and to provide updates on refuge issues in New Jersey. The meeting is scheduled for 9:30 a.m. in 359 Dirksen Senate Office Building.

Scott Kahan (Refuge Chief, Northeast Region), **Sharon Marino** (Deputy Regional Refuge Chief), and **Alex Kasdin** (CLA) will meet with *staff for Senator Shelley Moore Capito (R-WV)* as a courtesy and to provide updates on Canaan Valley National Wildlife Refuge. The meeting is scheduled for 10:00 a.m. in 172 Russell Senate Office Building.

Scott Kahan (Refuge Chief, Northeast Region), **Sharon Marino** (Deputy Regional Refuge Chief), and **Alex Kasdin** (CLA) will meet with *Becky Cairns, staff for Representative Niki Tsongas (D-MA),* as a courtesy and to provide updates on the Eastern Massachusetts National Wildlife Refuge Complex. The meeting is scheduled for 11:15 a.m. in 1714 Longworth House Office Building.

From: Gustavson, Angela
To: Angela Gustavson
Subject: Congressional Meeting Memo
Date: Monday, June 12, 2017 4:19:36 PM
Attachments: MM June 12.docx

Good afternoon,

The Congressional Meeting Memo for this week is attached.

Angela

Angela Gustavson
Deputy Chief
Division of Congressional and Legislative Affairs
U.S. Fish and Wildlife Service
Office: 703-358-2253
Mobile: 202-909-5105
angela_gustavson@fws.gov

U.S. FISH AND WILDLIFE SERVICE
MEETING MEMO

Week of June 12, 2017

BRIEFINGS/MEETINGS

Tuesday, June 13

Cindy Dohner (Regional Director, Southeast Region) and **Kristen Peters** (External Affairs, Southeast Region) will meet with *Representative Bruce Westerman (R-AR-4)* as a courtesy. The meeting is scheduled for 11:00 a.m. in 130 Cannon House Office Building.

Cindy Dohner (Regional Director, Southeast Region) and **Kristen Peters** (External Affairs, Southeast Region) will meet with *Corey Schrodt, staff for Representative Francis Rooney (R-FL-19),* as a courtesy. The meeting is scheduled for 1:00 p.m. in 120 Cannon House Office Building.

Cindy Dohner (Regional Director, Southeast Region) and **Kristen Peters** (External Affairs, Southeast Region) will meet with *Representative Brian Mast (R-FL-18)* as a courtesy. The meeting is scheduled for 1:30 p.m. in 2182 Rayburn House Office Building.

Cindy Dohner (Regional Director, Southeast Region) and **Kristen Peters** (External Affairs, Southeast Region) will meet with *Representative Clay Higgins (R-LA-3)* as a courtesy. The meeting is scheduled for 2:30 p.m. in 1711 Longworth House Office Building.

Cindy Dohner (Regional Director, Southeast Region) and **Kristen Peters** (External Affairs, Southeast Region) will meet with *Representative James Comer (R-KY-1)* as a courtesy. The meeting is scheduled for 4:00 p.m. in 1513 Longworth House Office Building.

Wednesday, June 14

Cindy Dohner (Regional Director, Southeast Region) and **Kristen Peters** (External Affairs, Southeast Region) will meet with *Representative Mike Johnson (R-LA-4)* as a courtesy. The meeting is scheduled for 10:00 a.m. in 327 Cannon House Office Building.

Cindy Dohner (Regional Director, Southeast Region) and **Kristen Peters** (External Affairs, Southeast Region) will meet with *Megan Olmstead, majority staff for House Natural Resources Committee,* to provide an update on red wolf recovery. The meeting is scheduled for 11:00 a.m.

Cindy Dohner (Regional Director, Southeast Region) and **Kristen Peters** (External Affairs, Southeast Region) will meet with *Representative Jenniferr Gonzalez-Colon (R-PR-AL)* as a courtesy. The meeting is scheduled for 12:00 p.m. in 1529 Longworth House Office Building.

Cindy Dohner (Regional Director, Southeast Region) and **Kristen Peters** (External Affairs, Southeast Region) will meet with *Andrew Hogin, staff for Representative David Kustoff (R-TN-8),* as a courtesy. The meeting is scheduled for 4:00 p.m. in 508 Cannon House Office Building.

Thursday, June 15

Cindy Dohner (Regional Director, Southeast Region) and **Kristen Peters** (External Affairs, Southeast Region) will meet with *Senator John Kennedy (R-LA)* as a courtesy. The meeting is scheduled for 9:15 a.m. in 383 Russell Senate Office Building.

Cindy Dohner (Regional Director, Southeast Region) and **Kristen Peters** (External Affairs, Southeast Region) will meet with *Representative Charlie Crist (D-FL-13)* as a courtesy. The meeting is scheduled for 10:30 a.m. in 427 Cannon House Office Building.

Cindy Dohner (Regional Director, Southeast Region) and **Kristen Peters** (External Affairs, Southeast Region) will meet with *Representative Darren Soto (D-FL-9)* as a courtesy. The meeting is scheduled for 2:00 p.m. in 1429 Longworth House Office Building.

Cindy Dohner (Regional Director, Southeast Region) and **Kristen Peters** (External Affairs, Southeast Region) will meet with *Elizabeth Mabry, minority staff for Senate Environment and Public Works Committee,* as a courtesy. The meeting is scheduled for 3:30 p.m. in 508 Hart Senate Office Building.

From: Skipwith, Aurelia
To: Dohner, Cynthia
Cc: Maureen Foster; Frazer, Gary; Casey Hammond; Jim Kurth; Johnson Virginia
Subject: Re: Background materials on red wolf recovery program
Date: Tuesday, April 25, 2017 9:07:08 AM

Cynthia,
What I understand from your message is that there are two sub-budgets within the Red Wolf Recovery Program: 1) NC NEP and 2) Captive Population/Recovery Plan. And any savings in NC NEP will be shifted over to that second budget. So, the budget of the revised Red Wolf Recovery Program will be at a minimum ~$1.2 million - the same as the current Program, but could potentially be more. Please further explain if I did not understand correctly.

Also, my last name is Skipwith. I know that sometimes spellcheck auto-correct my last name to Skipworth.

Thank you,

Aurelia Skipwith
Deputy Assistant Secretary
Fish & Wildlife and Parks

U.S. Department of Interior
1849 C Street, NW, Room 3148
Washington, DC 20240
(202) 208-5837

On Tue, Apr 25, 2017 at 8:14 AM, Dohner, Cynthia <cynthia_dohner@fws.gov> wrote:

> Ms. Skipworth,
>
> No, we anticipate that the cost of the revised NC NEP program will be reduced. Any reduction in the cost of that program will be redirected toward expanding the captive population and revising the recovery plan.
>
> Best -
> Cindy Dohner
>
> On Tue, Apr 25, 2017 at 6:35 AM, Aurelia Skipwith <aurelia_skipwith@ios.doi.gov> wrote:
>
> > Cynthia,
> > So, the revised Program will cost more than the current Program. Am I understanding that correctly?
> >
> > Aurelia Skipwith
> >
> > On Apr 24, 2017, at 1:02 PM, Dohner, Cynthia <cynthia_dohner@fws.gov> wrote:
> >
> > Yes, it includes those activities.

On Mon, Apr 24, 2017 at 12:19 PM, Aurelia Skipwith <aurelia_skipwith@ios.doi.gov> wrote:

Thank you for this, Cynthia.

Does the current ~$1.2 million budget include the breeding activities and other population maintenance? Thank you.

Aurelia Skipwith

On Apr 24, 2017, at 11:55 AM, Dohner, Cynthia <cynthia_dohner@fws.gov> wrote:

The overall red wolf recovery budget is just over $1.2 million dollars. The majority of this amount covers activities (e.g., responding the landowner concerns, rulemaking, etc.) related to managing the Eastern North Carolina Nonessential Experimental Population (NC NEP). We haven't yet finalized changes to the management of the NC NEP and, until we do, we can't estimate future costs. We do, however, anticipate that we'll be spending less in the future on the NC NEP, with the savings redirected toward expanding the captive population and revising the recovery plan. Let us know if you need additional information.

Best -
Cindy Dohner

On Sun, Apr 23, 2017 at 7:46 PM, Maureen Foster <maureen_foster@ios.doi.gov> wrote:

+ Virginia

Maureen D. Foster
Chief of Staff
Office of the Assistant Secretary for
Fish and Wildlife and Parks.
202.208.5970 office
202.306.3845 cell

On Apr 23, 2017, at 3:34 PM, Skipwith, Aurelia <aurelia_skipwith@ios.doi.gov> wrote:

Gary,
Please provide the budget of the current Red Wolf Recovery Program and the proposed budget for the revised Red Wolf Recovery Program. I need this information Monday morning. Thank you.

Aurelia Skipwith

On Fri, Apr 21, 2017 at 6:29 PM, Skipwith, Aurelia <aurelia_skipwith@ios.doi.gov> wrote:

> Thank you for these materials, Gary.
>
> Have a good weekend.
>
> Aurelia
>
> On Fri, Apr 21, 2017 at 6:10 PM, Frazer, Gary <gary_frazer@fws.gov> wrote:
>
> > Aurelia -- Attached is the Federal Register notice that I mentioned. Pp 3-7 provide the background on the recovery program and describe next steps.
> >
> > Also attached is the clearance briefing paper to summarize the purpose, substance, and issues associated with this notice. It was drafted to facilitate review and clearance of the FR notice, so is not a comprehensive treatment of the recovery program. Again, the guts of the FR notice is the best I have available right now.
> >
> > The electronic file of the PowerPoint is also attached.
> >
> > Call me or Regional Director Cindy Dohner (cell 678/427-0142) if you have any questions. And if you need a more comprehensive briefing paper on the recovery program, I'm sure the Region can generate one for you early next week. -- GDF
> >
> > *Gary Frazer*
> > *Assistant Director -- Ecological Services*
> > *U.S. Fish and Wildlife Service*
> > *(202) 208-4646*
> > *cell (202) 253-4578*

From:	Frazer, Gary
To:	Virginia Johnson; Maureen Foster; Casey Hammond; Jim Kurth; Steve Guertin; Juliette Lillie; Megan Apgar; Megan Bloomgren; Ann Navaro; BENJAMIN JESUP; Matt Huggler; Charisa Morris
Cc:	Gina Shultz; Bridget Fahey; Jeff Newman; Lois Wellman
Subject:	Agenda and briefing papers for ES Weekly FR Package Briefing
Date:	Wednesday, February 15, 2017 8:28:31 AM
Attachments:	Agenda 02.15.2017.docx FR2833 CH 2 MT stoneflies.docx FR2835 Listing 2 MT stoneflies.docx FR2786 Listing 2 Australian parrots.docx FRxxxx Petition 90 day batched.docx FR2856 Petition Bone Cave harvestman.docx FRxxxx Listing manatee.docx FR2844 Notice US-Russia polar bear.docx FR2838 ANPR red wolf NEP.docx FR2840 HCP Hoopeston wind farm.docx FR2834 HCP Coral Reef Commons.docx FR2811 HCP Heart of Texas.docx FR2832 HCP Am burying beetle.docx FR2863 HCP Lake and Volusia Co.docx FR2861 draft RP yellowcheek darter.pdf FR2839 draft RP giant garter snake.docx FR2821 SHORTGRASS BP (sp and ses).docx 2864 Notice permit Louisville Zoo.pdf

Did not process non-response attachments.

Attached is the agenda and the briefing papers for the packages that we will discuss today.

Virginia, Maureen, and Casey, we will get you hard copies today and, in the future, will deliver hard copies of the agenda and briefing papers at least 2 business days ahead of the weekly briefing.

Gary Frazer
Assistant Director -- Ecological Services
U.S. Fish and Wildlife Service
(202) 208-4646

Briefing Paper
Departmental Clearance

Title of Document: **Endangered and Threatened Wildlife and Plants; Nonessential Experimental Population of Red Wolves (Canis rufus) in North Carolina**

RIN, if applicable: **RIN 1018–BB98**

Popular Short Name, if applicable: Advance notice of proposed rulemaking; notice of intent to prepare an environmental impact statement.

Summary (Clearly and very briefly explain what the document does and, if applicable, where the subject of the document is located):

This document gives notice to the public that the Fish and Wildlife Service (FWS) will prepare a draft environmental impact statement pursuant to the National Environmental Policy Act (NEPA), in conjunction with development of a proposed rule to revise the existing nonessential experimental population designation of red wolves in North Carolina under section 10(j) of the Endangered Species Act (ESA). As such, we are announcing the initiation of a public scoping process to engage Federal, Tribal, State, and local governments; special interest groups; and the public in the identification of issues and concerns, potential impacts, and possible alternatives to the proposed action. Information obtained during the public scoping process will be used to develop the draft environmental assessment and promulgate a proposed rule.

Is timing critical? ☒ Yes ☐ No

If yes, date the document must publish or other action must occur: As soon as posible

What is driving the timing? Scheduled Event; Two public scoping meetings need to be scheduled as soon as possible. We must give the public at least 15 days notice of the meetings. Additionally, our target due date for the draft environmental assessment and proposed rule is December 2017.

What happens if the deadline is missed?

We will have to reschedule the public meetings, including rebooking facilities where the meetings will be held. Additionally, a delay in the scoping process will delay our development of a draft environmental assessment and proposed rule, which leaves us less time to draft these actions and meet our December 2017 target date. Although this action is not court-ordered, it is part of active litigation. If we do not move forward with our commitment to complete a proposed rule by December 2017, it could set us up for additional work and leave us vulnerable to more litigation in the future.

Background: *[Briefly provide any background information, in understandable language, that will help a reader quickly understand what the document is trying to do and why, along with additional information that is useful. Assume the reader knows little about the subject matter. Minimize use of acronyms or abbreviations and do not use them at all unless they are clearly defined. Is the document a high-profile, litigated matter?]*

The U.S. Fish and Wildlife Service, is announcing that it will prepare a draft environmental impact statement (EIS) pursuant to the National Environmental Policy Act (NEPA) of 1969, as

amended, in conjunction with development of a proposed rule to revise the existing nonessential experimental population designation of red wolves (Canis rufus) in North Carolina under section 10(j) of the Endangered Species Act of 1973, as amended.

Based on evaluations of the red wolf recovery program and the nonessential experimental population (NEP) in North Carolina, it became clear that the management of the nonessential experimental population of red wolves project is unacceptable to the Service and all stakeholders. The Service is considering whether the NEP should be managed with the captive population as one meta-population, whereby individuals could be moved not only from captivity into the wild but also from the wild into captivity. This will increase the size of the population and introduce the natural selection occurring in the NEP back into the captive population. Therefore, the Service is proposing to change the goal of the current NEP project from solely that of establishing a self-sustaining wild population to a goal of also supporting viability of the captive wolves of the red wolf breeding program. Per our regulations, to allow public participation and input, we must announce initiation of the public scoping process and the dates and times of public scoping meetings.

The proposed revision would recognize that the size, scope, and management of the NEP will be focused on maintaining a wild population on Federal lands within Dare County, North Carolina and on protecting the species by increasing the number and genetic diversity of wolves in captivity. These revisions will allow removal of isolated packs of animals from non-Federal lands at the landowners' request, incorporation of these animals into the wild/captive metapopulation, and better management of the remaining wild animals in accessible areas to minimize risks of hybridization. Management of wolves occupying Federal lands in Dare County will include population monitoring, animal husbandry, and control of coyotes and hybrids.

Issues: *[Controversial? What are the significant **issues**, **who will care**, and **how strongly** will they care?]*

Although we believe none of the interested parties will take a particular position on the notice itself, we anticipate both support and opposition to the revision of the ESA 10(j) rule. North Carolina Wildlife Resources Commission (NCWRC) supports a revision of the current 10(j) rule as they have recognized, along with the FWS, that improved management of the nonessential experimental population of the Red wolf is needed. The FWS will engage NCWRC in both the drafting of a proposed 10(j) rule and draft EIS.

We anticipate opposition to the revision of the 10(j) from several members of Congress and NGOs as they have expressed concerns and objections to our proposed path forward for the red wolf recovery program. In particular, they object to a perceived abandonment of management of red wolves in the wild and shift in focus away from establishing a self-sustaining population.

Additionally, there may be public outcry via news stories and social media due to the perceived abandonment of the red wolf recovery program associated with our intent to revise the current 10(j) rule for the NEP project.

Communications:

Media POC: Press release to be issued by Region 4: Jeff Fleming, 404-679-7287

Other outreach: County governments within the NEP project area, other Federal agencies, private landowners and the community adjacent to the NEP project area, and other interested parties, such as NGOs, will be contacted.

Is there an information collection associated with this document? ☐ Yes ☒ No

If yes, does it have a currently approved OMB Control Number? ☐ Yes ☒ No

OMB Control Number(s): Click here to enter OMB Control Number.

Does the document require a ☐ new OMB Control Number or ☐ a renewal of an existing approval?

If a new number or renewal is required, what is the current status? Click here to explain status.

If a regulatory action, has it been on a 90-Day List for the current stage? ☐ Yes ☒ No

If yes, on which 90-Day List did it first appear at the current stage?

Click here to enter response.

Did OIRA provide comments or change the significance? ☐ Yes ☐ No

If yes, summarize comments and resolution.

Click here to summarize OIRA comments and DOI response.

This approval is to go to ☐ the Federal Register for publication. ☐ OIRA for review.

Primary Contact:

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AIR FREQS

Date 2/14/19 Time 0800 Obs 20 Dur 21

ID #	SEX	YOB	FREQUENCY
MILLTAIL			100
11849	F	10	[redacted] 12HR
11835	M	10	[redacted] 12HR
12044	M	13	[redacted] 12HR
12046	M	13	[redacted] 12HR
12186	M	16	[redacted]
12225	F	17	[redacted] 12HR
12226	F	17	[redacted] 12HR
12228	M	16	[redacted] 12HR
W ARNWR			125
12045	F	13	[redacted] 12HR
20853	M		[redacted] 12HR
GATOR			200
11743	F	09	[redacted] 12HR
20923	M		[redacted] 12HR
HESTER			600
20902	F		[redacted] 12HR
WAUPAUPIN			695
20609	F		[redacted] 12HR
VENTURES			700 [redacted]
90937	F		[redacted]
11747	M	09	[redacted] 12HR
11965	F	12	[redacted] 12 HR
12029	F	13	[redacted] 12HR
HIGH SCHOOL			1100
20812	F		[redacted] 12HR
MATT H.S.			1101

30714 M [redacted] 12HR

ROSE BAY 1200

20904 F [redacted] 12HR

KILKENNY 1625

11958 M 12 [redacted] 12HR

S RICH 1676

40827 F [redacted] 12HR

RICH 1678

20845 M [redacted] 12HR

ALLSTAR 1680

20647 F [redacted] 12HR

BEECH RIDGE 1900

11963 M 12 [redacted] 12HR

12194 F [redacted] GPS[redacted] N/A

12195 F [redacted] 12HR

PANTEGO 1920

20848 M [redacted] 12HR

PUNGO 1990

12197 F [redacted] 12HR

32/99 2575

20665 M [redacted] 12HR

DICTELL 2850

20889 M [redacted] 12HR

HOLLY NECK 2915

30704 F [redacted]

BLUESTONE NEW 2920

20805 F [redacted] 12HR

90706 M [redacted] 12HR

N PHELPS 3240

20898	F		[redacted]	12HR

NORTHERN RD 3250

11985	F	12	[redacted]	12HR
11872	M	11	[redacted]	12HR
	F	11		12 HR

GREENVALLEY 3350

20721	F		[redacted]	12HR

DILLONS RIDGE 3475

20857	F		[redacted]	

COLUMBIA 3500

20843	F		[redacted]	12HR

RECENT FU 4500

20692	F		[redacted]	12HR
20765	F		[redacted]	12HR
20595	M		[redacted]	12HR
20675	M		[redacted]	12HR
11906	F	11	[redacted]	12HR
11951	M	12	[redacted]	12HR

Section A: General Information

Institution:_____

Studbook #:_____

Sex: _____

Age:_____

Date when report filled out:_____

Section B: Canine IBD Activity Index, Inflammatory Bowel Disease scoring questionnaire
This scoring system, developed for domestic dog, will give us a standardized way to look at the symptomatic presentation of IBD in red wolves. Please score each symptom/sign at the time of the fecal collection with 0 being the least severe and 3 being the most severe.

1. Attitude/activity =_____
    a. 0=normal
    b. 1=slightly decreased
    c. 2= moderately decreased
    d. 3=severely decreased

2. Appetite =_____
    (consider seasonal changes in consumption, typically more in winter, less in summer)
    a. 0=normal
    b. 1= slightly decreased
    c. 2= moderately decreased
    d. 3= severely decreased

3. Vomiting=_____
    a. 0=none
    b. 1=mild (1time/week)
    c. 2= moderate (2-3 times/week)
    d. 3=severe (>3 times/week)

4. Stool consistency=_____
    (red wolves have typically soft stool, the scoring has been altered to reflect this)
    a. 0=normal= slightly soft feces
    b. 1=soft feces or fecal blood mucus or both
    c. 2=very soft feces
    d. 3=watery diarrhea

5. Stool frequency=_____
    a. 0=normal
    b. 1=slightly increased (2-3 times/day)
    c. 2= moderately increased (2-5 times/day)
    d. 3= severely increased (>5 times/day)

6. Weight loss=_____
    a. 0=none
    b. 1=mild (<5% loss)
    c. 2= moderate (5-10% loss)
    d. 3=severe (>10% loss)

Council on Environmental Quality
Executive Office of the President

REGULATIONS

For Implementing The Procedural Provisions Of The

NATIONAL ENVIRONMENTAL POLICY ACT

Reprint
40 CFR Parts 1500-1508
(2005)

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(inside front cover)

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PART 1500—PURPOSE, POLICY, AND MANDATE

Sec.

1500.1 Purpose.
1500.2 Policy.
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1500.6 Agency authority.

AUTHORITY: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 *et seq.*), sec. 309 of the Clean Air Act, as amended (42 U.S.C. 7609) and E.O. 11514, Mar. 5, 1970, as amended by E.O. 11991, May 24, 1977).

SOURCE: 43 FR 55990, Nov. 28, 1978, unless otherwise noted.

§1500.1 Purpose.

(a) The National Environmental Policy Act (NEPA) is our basic national charter for protection of the environment. It establishes policy, sets goals (section 101), and provides means (section 102) for carrying out the policy. Section 102(2) contains "action-forcing" provisions to make sure that federal agencies act according to the letter and spirit of the Act. The regulations that follow implement section 102(2). Their purpose is to tell federal agencies what they must do to comply with the procedures and achieve the goals of the Act. The President, the federal agencies, and the courts share responsibility for enforcing the Act so as to achieve the substantive requirements of section 101.

(b) NEPA procedures must insure that environmental information is available to public officials and citizens before decisions are made and before actions are taken. The information must be of high quality. Accurate scientific analysis, expert agency comments, and public scrutiny are essential to implementing NEPA. Most important, NEPA documents must concentrate on the issues that are truly significant to the action in question, rather than amassing needless detail.

(c) Ultimately, of course, it is not better documents but better decisions that count. NEPA's purpose is not to generate paperwork—even excellent paperwork—but to foster excellent action. The NEPA process is intended to help public officials make decisions that are based on understanding of environmental consequences, and take actions that protect, restore, and enhance the environment. These regulations provide the direction to achieve this purpose.

§1500.2 Policy.

Federal agencies shall to the fullest extent possible:

(a) Interpret and administer the policies, regulations, and public laws of the United States in accordance with the policies set forth in the Act and in these regulations.

(b) Implement procedures to make the NEPA process more useful to decisionmakers and the public; to reduce paperwork and the accumulation of extraneous background data; and to emphasize real environmental issues and alternatives. Environmental impact statements shall be concise, clear, and to the point, and shall be supported by evidence that agencies have made the necessary environmental analyses.

(c) Integrate the requirements of NEPA with other planning and environmental review procedures required by law or by agency practice so that all such procedures run concurrently rather than consecutively.

(d) Encourage and facilitate public involvement in decisions which affect the quality of the human environment.

(e) Use the NEPA process to identify and assess the reasonable alternatives to proposed actions that will avoid or minimize adverse effects of these actions upon the quality of the human environment.

(f) Use all practicable means, consistent with the requirements of the Act and other essential considerations of national policy, to restore and enhance the quality of the human environment and avoid or minimize any possible adverse effects of their actions upon the quality of the human environment.

§1500.3 Mandate.

Parts 1500 through 1508 of this title provide regulations applicable to and binding on all fed-

eral agencies for implementing the procedural provisions of the National Environmental Policy Act of 1969, as amended (Pub. L. 91–190, 42 U.S.C. 4321 *et seq.*) (NEPA or the Act) except where compliance would be inconsistent with other statutory requirements. These regulations are issued pursuant to NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 *et seq.*) section 309 of the Clean Air Act, as amended (42 U.S.C. 7609) and Executive Order 11514, Protection and Enhancement of Environmental Quality (March 5, 1970, as amended by Executive Order 11991, May 24, 1977). These regulations, unlike the predecessor guidelines, are not confined to sec. 102(2)(C) (environmental impact statements). The regulations apply to the whole of section 102(2). The provisions of the Act and of these regulations must be read together as a whole in order to comply with the spirit and letter of the law. It is the Council's intention that judicial review of agency compliance with these regulations not occur before an agency has filed the final environmental impact statement, or has made a final finding of no significant impact (when such a finding will result in action affecting the environment), or takes action that will result in irreparable injury. Furthermore, it is the Council's intention that any trivial violation of these regulations not give rise to any independent cause of action.

§1500.4 Reducing paperwork.

Agencies shall reduce excessive paperwork by:

(a) Reducing the length of environmental impact statements (§1502.2(c)), by means such as setting appropriate page limits (§§1501.7(b)(1) and 1502.7).

(b) Preparing analytic rather than encyclopedic environmental impact statements (§1502.2(a)).

(c) Discussing only briefly issues other than significant ones (§1502.2(b)).

(d) Writing environmental impact statements in plain language (§1502.8).

(e) Following a clear format for environmental impact statements (§1502.10).

(f) Emphasizing the portions of the environmental impact statement that are useful to decisionmakers and the public (§§1502.14 and 1502.15) and reducing emphasis on background material (§1502.16).

(g) Using the scoping process, not only to identify significant environmental issues deserving of study, but also to deemphasize insignificant issues, narrowing the scope of the environmental impact statement process accordingly (§1501.7).

(h) Summarizing the environmental impact statement (§1502.12) and circulating the summary instead of the entire environmental impact statement if the latter is unusually long (§1502.19).

(i) Using program, policy, or plan environmental impact statements and tiering from statements of broad scope to those of narrower scope, to eliminate repetitive discussions of the same issues (§§1502.4 and 1502.20).

(j) Incorporating by reference (§1502.21).

(k) Integrating NEPA requirements with other environmental review and consultation requirements (§1502.25).

(l) Requiring comments to be as specific as possible (§1503.3).

(m) Attaching and circulating only changes to the draft environmental impact statement, rather than rewriting and circulating the entire statement when changes are minor (§1503.4(c)).

(n) Eliminating duplication with state and local procedures, by providing for joint preparation (§1506.2), and with other federal procedures, by providing that an agency may adopt appropriate environmental documents prepared by another agency (§1506.3).

(o) Combining environmental documents with other documents (§1506.4).

(p) Using categorical exclusions to define categories of actions which do not individually or cumulatively have a significant effect on the human environment and which are therefore exempt from requirements to prepare an environmental impact statement (§1508.4).

(q) Using a finding of no significant impact when an action not otherwise excluded will not have a significant effect on the human environment and is therefore exempt from requirements to prepare an environmental impact statement (§1508.13).

[43 FR 55990, Nov. 29, 1978; 44 FR 873, Jan. 3, 1979]

§1500.5 Reducing delay.

Agencies shall reduce delay by:

(a) Integrating the NEPA process into early planning (§1501.2).

(b) Emphasizing interagency cooperation before the environmental impact statement is prepared, rather than submission of adversary comments on a completed document (§1501.6).

(c) Insuring the swift and fair resolution of lead agency disputes (§1501.5).

(d) Using the scoping process for an early identification of what are and what are not the real issues (§1501.7).

(e) Establishing appropriate time limits for the environmental impact statement process (§§1501.7(b)(2) and 1501.8).

(f) Preparing environmental impact statements early in the process (§1502.5).

(g) Integrating NEPA requirements with other environmental review and consultation requirements (§1502.25).

(h) Eliminating duplication with state and local procedures by providing for joint preparation (§1506.2), and with other federal procedures by providing that an agency may adopt appropriate environmental documents prepared by another agency (§1506.3).

(i) Combining environmental documents with other documents (§1506.4).

(j) Using accelerated procedures for proposals for legislation (§1506.8).

(k) Using categorical exclusions to define categories of actions which do not individually or cumulatively have a significant effect on the human environment (§1508.4) and which are therefore exempt from requirements to prepare an environmental impact statement.

(l) Using a finding of no significant impact when an action not otherwise excluded will not have a significant effect on the human environment (§1508.13) and is therefore exempt from requirements to prepare an environmental impact statement.

§1500.6 Agency authority.

Each agency shall interpret the provisions of the Act as a supplement to its existing authority and as a mandate to view traditional policies and missions in the light of the Act's national environmental objectives. Agencies shall review their policies, procedures, and regulations accordingly and revise them as necessary to insure full compliance with the purposes and provisions of the Act. The phrase "to the fullest extent possible" in section 102 means that each agency of the federal government shall comply with that section unless existing law applicable to the agency's operations expressly prohibits or makes compliance impossible.

PART 1501—NEPA AND AGENCY PLANNING

Sec.

1501.1 Purpose.
1501.2 Apply NEPA early in the process.
1501.3 When to prepare an environmental assessment.
1501.4 Whether to prepare an environmental impact statement.
1501.5 Lead agencies.
1501.6 Cooperating agencies.
1501.7 Scoping.
1501.8 Time limits.

AUTHORITY: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 *et seq.*), sec. 309 of the Clean Air Act, as amended (42 U.S.C. 7609, and E.O. 11514 (Mar. 5, 1970, as amended by E.O. 11991, May 24, 1977).

SOURCE: 43 FR 55992, Nov. 29, 1978, unless otherwise noted.

§1501.1 Purpose.

The purposes of this part include:

(a) Integrating the NEPA process into early planning to insure appropriate consideration of NEPA's policies and to eliminate delay.

(b) Emphasizing cooperative consultation among agencies before the environmental impact statement is prepared rather than submission of adversary comments on a completed document.

(c) Providing for the swift and fair resolution of lead agency disputes.

(d) Identifying at an early stage the significant environmental issues deserving of study

and deemphasizing insignificant issues, narrowing the scope of the environmental impact statement accordingly.

(e) Providing a mechanism for putting appropriate time limits on the environmental impact statement process.

§1501.2 Apply NEPA early in the process.

Agencies shall integrate the NEPA process with other planning at the earliest possible time to insure that planning and decisions reflect environmental values, to avoid delays later in the process, and to head off potential conflicts. Each agency shall:

(a) Comply with the mandate of section 102(2)(A) to "utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decisionmaking which may have an impact on man's environment," as specified by §1507.2.

(b) Identify environmental effects and values in adequate detail so they can be compared to economic and technical analyses. Environmental documents and appropriate analyses shall be circulated and reviewed at the same time as other planning documents.

(c) Study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources as provided by section 102(2)(E) of the Act.

(d) Provide for cases where actions are planned by private applicants or other non-federal entities before federal involvement so that:

(1) Policies or designated staff are available to advise potential applicants of studies or other information foreseeably required for later federal action.

(2) The federal agency consults early with appropriate state and local agencies and Indian tribes and with interested private persons and organizations when its own involvement is reasonably foreseeable.

(3) The federal agency commences its NEPA process at the earliest possible time.

§1501.3 When to prepare an environmental assessment.

(a) Agencies shall prepare an environmental assessment (§1508.9) when necessary under the procedures adopted by individual agencies to supplement these regulations as described in §1507.3. An assessment is not necessary if the agency has decided to prepare an environmental impact statement.

(b) Agencies may prepare an environmental assessment on any action at any time in order to assist agency planning and decisionmaking.

§1501.4 Whether to prepare an environmental impact statement.

In determining whether to prepare an environmental impact statement the federal agency shall:

(a) Determine under its procedures supplementing these regulations (described in §1507.3) whether the proposal is one which:

(1) Normally requires an environmental impact statement, or

(2) Normally does not require either an environmental impact statement or an environmental assessment (categorical exclusion).

(b) If the proposed action is not covered by paragraph (a) of this section, prepare an environmental assessment (§1508.9). The agency shall involve environmental agencies, applicants, and the public, to the extent practicable, in preparing assessments required by §1508.9(a)(1).

(c) Based on the environmental assessment make its determination whether to prepare an environmental impact statement.

(d) Commence the scoping process (§1501.7), if the agency will prepare an environmental impact statement.

(e) Prepare a finding of no significant impact (§1508.13), if the agency determines on the basis of the environmental assessment not to prepare a statement.

(1) The agency shall make the finding of no significant impact available to the affected public as specified in §1506.6.

(2) In certain limited circumstances, which the agency may cover in its procedures under §1507.3, the agency shall make the finding of

no significant impact available for public review (including state and areawide clearinghouses) for 30 days before the agency makes its final determination whether to prepare an environmental impact statement and before the action may begin. The circumstances are:

(i) The proposed action is, or is closely similar to, one which normally requires the preparation of an environmental impact statement under the procedures adopted by the agency pursuant to §1507.3, or

(ii) The nature of the proposed action is one without precedent.

§1501.5 Lead agencies.

(a) A lead agency shall supervise the preparation of an environmental impact statement if more than one federal agency either:

(1) Proposes or is involved in the same action; or

(2) Is involved in a group of actions directly related to each other because of their functional interdependence or geographical proximity.

(b) Federal, state, or local agencies, including at least one federal agency, may act as joint lead agencies to prepare an environmental impact statement (§1506.2).

(c) If an action falls within the provisions of paragraph (a) of this section the potential lead agencies shall determine by letter or memorandum which agency shall be the lead agency and which shall be cooperating agencies. The agencies shall resolve the lead agency question so as not to cause delay. If there is disagreement among the agencies, the following factors (which are listed in order of descending importance) shall determine lead agency designation:

(1) Magnitude of agency's involvement.

(2) Project approval/disapproval authority.

(3) Expertise concerning the action's environmental effects.

(4) Duration of agency's involvement.

(5) Sequence of agency's involvement.

(d) Any federal agency, or any state or local agency or private person substantially affected by the absence of lead agency designation, may make a written request to the potential lead agencies that a lead agency be designated.

(e) If federal agencies are unable to agree on which agency will be the lead agency or if the procedure described in paragraph (c) of this section has not resulted within 45 days in a lead agency designation, any of the agencies or persons concerned may file a request with the Council asking it to determine which Federal agency shall be the lead agency. A copy of the request shall be transmitted to each potential lead agency. The request shall consist of:

(1) A precise description of the nature and extent of the proposed action.

(2) A detailed statement of why each potential lead agency should or should not be the lead agency under the criteria specified in paragraph (c) of this section.

(f) A response may be filed by any potential lead agency concerned within 20 days after a request is filed with the Council. The Council shall determine as soon as possible but not later than 20 days after receiving the request and all responses to it which federal agency shall be the lead agency and which other federal agencies shall be cooperating agencies.

[43 FR 55992, Nov. 29, 1978; 44 FR 873, Jan. 3, 1979]

§1501.6 Cooperating agencies.

The purpose of this section is to emphasize agency cooperation early in the NEPA process. Upon request of the lead agency, any other federal agency which has jurisdiction by law shall be a cooperating agency. In addition any other federal agency which has special expertise with respect to any environmental issue, which should be addressed in the statement may be a cooperating agency upon request of the lead agency. An agency may request the lead agency to designate it a cooperating agency.

(a) The lead agency shall:

(1) Request the participation of each cooperating agency in the NEPA process at the earliest possible time.

(2) Use the environmental analysis and proposals of cooperating agencies with jurisdiction by law or special expertise, to the maximum extent possible consistent with its responsibility as lead agency.

(3) Meet with a cooperating agency at the latter's request.

(b) Each cooperating agency shall:

(1) Participate in the NEPA process at the earliest possible time.

(2) Participate in the scoping process (described below in §1501.7).

(3) Assume on request of the lead agency responsibility for developing information and preparing environmental analyses including portions of the environmental impact statement concerning which the cooperating agency has special expertise.

(4) Make available staff support at the lead agency's request to enhance the latter's interdisciplinary capability.

(5) Normally use its own funds. The lead agency shall, to the extent available funds permit, fund those major activities or analyses it requests from cooperating agencies. Potential lead agencies shall include such funding requirements in their budget requests.

(c) A cooperating agency may in response to a lead agency's request for assistance in preparing the environmental impact statement (described in paragraph (b) (3), (4), or (5) of this section) reply that other program commitments preclude any involvement or the degree of involvement requested in the action that is the subject of the environmental impact statement. A copy of this reply shall be submitted to the Council.

§1501.7 Scoping.

There shall be an early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action. This process shall be termed scoping. As soon as practicable after its decision to prepare an environmental impact statement and before the scoping process the lead agency shall publish a notice of intent (§1508.22) in the FEDERAL REGISTER except as provided in §1507.3(e).

(a) As part of the scoping process the lead agency shall:

(1) Invite the participation of affected federal, state, and local agencies, any affected Indian tribe, the proponent of the action, and other interested persons (including those who might not be in accord with the action on environmental grounds), unless there is a limited exception under §1507.3(c). An agency may give notice in accordance with §1506.6.

(2) Determine the scope (§1508.25) and the significant issues to be analyzed in depth in the environmental impact statement.

(3) Identify and eliminate from detailed study the issues which are not significant or which have been covered by prior environmental review (§1506.3), narrowing the discussion of these issues in the statement to a brief presentation of why they will not have a significant effect on the human environment or providing a reference to their coverage elsewhere.

(4) Allocate assignments for preparation of the environmental impact statement among the lead and cooperating agencies, with the lead agency retaining responsibility for the statement.

(5) Indicate any public environmental assessments and other environmental impact statements which are being or will be prepared that are related to but are not part of the scope of the impact statement under consideration.

(6) Identify other environmental review and consultation requirements so the lead and cooperating agencies may prepare other required analyses and studies concurrently with, and integrated with, the environmental impact statement as provided in §1502.25.

(7) Indicate the relationship between the timing of the preparation of environmental analyses and the agency's tentative planning and decisionmaking schedule.

(b) As part of the scoping process the lead agency may:

(1) Set page limits on environmental documents (§1502.7).

(2) Set time limits (§1501.8).

(3) Adopt procedures under §1507.3 to combine its environmental assessment process with its scoping process.

(4) Hold an early scoping meeting or meetings which may be integrated with any other early planning meeting the agency has. Such a scoping meeting will often be appropriate when the impacts of a particular action are confined to specific sites.

(c) An agency shall revise the determinations made under paragraphs (a) and (b) of this section if substantial changes are made later in the proposed action, or if significant new circumstances or information arise which bear on the proposal or its impacts.

§1501.8 Time limits.

Although the Council has decided that prescribed universal time limits for the entire NEPA process are too inflexible, federal agencies are encouraged to set time limits appropriate to individual actions (consistent with the time intervals required by §1506.10). When multiple agencies are involved the reference to agency below means lead agency.

(a) The agency shall set time limits if an applicant for the proposed action requests them: *Provided*, That the limits are consistent with the purposes of NEPA and other essential considerations of national policy.

(b) The agency may:

(1) Consider the following factors in determining time limits:

(i) Potential for environmental harm.

(ii) Size of the proposed action.

(iii) State of the art of analytic techniques.

(iv) Degree of public need for the proposed action, including the consequences of delay.

(v) Number of persons and agencies affected.

(vi) Degree to which relevant information is known and if not known the time required for obtaining it.

(vii) Degree to which the action is controversial.

(viii) Other time limits imposed on the agency by law, regulations, or executive order.

(2) Set overall time limits or limits for each constituent part of the NEPA process, which may include:

(i) Decision on whether to prepare an environmental impact statement (if not already decided).

(ii) Determination of the scope of the environmental impact statement.

(iii) Preparation of the draft environmental impact statement.

(iv) Review of any comments on the draft environmental impact statement from the public and agencies.

(v) Preparation of the final environmental impact statement.

(vi) Review of any comments on the final environmental impact statement.

(vii) Decision on the action based in part on the environmental impact statement.

(3) Designate a person (such as the project manager or a person in the agency's office with NEPA responsibilities) to expedite the NEPA process.

(c) State or local agencies or members of the public may request a federal agency to set time limits.

PART 1502—ENVIRONMENTAL IMPACT STATEMENT

Sec.

1502.1 Purpose.
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1502.24 Methodology and scientific accuracy.
1502.25 Environmental review and consultation requirements.

AUTHORITY: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 *et seq.*), sec. 309 of the Clean Air Act, as amended (42 U.S.C. 7609), and E.O. 11514 (Mar. 5, 1970, as amended by E.O. 11991, May 24, 1977).

SOURCE: 43 FR 55994, Nov. 29, 1978, unless otherwise noted.

§1502.1 Purpose.

The primary purpose of an environmental impact statement is to serve as an action-forcing device to insure that the policies and goals defined in the Act are infused into the ongoing programs and actions of the federal government. It shall provide full and fair discussion of significant environmental impacts and shall inform decisionmakers and the public of the reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the human environment. Agencies shall focus on significant environmental issues and alternatives and shall reduce paperwork and the accumulation of extraneous background data. Statements shall be concise, clear, and to the point, and shall be supported by evidence that the agency has made the necessary environmental analyses. An environmental impact statement is more than a disclosure document. It shall be used by federal officials in conjunction with other relevant material to plan actions and make decisions.

§1502.2 Implementation.

To achieve the purposes set forth in §1502.1 agencies shall prepare environmental impact statements in the following manner:

(a) Environmental impact statements shall be analytic rather than encyclopedic.

(b) Impacts shall be discussed in proportion to their significance. There shall be only brief discussion of other than significant issues. As in a finding of no significant impact, there should be only enough discussion to show why more study is not warranted.

(c) Environmental impact statements shall be kept concise and shall be no longer than absolutely necessary to comply with NEPA and with these regulations. Length should vary first with potential environmental problems and then with project size.

(d) Environmental impact statements shall state how alternatives considered in it and decisions based on it will or will not achieve the requirements of sections 101 and 102(1) of the Act and other environmental laws and policies.

(e) The range of alternatives discussed in environmental impact statements shall encompass those to be considered by the ultimate agency decisionmaker.

(f) Agencies shall not commit resources prejudicing selection of alternatives before making a final decision (§1506.1).

(g) Environmental impact statements shall serve as the means of assessing the environmental impact of proposed agency actions, rather than justifying decisions already made.

§1502.3 Statutory requirements for statements.

As required by sec. 102(2)(C) of NEPA environmental impact statements (§1508.11) are to be included in every recommendation or report.

On proposals (§1508.23).

For legislation and (§1508.17).

Other major federal actions (§1508.18).

Significantly (§1508.27).

Affecting (§§1508.3, 1508.8).

The quality of the human environment (§1508.14).

§1502.4 Major Federal actions requiring the preparation of environmental impact statements.

(a) Agencies shall make sure the proposal which is the subject of an environmental impact statement is properly defined. Agencies shall use the criteria for scope (§1508.25) to determine which proposal(s) shall be the subject of a particular statement. Proposals or parts of proposals which are related to each other closely enough to be, in effect, a single course of action shall be evaluated in a single impact statement.

(b) Environmental impact statements may be prepared, and are sometimes required, for broad federal actions such as the adoption of new agency programs or regulations (§1508.18). Agencies shall prepare statements on broad actions so that they are relevant to policy and are timed to coincide with meaningful points in agency planning and decisionmaking.

(c) When preparing statements on broad actions (including proposals by more than one

agency), agencies may find it useful to evaluate the proposal(s) in one of the following ways:

(1) Geographically, including actions occurring in the same general location, such as body of water, region, or metropolitan area.

(2) Generically, including actions which have relevant similarities, such as common timing, impacts, alternatives, methods of implementation, media, or subject matter.

(3) By stage of technological development including federal or federally assisted research, development or demonstration programs for new technologies which, if applied, could significantly affect the quality of the human environment. Statements shall be prepared on such programs and shall be available before the program has reached a stage of investment or commitment to implementation likely to determine subsequent development or restrict later alternatives.

(d) Agencies shall as appropriate employ scoping (§1501.7), tiering (§1502.20), and other methods listed in §§1500.4 and 1500.5 to relate broad and narrow actions and to avoid duplication and delay.

§1502.5 Timing.

An agency shall commence preparation of an environmental impact statement as close as possible to the time the agency is developing or is presented with a proposal (§1508.23) so that preparation can be completed in time for the final statement to be included in any recommendation or report on the proposal. The statement shall be prepared early enough so that it can serve practically as an important contribution to the decisionmaking process and will not be used to rationalize or justify decisions already made (§§1500.2(c), 1501.2, and 1502.2). For instance:

(a) For projects directly undertaken by federal agencies the environmental impact statement shall be prepared at the feasibility analysis (go-no go) stage and may be supplemented at a later stage if necessary.

(b) For applications to the agency appropriate environmental assessments or statements shall be commenced no later than immediately after the application is received. Federal agencies are encouraged to begin preparation of such assessments or statements earlier, preferably jointly with applicable state or local agencies.

(c) For adjudication, the final environmental impact statement shall normally precede the final staff recommendation and that portion of the public hearing related to the impact study. In appropriate circumstances the statement may follow preliminary hearings designed to gather information for use in the statements.

(d) For informal rulemaking the draft environmental impact statement shall normally accompany the proposed rule.

§1502.6 Interdisciplinary preparation.

Environmental impact statements shall be prepared using an inter-disciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts (section 102(2)(A) of the Act). The disciplines of the preparers shall be appropriate to the scope and issues identified in the scoping process (§1501.7).

§1502.7 Page limits.

The text of final environmental impact statements (e.g., paragraphs (d) through (g) of §1502.10) shall normally be less than 150 pages and for proposals of unusual scope or complexity shall normally be less than 300 pages.

§1502.8 Writing.

Environmental impact statements shall be written in plain language and may use appropriate graphics so that decisionmakers and the public can readily understand them. Agencies should employ writers of clear prose or editors to write, review, or edit statements, which will be based upon the analysis and supporting data from the natural and social sciences and the environmental design arts.

§1502.9 Draft, final, and supplemental statements.

Except for proposals for legislation as provided in §1506.8 environmental impact statements shall be prepared in two stages and may be supplemented.

(a) Draft environmental impact statements shall be prepared in accordance with the scope decided upon in the scoping process. The lead agency shall work with the cooperating agencies and shall obtain comments as required in part 1503 of this chapter. The draft statement must fulfill and satisfy to the fullest extent possible the requirements established for final statements in section 102(2)(C) of the Act. If a draft statement is so inadequate as to preclude meaningful analysis, the agency shall prepare and circulate a revised draft of the appropriate portion. The agency shall make every effort to disclose and discuss at appropriate points in the draft statement all major points of view on the environmental impacts of the alternatives including the proposed action.

(b) Final environmental impact statements shall respond to comments as required in part 1503 of this chapter. The agency shall discuss at appropriate points in the final statement any responsible opposing view which was not adequately discussed in the draft statement and shall indicate the agency's response to the issues raised.

(c) Agencies:

(1) Shall prepare supplements to either draft or final environmental impact statements if:

(i) The agency makes substantial changes in the proposed action that are relevant to environmental concerns; or

(ii) There are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts.

(2) May also prepare supplements when the agency determines that the purposes of the Act will be furthered by doing so.

(3) Shall adopt procedures for introducing a supplement into its formal administrative record, if such a record exists.

(4) Shall prepare, circulate, and file a supplement to a statement in the same fashion (exclusive of scoping) as a draft and final statement unless alternative procedures are approved by the Council.

§1502.10 Recommended format.

Agencies shall use a format for environmental impact statements which will encourage good analysis and clear presentation of the alternatives including the proposed action. The following standard format for environmental impact statements should be followed unless the agency determines that there is a compelling reason to do otherwise:

(a) Cover sheet.

(b) Summary.

(c) Table of contents.

(d) Purpose of and need for action.

(e) Alternatives including proposed action (sections 102(2)(C)(iii) and 102(2)(E) of the Act).

(f) Affected environment.

(g) Environmental consequences (especially sections 102(2)(C)(i), (ii), (iv), and (v) of the Act).

(h) List of preparers.

(i) List of agencies, organizations, and persons to whom copies of the statement are sent.

(j) Index.

(k) Appendices (if any).

If a different format is used, it shall include paragraphs (a), (b), (c), (h), (i), and (j), of this section and shall include the substance of paragraphs (d), (e), (f), (g), and (k) of this section, as further described in §§1502.11 through 1502.18, in any appropriate format.

§1502.11 Cover sheet.

The cover sheet shall not exceed one page. It shall include:

(a) A list of the responsible agencies including the lead agency and any cooperating agencies.

(b) The title of the proposed action that is the subject of the statement (and if appropriate the titles of related cooperating agency actions), together with the state(s) and county(ies) (or other jurisdiction if applicable) where the action is located.

(c) The name, address, and telephone number of the person at the agency who can supply further information.

(d) A designation of the statement as a draft, final, or draft or final supplement.

(e) A one paragraph abstract of the statement.

(f) The date by which comments must be received (computed in cooperation with EPA

under §1506.10). The information required by this section may be entered on Standard Form 424 (in items 4, 6, 7, 10, and 18).

§1502.12 Summary.

Each environmental impact statement shall contain a summary which adequately and accurately summarizes the statement. The summary shall stress the major conclusions, areas of controversy (including issues raised by agencies and the public), and the issues to be resolved (including the choice among alternatives). The summary will normally not exceed 15 pages.

§1502.13 Purpose and need.

The statement shall briefly specify the underlying purpose and need to which the agency is responding in proposing the alternatives including the proposed action.

§1502.14 Alternatives including the proposed action.

This section is the heart of the environmental impact statement. Based on the information and analysis presented in the sections on the Affected Environment (§1502.15) and the Environmental Consequences (§1502.16), it should present the environmental impacts of the proposal and the alternatives in comparative form, thus sharply defining the issues and providing a clear basis for choice among options by the decisionmaker and the public. In this section agencies shall:

(a) Rigorously explore and objectively evaluate all reasonable alternatives, and for alternatives which were eliminated from detailed study, briefly discuss the reasons for their having been eliminated.

(b) Devote substantial treatment to each alternative considered in detail including the proposed action so that reviewers may evaluate their comparative merits.

(c) Include reasonable alternatives not within the jurisdiction of the lead agency.

(d) Include the alternative of no action.

(e) Identify the agency's preferred alternative or alternatives, if one or more exists, in the draft statement and identify such alternative in the final statement unless another law prohibits the expression of such a preference.

(f) Include appropriate mitigation measures not already included in the proposed action or alternatives.

§1502.15 Affected environment.

The environmental impact statement shall succinctly describe the environment of the area(s) to be affected or created by the alternatives under consideration. The description shall be no longer than is necessary to understand the effects of the alternatives. Data and analyses in a statement shall be commensurate with the importance of the impact, with less important material summarized, consolidated, or simply referenced. Agencies shall avoid useless bulk in statements and shall concentrate effort and attention on important issues. Verbose descriptions of the affected environment are themselves no measure of the adequacy of an environmental impact statement.

§1502.16 Environmental consequences.

This section forms the scientific and analytic basis for the comparisons under §1502.14. It shall consolidate the discussions of those elements required by sections 102(2)(C)(i), (ii), (iv), and (v) of NEPA which are within the scope of the statement and as much of section 102(2)(C)(iii) as is necessary to support the comparisons. The discussion will include the environmental impacts of the alternatives including the proposed action, any adverse environmental effects which cannot be avoided should the proposal be implemented, the relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and any irreversible or irretrievable commitments of resources which would be involved in the proposal should it be implemented. This section should not duplicate discussions in §1502.14. It shall include discussions of:

(a) Direct effects and their significance (§1508.8).

(b) Indirect effects and their significance (§1508.8).

(c) Possible conflicts between the proposed action and the objectives of federal, regional, state, and local (and in the case of a reservation, Indian tribe) land use plans, policies and controls for the area concerned. (See §1506.2(d).)

(d) The environmental effects of alternatives including the proposed action. The comparisons under §1502.14 will be based on this discussion.

(e) Energy requirements and conservation potential of various alternatives and mitigation measures.

(f) Natural or depletable resource requirements and conservation potential of various alternatives and mitigation measures.

(g) Urban quality, historic and cultural resources, and the design of the built environment, including the reuse and conservation potential of various alternatives and mitigation measures.

(h) Means to mitigate adverse environmental impacts (if not fully covered under §1502.14(f)).

[43 FR 55994, Nov. 29, 1978; 44 FR 873, Jan. 3, 1979]

§1502.17 List of preparers.

The environmental impact statement shall list the names, together with their qualifications (expertise, experience, professional disciplines), of the persons who were primarily responsible for preparing the environmental impact statement or significant background papers, including basic components of the statement (§§1502.6 and 1502.8). Where possible the persons who are responsible for a particular analysis, including analyses in background papers, shall be identified. Normally the list will not exceed two pages.

§1502.18 Appendix.

If an agency prepares an appendix to an environmental impact statement the appendix shall:

(a) Consist of material prepared in connection with an environmental impact statement (as distinct from material which is not so prepared and which is incorporated by reference (§1502.21)).

(b) Normally consist of material which substantiates any analysis fundamental to the impact statement.

(c) Normally be analytic and relevant to the decision to be made.

(d) Be circulated with the environmental impact statement or be readily available on request.

§1502.19 Circulation of the environmental impact statement.

Agencies shall circulate the entire draft and final environmental impact statements except for certain appendices as provided in §1502.18(d) and unchanged statements as provided in §1503.4(c). However, if the statement is unusually long, the agency may circulate the summary instead, except that the entire statement shall be furnished to:

(a) Any federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved and any appropriate federal, state or local agency authorized to develop and enforce environmental standards.

(b) The applicant, if any.

(c) Any person, organization, or agency requesting the entire environmental impact statement.

(d) In the case of a final environmental impact statement any person, organization, or agency which submitted substantive comments on the draft. If the agency circulates the summary and thereafter receives a timely request for the entire statement and for additional time to comment, the time for that requestor only shall be extended by at least 15 days beyond the minimum period.

§1502.20 Tiering.

Agencies are encouraged to tier their environmental impact statements to eliminate repetitive discussions of the same issues and to focus on the actual issues ripe for decision at each level of environmental review (§1508.28). Whenever a broad environmental impact statement has been prepared (such as a program or policy statement) and a subsequent statement or

environmental assessment is then prepared on an action included within the entire program or policy (such as a site specific action) the subsequent statement or environmental assessment need only summarize the issues discussed in the broader statement and incorporate discussions from the broader statement by reference and shall concentrate on the issues specific to the subsequent action. The subsequent document shall state where the earlier document is available. Tiering may also be appropriate for different stages of actions. (Section 1508.28).

§1502.21 Incorporation by reference.

Agencies shall incorporate material into an environmental impact statement by reference when the effect will be to cut down on bulk without impeding agency and public review of the action. The incorporated material shall be cited in the statement and its content briefly described. No material may be incorporated by reference unless it is reasonably available for inspection by potentially interested persons within the time allowed for comment. Material based on proprietary data which is itself not available for review and comment shall not be incorporated by reference.

§1502.22 Incomplete or unavailable information.

When an agency is evaluating reasonably foreseeable significant adverse effects on the human environment in an environmental impact statement and there is incomplete or unavailable information, the agency shall always make clear that such information is lacking.

(a) If the incomplete information relevant to reasonably foreseeable significant adverse impacts is essential to a reasoned choice among alternatives and the overall costs of obtaining it are not exorbitant, the agency shall include the information in the environmental impact statement.

(b) If the information relevant to reasonably foreseeable significant adverse impacts cannot be obtained because the overall costs of obtaining it are exorbitant or the means to obtain it are not known, the agency shall include within the environmental impact statement: (1) A statement that such information is incomplete or unavailable; (2) a statement of the relevance of the incomplete or unavailable information to evaluating reasonably foreseeable significant adverse impacts on the human environment; (3) a summary of existing credible scientific evidence which is relevant to evaluating the reasonably foreseeable significant adverse impacts on the human environment; and (4) the agency's evaluation of such impacts based upon theoretical approaches or research methods generally accepted in the scientific community. For the purposes of this section, "reasonably foreseeable" includes impacts which have catastrophic consequences, even if their probability of occurrence is low, provided that the analysis of the impacts is supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason.

(c) The amended regulation will be applicable to all environmental impact statements for which a Notice of Intent (40 CFR 1508.22) is published in the FEDERAL REGISTER on or after May 27, 1986. For environmental impact statements in progress, agencies may choose to comply with the requirements of either the original or amended regulation.

[51 FR 15625, Apr. 25, 1986]

§1502.23 Cost-benefit analysis.

If a cost-benefit analysis relevant to the choice among environmentally different alternatives is being considered for the proposed action, it shall be incorporated by reference or appended to the statement as an aid in evaluating the environmental consequences. To assess the adequacy of compliance with section 102(2)(B) of the Act the statement shall, when a cost-benefit analysis is prepared, discuss the relationship between that analysis and any analyses of unquantified environmental impacts, values, and amenities. For purposes of complying with the Act, the weighing of the merits and drawbacks of the various alternatives need not be displayed in a monetary cost-benefit analysis and should not be when there are

important qualitative considerations. In any event, an environmental impact statement should at least indicate those considerations, including factors not related to environmental quality, which are likely to be relevant and important to a decision.

§1502.24 Methodology and scientific accuracy.

Agencies shall insure the professional integrity, including scientific integrity, of the discussions and analyses in environmental impact statements. They shall identify any methodologies used and shall make explicit reference by footnote to the scientific and other sources relied upon for conclusions in the statement. An agency may place discussion of methodology in an appendix.

§1502.25 Environmental review and consultation requirements.

(a) To the fullest extent possible, agencies shall prepare draft environmental impact statements concurrently with and integrated with environmental impact analyses and related surveys and studies required by the Fish and Wildlife Coordination Act (16 U.S.C. 661 *et seq.*), the National Historic Preservation Act of 1966 (16 U.S.C. 470 *et seq.*), the Endangered Species Act of 1973 (16 U.S.C. 1531 *et seq.*), and other environmental review laws and executive orders.

(b) The draft environmental impact statement shall list all federal permits, licenses, and other entitlements which must be obtained in implementing the proposal. If it is uncertain whether a federal permit, license, or other entitlement is necessary, the draft environmental impact statement shall so indicate.

PART 1503—COMMENTING

Sec.

1503.1 Inviting comments.
1503.2 Duty to comment.
1503.3 Specificity of comments.
1503.4 Response to comments.

AUTHORITY: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 *et seq.*), sec. 309 of the Clean Air Act, as amended (42 U.S.C. 7609), and E.O. 11514 (Mar. 5, 1970, as amended by E.O. 11991, May 24, 1977).

SOURCE: 43 FR 55997, Nov. 29, 1978, unless otherwise noted.

§1503.1 Inviting comments.

(a) After preparing a draft environmental impact statement and before preparing a final environmental impact statement the agency shall:

(1) Obtain the comments of any federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved or which is authorized to develop and enforce environmental standards.

(2) Request the comments of:

(i) Appropriate state and local agencies which are authorized to develop and enforce environmental standards;

(ii) Indian tribes, when the effects may be on a reservation; and

(iii) Any agency which has requested that it receive statements on actions of the kind proposed. Office of Management and Budget Circular A–95 (Revised), through its system of clearinghouses, provides a means of securing the views of state and local environmental agencies. The clearinghouses may be used, by mutual agreement of the lead agency and the clearinghouse, for securing state and local reviews of the draft environmental impact statements.

(3) Request comments from the applicant, if any.

(4) Request comments from the public, affirmatively soliciting comments from those persons or organizations who may be interested or affected.

(b) An agency may request comments on a final environmental impact statement before the decision is finally made. In any case other agencies or persons may make comments before the final decision unless a different time is provided under §1506.10.

§1503.2 Duty to comment.

Federal agencies with jurisdiction by law or special expertise with respect to any environmental impact involved and agencies which are authorized to develop and enforce environmen-

tal standards shall comment on statements within their jurisdiction, expertise, or authority. Agencies shall comment within the time period specified for comment in §1506.10. A Federal agency may reply that it has no comment. If a cooperating agency is satisfied that its views are adequately reflected in the environmental impact statement, it should reply that it has no comment.

§1503.3 Specificity of comments.

(a) Comments on an environmental impact statement or on a proposed action shall be as specific as possible and may address either the adequacy of the statement or the merits of the alternatives discussed or both.

(b) When a commenting agency criticizes a lead agency's predictive methodology, the commenting agency should describe the alternative methodology which it prefers and why.

(c) A cooperating agency shall specify in its comments whether it needs additional information to fulfill other applicable environmental reviews or consultation requirements and what information it needs. In particular, it shall specify any additional information it needs to comment adequately on the draft statement's analysis of significant site-specific effects associated with the granting or approving by that cooperating agency of necessary federal permits, licenses, or entitlements.

(d) When a cooperating agency with jurisdiction by law objects to or expresses reservations about the proposal on grounds of environmental impacts, the agency expressing the objection or reservation shall specify the mitigation measures it considers necessary to allow the agency to grant or approve applicable permit, license, or related requirements or concurrences.

§1503.4 Response to comments.

(a) An agency preparing a final environmental impact statement shall assess and consider comments both individually and collectively, and shall respond by one or more of the means listed below, stating its response in the final statement. Possible responses are to:

(1) Modify alternatives including the proposed action.

(2) Develop and evaluate alternatives not previously given serious consideration by the agency.

(3) Supplement, improve, or modify its analyses.

(4) Make factual corrections.

(5) Explain why the comments do not warrant further agency response, citing the sources, authorities, or reasons which support the agency's position and, if appropriate, indicate those circumstances which would trigger agency reappraisal or further response.

(b) All substantive comments received on the draft statement (or summaries thereof where the response has been exceptionally voluminous), should be attached to the final statement whether or not the comment is thought to merit individual discussion by the agency in the text of the statement.

(c) If changes in response to comments are minor and are confined to the responses described in paragraphs (a)(4) and (5) of this section, agencies may write them on errata sheets and attach them to the statement instead of rewriting the draft statement. In such cases only the comments, the responses, and the changes and not the final statement need be circulated (§1502.19). The entire document with a new cover sheet shall be filed as the final statement (§1506.9).

PART 1504—PREDECISION REFERRALS TO THE COUNCIL OF PROPOSED FEDERAL ACTIONS DETERMINED TO BE ENVIRONMENTALLY UNSATISFACTORY

Sec.

1504.1 Purpose.
1504.2 Criteria for referral.
1504.3 Procedure for referrals and response.

AUTHORITY: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 *et seq.*), sec. 309 of the Clean Air Act, as amended (42 U.S.C. 7609), and E.O. 11514 (Mar. 5, 1970, as amended by E.O. 11991, May 24, 1977).

Source: 43FR 55998, Nov. 29, 1978 unless otherwise noted.

§1504.1 Purpose.

(a) This part establishes procedures for referring to the Council federal interagency disagreements concerning proposed major federal actions that might cause unsatisfactory environmental effects. It provides means for early resolution of such disagreements.

(b) Under section 309 of the Clean Air Act (42 U.S.C. 7609), the Administrator of the Environmental Protection Agency is directed to review and comment publicly on the environmental impacts of federal activities, including actions for which environmental impact statements are prepared. If after this review the Administrator determines that the matter is "unsatisfactory from the standpoint of public health or welfare or environmental quality," section 309 directs that the matter be referred to the Council (hereafter "environmental referrals").

(c) Under section 102(2)(C) of the Act other federal agencies may make similar reviews of environmental impact statements, including judgments on the acceptability of anticipated environmental impacts. These reviews must be made available to the President, the Council and the public.

[43 FR 55998, Nov. 29, 1978]

§1504.2 Criteria for referral.

Environmental referrals should be made to the Council only after concerted, timely (as early as possible in the process), but unsuccessful attempts to resolve differences with the lead agency. In determining what environmental objections to the matter are appropriate to refer to the Council, an agency should weigh potential adverse environmental impacts, considering:

(a) Possible violation of national environmental standards or policies.

(b) Severity.

(c) Geographical scope.

(d) Duration.

(e) Importance as precedents.

(f) Availability of environmentally preferable alternatives.

[43 FR 55998, Nov. 29, 1978]

§1504.3 Procedure for referrals and response.

(a) A federal agency making the referral to the Council shall:

(1) Advise the lead agency at the earliest possible time that it intends to refer a matter to the Council unless a satisfactory agreement is reached.

(2) Include such advice in the referring agency's comments on the draft environmental impact statement, except when the statement does not contain adequate information to permit an assessment of the matter's environmental acceptability.

(3) Identify any essential information that is lacking and request that it be made available at the earliest possible time.

(4) Send copies of such advice to the Council.

(b) The referring agency shall deliver its referral to the Council not later than twenty-five (25) days after the final environmental impact statement has been made available to the Environmental Protection Agency, commenting agencies, and the public. Except when an extension of this period has been granted by the lead agency, the Council will not accept a referral after that date.

(c) The referral shall consist of:

(1) A copy of the letter signed by the head of the referring agency and delivered to the lead agency informing the lead agency of the referral and the reasons for it, and requesting that no action be taken to implement the matter until the Council acts upon the referral. The letter shall include a copy of the statement referred to in (c)(2) of this section.

(2) A statement supported by factual evidence leading to the conclusion that the matter is unsatisfactory from the standpoint of public health or welfare or environmental quality. The statement shall:

(i) Identify any material facts in controversy and incorporate (by reference if appropriate) agreed upon facts,

(ii) Identify any existing environmental requirements or policies which would be violated by the matter,

(iii) Present the reasons why the referring agency believes the matter is environmentally unsatisfactory,

(iv) Contain a finding by the agency whether the issue raised is of national importance because of the threat to national environmental resources or policies or for some other reason,

(v) Review the steps taken by the referring agency to bring its concerns to the attention of the lead agency at the earliest possible time, and

(vi) Give the referring agency's recommendations as to what mitigation alternative, further study, or other course of action (including abandonment of the matter) are necessary to remedy the situation.

(d) Not later than twenty-five (25) days after the referral to the Council the lead agency may deliver a response to the Council, and the referring agency. If the lead agency requests more time and gives assurance that the matter will not go forward in the interim, the Council may grant an extension. The response shall:

(1) Address fully the issues raised in the referral.

(2) Be supported by evidence.

(3) Give the lead agency's response to the referring agency's recommendations.

(e) Interested persons (including the applicant) may deliver their views in writing to the Council. Views in support of the referral should be delivered not later than the referral. Views in support of the response shall be delivered not later than the response.

(f) Not later than twenty-five (25) days after receipt of both the referral and any response or upon being informed that there will be no response (unless the lead agency agrees to a longer time), the Council may take one or more of the following actions:

(1) Conclude that the process of referral and response has successfully resolved the problem.

(2) Initiate discussions with the agencies with the objective of mediation with referring and lead agencies.

(3) Hold public meetings or hearings to obtain additional views and information.

(4) Determine that the issue is not one of national importance and request the referring and lead agencies to pursue their decision process.

(5) Determine that the issue should be further negotiated by the referring and lead agencies and is not appropriate for Council consideration until one or more heads of agencies report to the Council that the agencies' disagreements are irreconcilable.

(6) Publish its findings and recommendations (including where appropriate a finding that the submitted evidence does not support the position of an agency).

(7) When appropriate, submit the referral and the response together with the Council's recommendation to the President for action.

(g) The Council shall take no longer than 60 days to complete the actions specified in paragraph (f)(2), (3), or (5) of this section.

(h) When the referral involves an action required by statute to be determined on the record after opportunity for agency hearing, the referral shall be conducted in a manner consistent with 5 U.S.C. 557(d) (Administrative Procedure Act).

[43 FR 55998, Nov. 29, 1978; 44 FR 873, Jan. 3, 1979]

PART 1505—NEPA AND AGENCY DECISIONMAKING

Sec.

1505.1 Agency decisionmaking procedures.
1505.2 Record of decision in cases requiring environmental impact statements.
1505.3 Implementing the decision.

AUTHORITY: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 *et seq.*), sec. 309 of the Clean Air Act, as amended (42 U.S.C. 7609), and E.O. 11514 (Mar. 5, 1970, as amended by E.O. 11991, May 24, 1977).

SOURCE: 43 FR 55999, Nov. 29, 1978, unless otherwise noted.

§1505.1 Agency decisionmaking procedures.

Agencies shall adopt procedures (§1507.3) to ensure that decisions are made in accordance with the policies and purposes of the Act. Such procedures shall include but not be limited to:

(a) Implementing procedures under section 102(2) to achieve the requirements of sections 101 and 102(1).

(b) Designating the major decision points for the agency's principal programs likely to have a significant effect on the human environment

and assuring that the NEPA process corresponds with them.

(c) Requiring that relevant environmental documents, comments, and responses be part of the record in formal rulemaking or adjudicatory proceedings.

(d) Requiring that relevant environmental documents, comments, and responses accompany the proposal through existing agency review processes so that agency officials use the statement in making decisions.

(e) Requiring that the alternatives considered by the decisionmaker are encompassed by the range of alternatives discussed in the relevant environmental documents and that the decisionmaker consider the alternatives described in the environmental impact statement. If another decision document accompanies the relevant environmental documents to the decisionmaker, agencies are encouraged to make available to the public before the decision is made any part of that document that relates to the comparison of alternatives.

§1505.2 Record of decision in cases requiring environmental impact statements.

At the time of its decision (§1506.10) or, if appropriate, its recommendation to Congress, each agency shall prepare a concise public record of decision. The record, which may be integrated into any other record prepared by the agency, including that required by OMB Circular A–95 (Revised), part I, sections 6(c) and (d), and part II, section 5(b)(4), shall:

(a) State what the decision was.

(b) Identify all alternatives considered by the agency in reaching its decision, specifying the alternative or alternatives which were considered to be environmentally preferable. An agency may discuss preferences among alternatives based on relevant factors including economic and technical considerations and agency statutory missions. An agency shall identify and discuss all such factors including any essential considerations of national policy which were balanced by the agency in making its decision and state how those considerations entered into its decision.

(c) State whether all practicable means to avoid or minimize environmental harm from the alternative selected have been adopted, and if not, why they were not. A monitoring and enforcement program shall be adopted and summarized where applicable for any mitigation.

§1505.3 Implementing the decision.

Agencies may provide for monitoring to assure that their decisions are carried out and should do so in important cases. Mitigation (§1505.2(c)) and other conditions established in the environmental impact statement or during its review and committed as part of the decision shall be implemented by the lead agency or other appropriate consenting agency. The lead agency shall:

(a) Include appropriate conditions in grants, permits or other approvals.

(b) Condition funding of actions on mitigation.

(c) Upon request, inform cooperating or commenting agencies on progress in carrying out mitigation measures which they have proposed and which were adopted by the agency making the decision.

(d) Upon request, make available to the public the results of relevant monitoring.

PART 1506—OTHER REQUIREMENTS OF NEPA

Sec.

1506.1 Limitations on actions during NEPA process.
1506.2 Elimination of duplication with state and local procedures.
1506.3 Adoption.
1506.4 Combining documents.
1506.5 Agency responsibility.
1506.6 Public involvement.
1506.7 Further guidance.
1506.8 Proposals for legislation.
1506.9 Filing requirements.
1506.10 Timing of agency action.
1506.11 Emergencies.
1506.12 Effective date.

AUTHORITY: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 *et seq.*), sec. 309 of the Clean Air Act, as amended (42 U.S.C. 7609), and E.O. 11514 (Mar. 5, 1970, as amended by E.O. 11991, May 24, 1977).

SOURCE: 43 FR 56000, Nov. 29, 1978, unless otherwise noted.

§1506.1 Limitations on actions during NEPA process.

(a) Until an agency issues a record of decision as provided in §1505.2 (except as provided in paragraph (c) of this section), no action concerning the proposal shall be taken which would:

(1) Have an adverse environmental impact; or

(2) Limit the choice of reasonable alternatives.

(b) If any agency is considering an application from a non-federal entity, and is aware that the applicant is about to take an action within the agency's jurisdiction that would meet either of the criteria in paragraph (a) of this section, then the agency shall promptly notify the applicant that the agency will take appropriate action to insure that the objectives and procedures of NEPA are achieved.

(c) While work on a required program environmental impact statement is in progress and the action is not covered by an existing program statement, agencies shall not undertake in the interim any major federal action covered by the program which may significantly affect the quality of the human environment unless such action:

(1) Is justified independently of the program;

(2) Is itself accompanied by an adequate environmental impact statement; and

(3) Will not prejudice the ultimate decision on the program. Interim action prejudices the ultimate decision on the program when it tends to determine subsequent development or limit alternatives.

(d) This section does not preclude development by applicants of plans or designs or performance of other work necessary to support an application for federal, state or local permits or assistance. Nothing in this section shall preclude Rural Electrification Administration approval of minimal expenditures not affecting the environment (e.g. long leadtime equipment and purchase options) made by non-governmental entities seeking loan guarantees from the Administration.

§1506.2 Elimination of duplication with State and local procedures.

(a) Agencies authorized by law to cooperate with state agencies of statewide jurisdiction pursuant to section 102(2)(D) of the Act may do so.

(b) Agencies shall cooperate with state and local agencies to the fullest extent possible to reduce duplication between NEPA and state and local requirements, unless the agencies are specifically barred from doing so by some other law. Except for cases covered by paragraph (a) of this section, such cooperation shall to the fullest extent possible include:

(1) Joint planning processes.

(2) Joint environmental research and studies.

(3) Joint public hearings (except where otherwise provided by statute).

(4) Joint environmental assessments.

(c) Agencies shall cooperate with state and local agencies to the fullest extent possible to reduce duplication between NEPA and comparable State and local requirements, unless the agencies are specifically barred from doing so by some other law. Except for cases covered by paragraph (a) of this section, such cooperation shall to the fullest extent possible include joint environmental impact statements. In such cases one or more federal agencies and one or more state or local agencies shall be joint lead agencies. Where state laws or local ordinances have environmental impact statement requirements in addition to but not in conflict with those in NEPA, federal agencies shall cooperate in fulfilling these requirements as well as those of federal laws so that one document will comply with all applicable laws.

(d) To better integrate environmental impact statements into state or local planning processes, statements shall discuss any inconsistency of a proposed action with any approved state or local plan and laws (whether or not federally sanctioned). Where an inconsistency exists, the statement should describe the extent to which the agency would reconcile its proposed action with the plan or law.

§1506.3 Adoption.

(a) An agency may adopt a federal draft or final environmental impact statement or portion

thereof provided that the statement or portion thereof meets the standards for an adequate statement under these regulations.

(b) If the actions covered by the original environmental impact statement and the proposed action are substantially the same, the agency adopting another agency's statement is not required to recirculate it except as a final statement. Otherwise the adopting agency shall treat the statement as a draft and recirculate it (except as provided in paragraph (c) of this section).

(c) A cooperating agency may adopt without recirculating the environmental impact statement of a lead agency when, after an independent review of the statement, the cooperating agency concludes that its comments and suggestions have been satisfied.

(d) When an agency adopts a statement which is not final within the agency that prepared it, or when the action it assesses is the subject of a referral under part 1504, or when the statement's adequacy is the subject of a judicial action which is not final, the agency shall so specify.

§1506.4 Combining documents.

Any environmental document in compliance with NEPA may be combined with any other agency document to reduce duplication and paperwork.

§1506.5 Agency responsibility.

(a) Information. If an agency requires an applicant to submit environmental information for possible use by the agency in preparing an environmental impact statement, then the agency should assist the applicant by outlining the types of information required. The agency shall independently evaluate the information submitted and shall be responsible for its accuracy. If the agency chooses to use the information submitted by the applicant in the environmental impact statement, either directly or by reference, then the names of the persons responsible for the independent evaluation shall be included in the list of preparers (§1502.17). It is the intent of this paragraph that acceptable work not be redone, but that it be verified by the agency.

(b) Environmental assessments. If an agency permits an applicant to prepare an environmental assessment, the agency, besides fulfilling the requirements of paragraph (a) of this section, shall make its own evaluation of the environmental issues and take responsibility for the scope and content of the environmental assessment.

(c) Environmental impact statements. Except as provided in §§1506.2 and 1506.3 any environmental impact statement prepared pursuant to the requirements of NEPA shall be prepared directly by or by a contractor selected by the lead agency or where appropriate under §1501.6(b), a cooperating agency. It is the intent of these regulations that the contractor be chosen solely by the lead agency, or by the lead agency in cooperation with cooperating agencies, or where appropriate by a cooperating agency to avoid any conflict of interest. Contractors shall execute a disclosure statement prepared by the lead agency, or where appropriate the cooperating agency, specifying that they have no financial or other interest in the outcome of the project. If the document is prepared by contract, the responsible federal official shall furnish guidance and participate in the preparation and shall independently evaluate the statement prior to its approval and take responsibility for its scope and contents. Nothing in this section is intended to prohibit any agency from requesting any person to submit information to it or to prohibit any person from submitting information to any agency.

§1506.6 Public involvement.

Agencies shall:

(a) Make diligent efforts to involve the public in preparing and implementing their NEPA procedures.

(b) Provide public notice of NEPA-related hearings, public meetings, and the availability of environmental documents so as to inform those persons and agencies who may be interested or affected.

(1) In all cases the agency shall mail notice to those who have requested it on an individual action.

(2) In the case of an action with effects of national concern notice shall include publication in the FEDERAL REGISTER and notice by mail to

national organizations reasonably expected to be interested in the matter and may include listing in the 102 Monitor. An agency engaged in rulemaking may provide notice by mail to national organizations who have requested that notice regularly be provided. Agencies shall maintain a list of such organizations.

(3) In the case of an action with effects primarily of local concern the notice may include:

(i) Notice to state and areawide clearinghouses pursuant to OMB Circular A–95 (Revised).

(ii) Notice to Indian tribes when effects may occur on reservations.

(iii) Following the affected state's public notice procedures for comparable actions.

(iv) Publication in local newspapers (in papers of general circulation rather than legal papers).

(v) Notice through other local media.

(vi) Notice to potentially interested community organizations including small business associations.

(vii) Publication in newsletters that may be expected to reach potentially interested persons.

(viii) Direct mailing to owners and occupants of nearby or affected property.

(ix) Posting of notice on and off site in the area where the action is to be located.

(c) Hold or sponsor public hearings or public meetings whenever appropriate or in accordance with statutory requirements applicable to the agency. Criteria shall include whether there is:

(1) Substantial environmental controversy concerning the proposed action or substantial interest in holding the hearing.

(2) A request for a hearing by another agency with jurisdiction over the action supported by reasons why a hearing will be helpful. If a draft environmental impact statement is to be considered at a public hearing, the agency should make the statement available to the public at least 15 days in advance (unless the purpose of the hearing is to provide information for the draft environmental impact statement).

(d) Solicit appropriate information from the public.

(e) Explain in its procedures where interested persons can get information or status reports on environmental impact statements and other elements of the NEPA process.

(f) Make environmental impact statements, the comments received, and any underlying documents available to the public pursuant to the provisions of the Freedom of Information Act (5 U.S.C. 552), without regard to the exclusion for interagency memoranda where such memoranda transmit comments of Federal agencies on the environmental impact of the proposed action. Materials to be made available to the public shall be provided to the public without charge to the extent practicable, or at a fee which is not more than the actual costs of reproducing copies required to be sent to other federal agencies, including the Council.

§1506.7 Further guidance.

The Council may provide further guidance concerning NEPA and its procedures including:

(a) A handbook which the Council may supplement from time to time, which shall in plain language provide guidance and instructions concerning the application of NEPA and these regulations.

(b) Publication of the Council's Memoranda to Heads of Agencies.

(c) In conjunction with the Environmental Protection Agency and the publication of the 102 Monitor, notice of:

(1) Research activities;

(2) Meetings and conferences related to NEPA; and

(3) Successful and innovative procedures used by agencies to implement NEPA.

§1506.8 Proposals for legislation.

(a) The NEPA process for proposals for legislation (§1508.17) significantly affecting the quality of the human environment shall be integrated with the legislative process of the Congress. A legislative environmental impact statement is the detailed statement required by law to be included in a recommendation or report on a legislative proposal to Congress. A legislative environmental impact statement shall be considered part of the formal transmittal of a legislative proposal to Congress; however, it may be transmitted to Congress up to 30 days later in order to allow time for completion of an accurate statement which can serve as the basis for public and Congressional debate. The

statement must be available in time for Congressional hearings and deliberations.

(b) Preparation of a legislative environmental impact statement shall conform to the requirements of these regulations except as follows:

(1) There need not be a scoping process.

(2) The legislative statement shall be prepared in the same manner as a draft statement, but shall be considered the "detailed statement" required by statute; *Provided*, That when any of the following conditions exist both the draft and final environmental impact statement on the legislative proposal shall be prepared and circulated as provided by §§1503.1 and 1506.10.

(i) A Congressional committee with jurisdiction over the proposal has a rule requiring both draft and final environmental impact statements.

(ii) The proposal results from a study process required by statute (such as those required by the Wild and Scenic Rivers Act (16 U.S.C. 1271 *et seq.*) and the Wilderness Act (16 U.S.C. 1131 *et seq.*)).

(iii) Legislative approval is sought for federal or federally assisted construction or other projects which the agency recommends be located at specific geographic locations. For proposals requiring an environmental impact statement for the acquisition of space by the General Services Administration, a draft statement shall accompany the Prospectus or the 11(b) Report of Building Project Surveys to the Congress, and a final statement shall be completed before site acquisition.

(iv) The agency decides to prepare draft and final statements.

(c) Comments on the legislative statement shall be given to the lead agency which shall forward them along with its own responses to the Congressional committees with jurisdiction.

§1506.9 Filing requirements.

Environmental impact statements together with comments and responses shall be filed with the Environmental Protection Agency, attention Office of Federal Activities (MC2252-A), 1200 Pennsylvania Ave., NW., Washington, DC 20460. Statements shall be filed with EPA no earlier than they are also transmitted to commenting agencies and made available to the public. EPA shall deliver one copy of each statement to the Council, which shall satisfy the requirement of availability to the President. EPA may issue guidelines to agencies to implement its responsibilities under this section and §1506.10.

§1506.10 Timing of agency action.

(a) The Environmental Protection Agency shall publish a notice in the FEDERAL REGISTER each week of the environmental impact statements filed during the preceding week. The minimum time periods set forth in this section shall be calculated from the date of publication of this notice.

(b) No decision on the proposed action shall be made or recorded under §1505.2 by a federal agency until the later of the following dates:

(1) Ninety (90) days after publication of the notice described above in paragraph (a) of this section for a draft environmental impact statement.

(2) Thirty (30) days after publication of the notice described above in paragraph (a) of this section for a final environmental impact statement.

An exception to the rules on timing may be made in the case of an agency decision which is subject to a formal internal appeal. Some agencies have a formally established appeal process which allows other agencies or the public to take appeals on a decision and make their views known, after publication of the final environmental impact statement. In such cases, where a real opportunity exists to alter the decision, the decision may be made and recorded at the same time the environmental impact statement is published. This means that the period for appeal of the decision and the 30-day period prescribed in paragraph (b)(2) of this section may run concurrently. In such cases the environmental impact statement shall explain the timing and the public's right of appeal. An agency engaged in rulemaking under the Administrative Procedure Act or other statute for the purpose of protecting the public health or safety, may waive the time period in paragraph (b)(2) of this

section and publish a decision on the final rule simultaneously with publication of the notice of the availability of the final environmental impact statement as described in paragraph (a) of this section.

(c) If the final environmental impact statement is filed within ninety (90) days after a draft environmental impact statement is filed with the Environmental Protection Agency, the minimum thirty (30) day period and the minimum ninety (90) day period may run concurrently. However, subject to paragraph (d) of this section agencies shall allow not less than 45 days for comments on draft statements.

(d) The lead agency may extend prescribed periods. The Environmental Protection Agency may upon a showing by the lead agency of compelling reasons of national policy reduce the prescribed periods and may upon a showing by any other Federal agency of compelling reasons of national policy also extend prescribed periods, but only after consultation with the lead agency. (Also see §1507.3(d).) Failure to file timely comments shall not be a sufficient reason for extending a period. If the lead agency does not concur with the extension of time, EPA may not extend it for more than 30 days. When the Environmental Protection Agency reduces or extends any period of time it shall notify the Council.

[43 FR 56000, Nov. 29, 1978; 44 FR 874, Jan. 3, 1979]

§1506.11 Emergencies.

Where emergency circumstances make it necessary to take an action with significant environmental impact without observing the provisions of these regulations, the federal agency taking the action should consult with the Council about alternative arrangements. Agencies and the Council will limit such arrangements to actions necessary to control the immediate impacts of the emergency. Other actions remain subject to NEPA review.

§1506.12 Effective date.

The effective date of these regulations is July 30, 1979, except that for agencies that administer programs that qualify under section 102(2)(D) of the Act or under section 104(h) of the Housing and Community Development Act of 1974 an additional four months shall be allowed for the State or local agencies to adopt their implementing procedures.

(a) These regulations shall apply to the fullest extent practicable to ongoing activities and environmental documents begun before the effective date. These regulations do not apply to an environmental impact statement or supplement if the draft statement was filed before the effective date of these regulations. No completed environmental documents need be redone by reasons of these regulations. Until these regulations are applicable, the Council's guidelines published in the FEDERAL REGISTER of August 1, 1973, shall continue to be applicable. In cases where these regulations are applicable the guidelines are superseded. However, nothing shall prevent an agency from proceeding under these regulations at an earlier time.

(b) NEPA shall continue to be applicable to actions begun before January 1, 1970, to the fullest extent possible.

PART 1507—AGENCY COMPLIANCE

Sec.
1507.1 Compliance.
1507.2 Agency capability to comply.
1507.3 Agency procedures.

AUTHORITY: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 *et seq.*), sec. 309 of the Clean Air Act, as amended (42 U.S.C. 7609), and E.O. 11514 (Mar. 5, 1970, as amended by E.O. 11991, May 24, 1977).

SOURCE: 43 FR 56002, Nov. 29, 1978, unless otherwise noted.

§1507.1 Compliance.

All agencies of the federal government shall comply with these regulations. It is the intent of these regulations to allow each agency flexibility in adapting its implementing procedures authorized by §1507.3 to the requirements of other applicable laws.

§1507.2 Agency capability to comply.

Each agency shall be capable (in terms of personnel and other resources) of complying

with the requirements enumerated below. Such compliance may include use of other's resources, but the using agency shall itself have sufficient capability to evaluate what others do for it. Agencies shall:

(a) Fulfill the requirements of section 102(2)(A) of the Act to utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decisionmaking which may have an impact on the human environment. Agencies shall designate a person to be responsible for overall review of agency NEPA compliance.

(b) Identify methods and procedures required by section 102(2)(B) to insure that presently unquantified environmental amenities and values may be given appropriate consideration.

(c) Prepare adequate environmental impact statements pursuant to section 102(2)(C) and comment on statements in the areas where the agency has jurisdiction by law or special expertise or is authorized to develop and enforce environmental standards.

(d) Study, develop, and describe alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources. This requirement of section 102(2)(E) extends to all such proposals, not just the more limited scope of section 102(2)(C)(iii) where the discussion of alternatives is confined to impact statements.

(e) Comply with the requirements of section 102(2)(H) that the agency initiate and utilize ecological information in the planning and development of resource-oriented projects.

(f) Fulfill the requirements of sections 102(2)(F), 102(2)(G), and 102(2)(I), of the Act and of Executive Order 11514, Protection and Enhancement of Environmental Quality, Sec. 2.

§1507.3 Agency procedures.

(a) Not later than eight months after publication of these regulations as finally adopted in the FEDERAL REGISTER, or five months after the establishment of an agency, whichever shall come later, each agency shall as necessary adopt procedures to supplement these regulations. When the agency is a department, major subunits are encouraged (with the consent of the department) to adopt their own procedures. Such procedures shall not paraphrase these regulations. They shall confine themselves to implementing procedures. Each agency shall consult with the Council while developing its procedures and before publishing them in the FEDERAL REGISTER for comment. Agencies with similar programs should consult with each other and the Council to coordinate their procedures, especially for programs requesting similar information from applicants. The procedures shall be adopted only after an opportunity for public review and after review by the Council for conformity with the Act and these regulations. The Council shall complete its review within 30 days. Once in effect they shall be filed with the Council and made readily available to the public. Agencies are encouraged to publish explanatory guidance for these regulations and their own procedures. Agencies shall continue to review their policies and procedures and in consultation with the Council to revise them as necessary to ensure full compliance with the purposes and provisions of the Act.

(b) Agency procedures shall comply with these regulations except where compliance would be inconsistent with statutory requirements and shall include:

(1) Those procedures required by §§1501.2(d), 1502.9(c)(3), 1505.1, 1506.6(e), and 1508.4.

(2) Specific criteria for and identification of those typical classes of action:

(i) Which normally do require environmental impact statements.

(ii) Which normally do not require either an environmental impact statement or an environmental assessment (categorical exclusions (§1508.4)).

(iii) Which normally require environmental assessments but not necessarily environmental impact statements.

(c) Agency procedures may include specific criteria for providing limited exceptions to the provisions of these regulations for classified proposals. They are proposed actions which are specifically authorized under criteria established by an Executive Order or statute to be kept secret in the interest of national defense or foreign policy and are in fact properly classified pursuant to such Executive Order or statute. Environmental assess-

ments and environmental impact statements which address classified proposals may be safeguarded and restricted from public dissemination in accordance with agencies' own regulations applicable to classified information. These documents may be organized so that classified portions can be included as annexes, in order that the unclassified portions can be made available to the public.

(d) Agency procedures may provide for periods of time other than those presented in §1506.10 when necessary to comply with other specific statutory requirements.

(e) Agency procedures may provide that where there is a lengthy period between the agency's decision to prepare an environmental impact statement and the time of actual preparation, the notice of intent required by §1501.7 may be published at a reasonable time in advance of preparation of the draft statement.

PART 1508—TERMINOLOGY AND INDEX

Sec.

1508.1 Terminology.
1508.2 Act.
1508.3 Affecting.
1508.4 Categorical exclusion.
1508.5 Cooperating agency.
1508.6 Council.
1508.7 Cumulative impact.
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1508.14 Human environment.
1508.15 Jurisdiction by law.
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1508.17 Legislation.
1508.18 Major Federal action.
1508.19 Matter.
1508.20 Mitigation.
1508.21 NEPA process.
1508.22 Notice of intent.
1508.23 Proposal.
1508.24 Referring agency.
1508.25 Scope.
1508.26 Special expertise.
1508.27 Significantly.
1508.28 Tiering.

AUTHORITY: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 *et seq.*), sec. 309 of the Clean Air Act, as amended (42 U.S.C. 7609), and E.O. 11514 (Mar. 5, 1970, as amended by E.O. 11991, May 24, 1977).

SOURCE: 43 FR 56003, Nov. 29, 1978, unless otherwise noted.

§1508.1 Terminology.

The terminology of this part shall be uniform throughout the federal government.

§1508.2 Act.

"Act" means the National Environmental Policy Act, as amended (42 U.S.C. 4321, *et seq.*) which is also referred to as "NEPA."

§1508.3 Affecting.

"Affecting" means will or may have an effect on.

§1508.4 Categorical exclusion.

"Categorical exclusion" means a category of actions which do not individually or cumulatively have a significant effect on the human environment and which have been found to have no such effect in procedures adopted by a federal agency in implementation of these regulations (§1507.3) and for which, therefore, neither an environmental assessment nor an environmental impact statement is required. An agency may decide in its procedures or otherwise, to prepare environmental assessments for the reasons stated in §1508.9 even though it is not required to do so. Any procedures under this section shall provide for extraordinary circumstances in which a normally excluded action may have a significant environmental effect.

§1508.5 Cooperating agency.

"Cooperating agency" means any federal agency other than a lead agency which has jurisdiction by law or special expertise with respect to any environmental impact involved

in a proposal (or a reasonable alternative) for legislation or other major federal action significantly affecting the quality of the human environment. The selection and responsibilities of a cooperating agency are described in §1501.6. A state or local agency of similar qualifications or, when the effects are on a reservation, an Indian tribe, may by agreement with the lead agency become a cooperating agency.

§1508.6 Council.

"Council" means the Council on Environmental Quality established by title II of the Act.

§1508.7 Cumulative impact.

"Cumulative impact" is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

§1508.8 Effects.

"Effects" include:

(a) Direct effects, which are caused by the action and occur at the same time and place.

(b) Indirect effects, which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems.

Effects and impacts as used in these regulations are synonymous. Effects includes ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative. Effects may also include those resulting from actions which may have both beneficial and detrimental effects, even if on balance the agency believes that the effect will be beneficial.

§1508.9 Environmental assessment.

"Environmental assessment":

(a) Means a concise public document for which a federal agency is responsible that serves to:

(1) Briefly provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact.

(2) Aid an agency's compliance with the Act when no environmental impact statement is necessary.

(3) Facilitate preparation of a statement when one is necessary.

(b) Shall include brief discussions of the need for the proposal, of alternatives as required by section 102(2)(E), of the environmental impacts of the proposed action and alternatives, and a listing of agencies and persons consulted.

§1508.10 Environmental document.

"Environmental document" includes the documents specified in §1508.9 (environmental assessment), §1508.11 (environmental impact statement), §1508.13 (finding of no significant impact), and §1508.22 (notice of intent).

§1508.11 Environmental impact statement.

"Environmental impact statement" means a detailed written statement as required by section 102(2)(C) of the Act.

§1508.12 Federal agency.

"Federal agency" means all agencies of the federal government. It does not mean the Congress, the Judiciary, or the President, including the performance of staff functions for the President in his Executive Office. It also includes for purposes of these regulations states and units of general local government and Indian tribes assuming NEPA responsibilities under section 104(h) of the Housing and Community Development Act of 1974.

§1508.13 Finding of no significant impact.

"Finding of no significant impact" means a document by a federal agency briefly presenting the reasons why an action, not otherwise excluded (§1508.4), will not have a significant effect on the human environment and for which an environmental impact statement there fore will not be prepared. It shall include the environmental assessment or a summary of it and shall note any other environmental documents related to it (§1501.7(a)(5)). If the assessment is included, the finding need not repeat any of the discussion in the assessment but may incorporate it by reference.

§1508.14 Human environment.

"Human environment" shall be interpreted comprehensively to include the natural and physical environment and the relationship of people with that environment. (See the definition of "effects" (§1508.8).) This means that economic or social effects are not intended by themselves to require preparation of an environmental impact statement. When an environmental impact statement is prepared and economic or social and natural or physical environmental effects are interrelated, then the environmental impact statement will discuss all of these effects on the human environment.

§1508.15 Jurisdiction by law.

"Jurisdiction by law" means agency authority to approve, veto, or finance all or part of the proposal.

§1508.16 Lead agency.

"Lead agency" means the agency or agencies preparing or having taken primary responsibility for preparing the environmental impact statement.

§1508.17 Legislation.

"Legislation" includes a bill or legislative proposal to Congress developed by or with the significant cooperation and support of a federal agency, but does not include requests for appropriations. The test for significant cooperation is whether the proposal is in fact predominantly that of the agency rather than another source. Drafting does not by itself constitute significant cooperation. Proposals for legislation include requests for ratification of treaties. Only the agency which has primary responsibility for the subject matter involved will prepare a legislative environmental impact statement.

§1508.18 Major federal action.

"Major federal action" includes actions with effects that may be major and which are potentially subject to federal control and responsibility. Major reinforces but does not have a meaning independent of significantly (§1508.27). Actions include the circumstance where the responsible officials fail to act and that failure to act is reviewable by courts or administrative tribunals under the Administrative Procedure Act or other applicable law as agency action.

(a) Actions include new and continuing activities, including projects and programs entirely or partly financed, assisted, conducted, regulated, or approved by federal agencies; new or revised agency rules, regulations, plans, policies, or procedures; and legislative proposals (§§1506.8, 1508.17). Actions do not include funding assistance solely in the form of general revenue sharing funds, distributed under the State and Local Fiscal Assistance Act of 1972, 31 U.S.C. 1221 *et seq.*, with no federal agency control over the subsequent use of such funds. Actions do not include bringing judicial or administrative civil or criminal enforcement actions.

(b) Federal actions tend to fall within one of the following categories:

(1) Adoption of official policy, such as rules, regulations, and interpretations adopted pursuant to the Administrative Procedure Act, 5 U.S.C. 551 *et seq.*; treaties and international conventions or agreements; formal documents establishing an agency's policies which will result in or substantially alter agency programs.

(2) Adoption of formal plans, such as official documents prepared or approved by federal agencies which guide or prescribe alternative

uses of federal resources, upon which future agency actions will be based.

(3) Adoption of programs, such as a group of concerted actions to implement a specific policy or plan; systematic and connected agency decisions allocating agency resources to implement a specific statutory program or executive directive.

(4) Approval of specific projects, such as construction or management activities located in a defined geographic area. Projects include actions approved by permit or other regulatory decision as well as federal and federally assisted activities.

§1508.19 Matter.

"Matter" includes for purposes of Part 1504:

(a) With respect to the Environmental Protection Agency, any proposed legislation, project, action or regulation as those terms are used in section 309(a) of the Clean Air Act (42 U.S.C. 7609).

(b) With respect to all other agencies, any proposed major federal action to which section 102(2)(C) of NEPA applies.

§1508.20 Mitigation.

"Mitigation" includes:

(a) Avoiding the impact altogether by not taking a certain action or parts of an action.

(b) Minimizing impacts by limiting the degree or magnitude of the action and its implementation.

(c) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.

(d) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.

(e) Compensating for the impact by replacing or providing substitute resources or environments.

§1508.21 NEPA process.

"NEPA process" means all measures necessary for compliance with the requirements of section 2 and title I of NEPA.

§1508.22 Notice of intent.

"Notice of intent" means a notice that an environmental impact statement will be prepared and considered. The notice shall briefly:

(a) Describe the proposed action and possible alternatives.

(b) Describe the agency's proposed scoping process including whether, when, and where any scoping meeting will be held.

(c) State the name and address of a person within the agency who can answer questions about the proposed action and the environmental impact statement.

§1508.23 Proposal.

"Proposal" exists at that stage in the development of an action when an agency subject to the Act has a goal and is actively preparing to make a decision on one or more alternative means of accomplishing that goal and the effects can be meaningfully evaluated. Preparation of an environmental impact statement on a proposal should be timed (§1502.5) so that the final statement may be completed in time for the statement to be included in any recommendation or report on the proposal. A proposal may exist in fact as well as by agency declaration that one exists.

§1508.24 Referring agency.

"Referring agency" means the federal agency which has referred any matter to the Council after a determination that the matter is unsatisfactory from the standpoint of public health or welfare or environmental quality.

§1508.25 Scope.

"Scope" consists of the range of actions, alternatives, and impacts to be considered in an environmental impact statement. The scope of an individual statement may depend on its relationships to other statements (§§1502.20 and 1508.28). To determine the scope of environmental impact statements, agencies shall consider 3 types of actions, 3 types of alternatives, and 3 types of impacts. They include:

(a) Actions (other than unconnected single actions) which may be:

(1) Connected actions, which means that they are closely related and therefore should be discussed in the same impact statement. Actions are connected if they:

(i) Automatically trigger other actions which may require environmental impact statements.

(ii) Cannot or will not proceed unless other actions are taken previously or simultaneously.

(iii) Are interdependent parts of a larger action and depend on the larger action for their justification.

(2) Cumulative actions, which when viewed with other proposed actions have cumulatively significant impacts and should therefore be discussed in the same impact statement.

(3) Similar actions, which when viewed with other reasonably foreseeable or proposed agency actions, have similarities that provide a basis for evaluating their environmental consequencies together, such as common timing or geography. An agency may wish to analyze these actions in the same impact statement. It should do so when the best way to assess adequately the combined impacts of similar actions or reasonable alternatives to such actions is to treat them in a single impact statement.

(b) Alternatives, which include:

(1) No action alternative.

(2) Other reasonable courses of actions.

(3) Mitigation measures (not in the proposed action).

(c) Impacts, which may be: (1) direct; (2) indirect; (3) cumulative.

§1508.26 Special expertise.

"Special expertise" means statutory responsibility, agency mission, or related program experience.

§1508.27 Significantly.

"Significantly" as used in NEPA requires considerations of both context and intensity:

(a) *Context.* This means that the significance of an action must be analyzed in several contexts such as society as a whole (human, national), the affected region, the affected interests, and the locality. Significance varies with the setting of the proposed action. For instance, in the case of a site-specific action, significance would usually depend upon the effects in the locale rather than in the world as a whole. Both short and long-term effects are relevant.

(b) *Intensity.* This refers to the severity of impact. Responsible officials must bear in mind that more than one agency may make decisions about partial aspects of a major action. The following should be considered in evaluating intensity:

(1) Impacts that may be both beneficial and adverse. A significant effect may exist even if the federal agency believes that on balance the effect will be beneficial.

(2) The degree to which the proposed action affects public health or safety.

(3) Unique characteristics of the geographic area such as proximity to historic or cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas.

(4) The degree to which the effects on the quality of the human environment are likely to be highly controversial.

(5) The degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks.

(6) The degree to which the action may establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration.

(7) Whether the action is related to other actions with individually insignificant but cumulatively significant impacts. Significance exists if it is reasonable to anticipate a cumulatively significant impact on the environment. Significance cannot be avoided by terming an action temporary or by breaking it down into small component parts.

(8) The degree to which the action may adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places or may cause loss or destruction of significant scientific, cultural, or historical resources.

(9) The degree to which the action may adversely affect an endangered or threatened species or its habitat that has been determined to be critical under the Endangered Species Act of 1973.

(10) Whether the action threatens a violation of federal, state, or local law or requirements imposed for the protection of the environment. [43 FR 56003, Nov. 29, 1978; 44 FR 874, Jan. 3, 1979]

§1508.28 Tiering.

"Tiering" refers to the coverage of general matters in broader environmental impact statements (such as national program or policy statements) with subsequent narrower statements or environmental analyses (such as regional or basinwide program statements or ultimately site-specific statements) incorporating by reference the general discussions and concentrating solely on the issues specific to the statement subsequently prepared. Tiering is appropriate when the sequence of statements or analyses is:

(a) From a program, plan, or policy environmental impact statement to a program, plan, orpolicy statement or analysis of lesser scope or to a site-specific statement or analysis.

(b) From an environmental impact statement on a specific action at an early stage (such as need and site selection) to a supplement (which is preferred) or a subsequent statement or analysis at a later stage (such as environmental mitigation). Tiering in such cases is appropriate when it helps the lead agency to focus on the issues which are ripe for decision and exclude from consideration issues already decided or not yet ripe.

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It is compiled and kept up-to-date by the Council on Environmental Quality.

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THE NATIONAL ENVIRONMENTAL POLICY ACT OF 1969, as amended (Pub. L. 91-190, 42 U.S.C. 4321-4347, January 1, 1970, as amended by Pub. L. 94-52, July 3, 1975, Pub. L. 94-83, August 9, 1975, and Pub. L. 97-258, § 4(b), Sept. 13, 1982)

An Act to establish a national policy for the environment, to provide for the establishment of a Council on Environmental Quality, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "National Environmental Policy Act of 1969."

PURPOSE

Sec. 2 [42 USC § 4321].

The purposes of this Act are: To declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality.

TITLE I

Congressional Declaration of National Environmental Policy

Sec. 101 [42 USC § 4331].

(a) The Congress, recognizing the profound impact of man's activity on the interrelations of all components of the natural environment, particularly the profound influences of population growth, high-density urbanization, industrial expansion, resource exploitation, and new and expanding technological advances and recognizing further the critical importance of restoring and maintaining environmental quality to the overall welfare and development of man, declares that it is the continuing policy of the federal government, in cooperation with state and local governments, and other concerned public and private organizations, to use all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans.

(b) In order to carry out the policy set forth in this Act, it is the continuing responsibility of the federal government to use all practicable means, consistent with other essential considerations of national policy, to improve and coordinate federal plans, functions, programs, and resources to the end that the Nation may —

1. fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;
2. assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings;
3. attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences;
4. preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity, and variety of individual choice;
5. achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities; and
6. enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

(c) The Congress recognizes that each person should enjoy a healthful environment and that each person has a responsibility to contribute to the preservation and enhancement of the environment.

Sec. 102 [42 USC § 4332].

The Congress authorizes and directs that, to the fullest extent possible: (1) the policies, regulations, and public laws of the United States shall be interpreted and administered in accordance

with the policies set forth in this Act, and (2) all agencies of the federal government shall —

(A) utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decisionmaking which may have an impact on man's environment;

(B) identify and develop methods and procedures, in consultation with the Council on Environmental Quality established by title II of this Act, which will insure that presently unquantified environmental amenities and values may be given appropriate consideration in decisionmaking along with economic and technical considerations;

(C) include in every recommendation or report on proposals for legislation and other major federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on —

(i) the environmental impact of the proposed action,

(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,

(iii) alternatives to the proposed action,

(iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

(v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Prior to making any detailed statement, the responsible federal official shall consult with and obtain the comments of any federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved. Copies of such statement and the comments and views of the appropriate federal, state, and local agencies, which are authorized to develop and enforce environmental standards, shall be made available to the President, the Council on Environmental Quality and to the public as provided by section 552 of title 5, United States Code, and shall accompany the proposal through the existing agency review processes;

(D) Any detailed statement required under subparagraph (C) after January 1, 1970, for any major federal action funded under a program of grants to States shall not be deemed to be legally insufficient solely by reason of having been prepared by a state agency or official, if:

(i) the state agency or official has statewide jurisdiction and has the responsibility for such action,

(ii) the responsible federal official furnishes guidance and participates in such preparation,

(iii) the responsible federal official independently evaluates such statement prior to its approval and adoption, and

(iv) after January 1, 1976, the responsible federal official provides early notification to, and solicits the views of, any other state or any federal land management entity of any action or any alternative thereto which may have significant impacts upon such state or affected federal land management entity and, if there is any disagreement on such impacts, prepares a written assessment of such impacts and views for incorporation into such detailed statement.

The procedures in this subparagraph shall not relieve the federal official of his responsibilities for the scope, objectivity, and content of the entire statement or of any other responsibility under this Act; and further, this subparagraph does not affect the legal sufficiency of statements prepared by state agencies with less than statewide jurisdiction.

(E) study, develop, and describe appropriate alternatives to recommended courses of

action in any proposal which involves unresolved conflicts concerning alternative uses of available resources;

(F) recognize the worldwide and long-range character of environmental problems and, where consistent with the foreign policy of the United States, lend appropriate support to initiatives, resolutions, and programs designed to maximize international cooperation in anticipating and preventing a decline in the quality of mankind's world environment;

(G) make available to states, counties, municipalities, institutions, and individuals, advice and information useful in restoring, maintaining, and enhancing the quality of the environment;

(H) initiate and utilize ecological information in the planning and development of resource-oriented projects; and

(I) assist the Council on Environmental Quality established by title II of this Act.

Sec. 103 [42 USC § 4333].

All agencies of the federal government shall review their present statutory authority, administrative regulations, and current policies and procedures for the purpose of determining whether there are any deficiencies or inconsistencies therein which prohibit full compliance with the purposes and provisions of this Act and shall propose to the President not later than July 1, 1971, such measures as may be necessary to bring their authority and policies into conformity with the intent, purposes, and procedures set forth in this Act.

Sec. 104 [42 USC § 4334].

Nothing in section 102 [42 USC § 4332] or 103 [42 USC § 4333] shall in any way affect the specific statutory obligations of any federal agency (1) to comply with criteria or standards of environmental quality, (2) to coordinate or consult with any other federal or state agency, or (3) to act, or refrain from acting contingent upon the recommendations or certification of any other federal or state agency.

Sec. 105 [42 USC § 4335].

The policies and goals set forth in this Act are supplementary to those set forth in existing authorizations of federal agencies.

TITLE II

COUNCIL ON ENVIRONMENTAL QUALITY

Sec. 201 [42 USC § 4341].

The President shall transmit to the Congress annually beginning July 1, 1970, an Environmental Quality Report (hereinafter referred to as the "report") which shall set forth (1) the status and condition of the major natural, manmade, or altered environmental classes of the Nation, including, but not limited to, the air, the aquatic, including marine, estuarine, and fresh water, and the terrestrial environment, including, but not limited to, the forest, dryland, wetland, range, urban, suburban an rural environment; (2) current and foreseeable trends in the quality, management and utilization of such environments and the effects of those trends on the social, economic, and other requirements of the Nation; (3) the adequacy of available natural resources for fulfilling human and economic requirements of the Nation in the light of expected population pressures; (4) a review of the programs and activities (including regulatory activities) of the federal government, the state and local governments, and nongovernmental entities or individuals with particular reference to their effect on the environment and on the conservation, development and utilization of natural resources; and (5) a program for remedying the deficiencies of existing programs and activities, together with recommendations for legislation.

Sec. 202 [42 USC § 4342].

There is created in the Executive Office of the President a Council on Environmental Quality (hereinafter referred to as the "Council"). The Council shall be composed of three members who shall be appointed by the President to serve at his pleasure, by and with the advice and consent of the Senate. The President shall designate one of the members of the Council to serve as Chairman. Each member shall be a person who,

as a result of his training, experience, and attainments, is exceptionally well qualified to analyze and interpret environmental trends and information of all kinds; to appraise programs and activities of the federal government in the light of the policy set forth in title I of this Act; to be conscious of and responsive to the scientific, economic, social, aesthetic, and cultural needs and interests of the Nation; and to formulate and recommend national policies to promote the improvement of the quality of the environment.

Sec. 203 [42 USC § 4343].

(a) The Council may employ such officers and employees as may be necessary to carry out its functions under this Act. In addition, the Council may employ and fix the compensation of such experts and consultants as may be necessary for the carrying out of its functions under this Act, in accordance with section 3109 of title 5, United States Code (but without regard to the last sentence thereof).

(b) Notwithstanding section 1342 of Title 31, the Council may accept and employ voluntary and uncompensated services in furtherance of the purposes of the Council.

Sec. 204 [42 USC § 4344].

It shall be the duty and function of the Council —

1. to assist and advise the President in the preparation of the Environmental Quality Report required by section 201 [42 USC § 4341] of this title;
2. to gather timely and authoritative information concerning the conditions and trends in the quality of the environment both current and prospective, to analyze and interpret such information for the purpose of determining whether such conditions and trends are interfering, or are likely to interfere, with the achievement of the policy set forth in title I of this Act, and to compile and submit to the President studies relating to such conditions and trends;
3. to review and appraise the various programs and activities of the federal government in the light of the policy set forth in title I of this Act for the purpose of determining the extent to which such programs and activities are contributing to the achievement of such policy, and to make recommendations to the President with respect thereto;
4. to develop and recommend to the President national policies to foster and promote the improvement of environmental quality to meet the conservation, social, economic, health, and other requirements and goals of the Nation;
5. to conduct investigations, studies, surveys, research, and analyses relating to ecological systems and environmental quality;
6. to document and define changes in the natural environment, including the plant and animal systems, and to accumulate necessary data and other information for a continuing analysis of these changes or trends and an interpretation of their underlying causes;
7. to report at least once each year to the President on the state and condition of the environment; and
8. to make and furnish such studies, reports thereon, and recommendations with respect to matters of policy and legislation as the President may request.

Sec. 205 [42 USC § 4345].

In exercising its powers, functions, and duties under this Act, the Council shall —

1. consult with the Citizens' Advisory Committee on Environmental Quality established by Executive Order No. 11472, dated May 29, 1969, and with such representatives of science, industry, agriculture, labor, conservation organizations, state and local governments and other groups, as it deems advisable; and
2. utilize, to the fullest extent possible, the services, facilities and information (including statistical information) of public and private agencies and organizations, and individuals, in order that duplication

of effort and expense may be avoided, thus assuring that the Council's activities will not unnecessarily overlap or conflict with similar activities authorized by law and performed by established agencies.

Sec. 206 [42 USC § 4346].

Members of the Council shall serve full time and the Chairman of the Council shall be compensated at the rate provided for Level II of the Executive Schedule Pay Rates [5 USC § 5313]. The other members of the Council shall be compensated at the rate provided for Level IV of the Executive Schedule Pay Rates [5 USC § 5315].

Sec. 207 [42 USC § 4346a].

The Council may accept reimbursements from any private nonprofit organization or from any department, agency, or instrumentality of the federal government, any state, or local government, for the reasonable travel expenses incurred by an officer or employee of the Council in connection with his attendance at any conference, seminar, or similar meeting conducted for the benefit of the Council.

Sec. 208 [42 USC § 4346b].

The Council may make expenditures in support of its international activities, including expenditures for: (1) international travel; (2) activities in implementation of international agreements; and (3) the support of international exchange programs in the United States and in foreign countries.

Sec. 209 [42 USC § 4347].

There are authorized to be appropriated to carry out the provisions of this chapter not to exceed $300,000 for fiscal year 1970, $700,000 for fiscal year 1971, and $1,000,000 for each fiscal year thereafter.

The Environmental Quality Improvement Act, as amended (Pub. L. No. 91- 224, Title II, April 3, 1970; Pub. L. No. 97-258, September 13, 1982; and Pub. L. No. 98-581, October 30, 1984.

42 USC § 4372.

(a) There is established in the Executive Office of the President an office to be known as the Office of Environmental Quality (hereafter in this chapter referred to as the "Office"). The Chairman of the Council on Environmental Quality established by Public Law 91-190 shall be the Director of the Office. There shall be in the Office a Deputy Director who shall be appointed by the President, by and with the advice and consent of the Senate.

(b) The compensation of the Deputy Director shall be fixed by the President at a rate not in excess of the annual rate of compensation payable to the Deputy Director of the Office of Management and Budget.

(c) The Director is authorized to employ such officers and employees (including experts and consultants) as may be necessary to enable the Office to carry out its functions; under this chapter and Public Law 91-190, except that he may employ no more than ten specialists and other experts without regard to the provisions of Title 5, governing appointments in the competitive service, and pay such specialists and experts without regard to the provisions of chapter 51 and subchapter III of chapter 53 of such title relating to classification and General Schedule pay rates, but no such specialist or expert shall be paid at a rate in excess of the maximum rate for GS-18 of the General Schedule under section 5332 of Title 5.

(d) In carrying out his functions the Director shall assist and advise the President on policies and programs of the federal government affecting environmental quality by —

1. providing the professional and administrative staff and support for the Council on Environmental Quality established by Public Law 91- 190;
2. assisting the federal agencies and departments in appraising the effectiveness of existing and proposed facilities, programs, policies, and activities of the federal government, and those specific major projects designated by the President which do not require individual project authorization by Congress, which affect environmental quality;

3. reviewing the adequacy of existing systems for monitoring and predicting environmental changes in order to achieve effective coverage and efficient use of research facilities and other resources;

4. promoting the advancement of scientific knowledge of the effects of actions and technology on the environment and encouraging the development of the means to prevent or reduce adverse effects that endanger the health and well-being of man;

5. assisting in coordinating among the federal departments and agencies those programs and activities which affect, protect, and improve environmental quality;

6. assisting the federal departments and agencies in the development and interrelationship of environmental quality criteria and standards established throughout the federal government;

7. collecting, collating, analyzing, and interpreting data and information on environmental quality, ecological research, and evaluation.

(e) The Director is authorized to contract with public or private agencies, institutions, and organizations and with individuals without regard to section 3324(a) and (b) of Title 31 and section 5 of Title 41 in carrying out his functions.

42 USC § 4373.

Each Environmental Quality Report required by Public Law 91-190 shall, upon transmittal to Congress, be referred to each standing committee having jurisdiction over any part of the subject matter of the Report.

42 USC § 4374.

There are hereby authorized to be appropriated for the operations of the Office of Environmental Quality and the Council on Environmental Quality not to exceed the following sums for the following fiscal years which sums are in addition to those contained in Public Law 91- 190:

(a) $2,126,000 for the fiscal year ending September 30, 1979.

(b) $3,000,000 for the fiscal years ending September 30, 1980, and September 30, 1981.

(c) $44,000 for the fiscal years ending September 30, 1982, 1983, and 1984.

(d) $480,000 for each of the fiscal years ending September 30, 1985 and 1986.

42 USC § 4375.

(a) There is established an Office of Environmental Quality Management Fund (hereinafter referred to as the "Fund") to receive advance payments from other agencies or accounts that may be used solely to finance —

1. study contracts that are jointly sponsored by the Office and one or more other federal agencies; and

2. Federal interagency environmental projects (including task forces) in which the Office participates.

(b) Any study contract or project that is to be financed under subsection (a) of this section may be initiated only with the approval of the Director.

(c) The Director shall promulgate regulations setting forth policies and procedures for operation of the Fund.

THE CLEAN AIR ACT § 309*

§ 7609. Policy review

(a) The Administrator shall review and comment in writing on the environmental impact of any matter relating to duties and responsibilities granted pursuant to this chapter or other provisions of the authority of the Administration, contained in any (1) legislation proposed by any federal department or agency, (2) newly authorized federal projects for construction and any major federal agency action (other than a project for construction) to which section 4332(2)(C) of the title applies, and (3) proposed regulations published by any department or agency of the federal government. Such written comment shall be made public at the conclusion of any such review.

(b) In the event the Administrator determines that any such legislation, action, or regulation is unsatisfactory from the standpoint of public health or welfare or environmental quality, he shall publish his determination and the matter shall be referred to the Council on Environmental Quality.

*July 14, 1955, c. 360, § 309, as added December 31, 1970, Pub. L. 91-604 § 12(a), 42 U.S.C. § 7609 (1970).

Executive Order 11514—Protection and enhancement of environmental quality

Source: The provisions of Executive Order 11514 of Mar. 5, 1970, appear at 35 FR 4247, 3 CFR, 1966-1970, Comp., p. 902, unless otherwise noted.

By virtue of the authority vested in me as President of the United States and in furtherance of the purpose and policy of the National Environmental Policy Act of 1969 (Public Law No. 91-190, approved January 1, 1970), it is ordered as follows:

Section 1. *Policy.* The federal government shall provide leadership in protecting and enhancing the quality of the Nation's environment to sustain and enrich human life. Federal agencies shall initiate measures needed to direct their policies, plans and programs so as to meet national environmental goals. The Council on Environmental Quality, through the Chairman, shall advise and assist the President in leading this national effort.

Sec. 2. *Responsibilities of federal agencies.* Consonant with Title I of the National Environmental Policy Act of 1969, hereafter referred to as the "Act", the heads of federal agencies shall:

(a) Monitor, evaluate, and control on a continuing basis their agencies' activities so as to protect and enhance the quality of the environment. Such activities shall include those directed to controlling pollution and enhancing the environment and those designed to accomplish other program objectives which may affect the quality of the environment. Agencies shall develop programs and measures to protect and enhance environmental quality and shall assess progress in meeting the specific objectives of such activities. Heads of agencies shall consult with appropriate federal, state and local agencies in carrying out their activities as they affect the quality of the environment.

(b) Develop procedures to ensure the fullest practicable provision of timely public information and understanding of federal plans and programs with environmental impact in order to obtain the views of interested parties. These procedures shall include, whenever appropriate, provision for public hearings, and shall provide the public with relevant information, including information on alternative courses of action. federal agencies shall also encourage state and local agencies to adopt similar procedures for informing the public concerning their activities affecting the quality of the environment.

(c) Insure that information regarding existing or potential environmental problems and control methods developed as part of research, development, demonstration, test, or evaluation activities is made available to federal agencies, states, counties, municipalities, institutions, and other entities, as appropriate.

(d) Review their agencies' statutory authority, administrative regulations, policies, and procedures, including those relating to loans, grants,

contracts, leases, licenses, or permits, in order to identify any deficiencies or inconsistencies therein which prohibit or limit full compliance with the purposes and provisions of the Act. A report on this review and the corrective actions taken or planned, including such measures to be proposed to the President as may be necessary to bring their authority and policies into conformance with the intent, purposes, and procedures of the Act, shall be provided to the Council on Environmental Quality not later than September 1, 1970.

(e) Engage in exchange of data and research results, and cooperate with agencies of other governments to foster the purposes of the Act.

(f) Proceed, in coordination with other agencies, with actions required by section 102 of the Act.

(g) In carrying out their responsibilities under the Act and this Order, comply with the regulations issued by the Council except where such compliance would be inconsistent with statutory requirements.

[Sec. 2 amended by Executive Order 11991 of May 24, 1977, 42 FR 26967, 3 CFR, 1977 Comp., p. 123]

Sec. 3. *Responsibilities of Council on Environmental Quality.* The Council on Environmental Quality shall:

(a) Evaluate existing and proposed policies and activities of the federal government directed to the control of pollution and the enhancement of the environment and to the accomplishment of other objectives which affect the quality of the environment. This shall include continuing review of procedures employed in the development and enforcement of federal standards affecting environmental quality. Based upon such evaluations the Council shall, where appropriate, recommend to the President policies and programs to achieve more effective protection and enhancement of environmental quality and shall, where appropriate, seek resolution of significant environmental issues.

(b) Recommend to the President and to the agencies priorities among programs designed for the control of pollution and for the enhancement of the environment.

(c) Determine the need for new policies and programs for dealing with environmental problems not being adequately addressed.

(d) Conduct, as it determines to be appropriate, public hearings or conferences on issues of environmental significance.

(e) Promote the development and use of indices and monitoring systems (1) to assess environmental conditions and trends, (2) to predict the environmental impact of proposed public and private actions, and (3) to determine the effectiveness of programs for protecting and enhancing environmental quality.

(f) Coordinate federal programs related to environmental quality.

(g) Advise and assist the President and the agencies in achieving international cooperation for dealing with environmental problems, under the foreign policy guidance of the Secretary of State.

(h) Issue regulations to federal agencies for the implementation of the procedural provisions of the Act (42 U.S.C. 4332(2)). Such regulations shall be developed after consultation with affected agencies and after such public hearings as may be appropriate. They will be designed to make the environmental impact statement process more useful to decisionmakers and the public; and to reduce paperwork and the accumulation of extraneous background data, in order to emphasize the need to focus on real environmental issues and alternatives. They will require impact statements to be concise, clear, and to the point, and supported by evidence that agencies have made the necessary environmental analyses. The Council shall include in its regulations procedures (1) for the early preparation of environmental impact statements, and (2) for the referral to the Council of conflicts between agencies concerning the implementation of the National Environmental Policy Act of 1969, as amended, and Section 309 of the Clean Air Act, as amended, for the Council's recommendation as to their prompt resolution.

(i) Issue such other instructions to agencies, and request such reports and other information from them, as may be required to carry out the

Council's responsibilities under the Act. (j) Assist the President in preparing the annual Environmental Quality Report provided for in section 201 of the Act.

(k) Foster investigations, studies, surveys, research, and analyses relating to (i) ecological systems and environmental quality, (ii) the impact of new and changing technologies thereon, and (iii) means of preventing or reducing adverse effects from such technologies.

[Sec. 3 amended by Executive Order 11991 of May 24, 1977, 42 FR 26967, 3 CFR, 1977 Comp., p. 123]

Sec. 4. *Amendments of E.O. 11472.*

[Sec. 4 amends Executive Order 11472 of May 29, 1969, Chapter 40. The amendments have been incorporated into that order.]

NEPAnet:

http://ceq.eh.doe.gov/nepanet.htm

NEPAnet is the web site established to serve as a central repository for NEPA information. It provides access to NEPA, the regulations and procedures employed by federal agencies, CEQ guidance, and NEPA points of contact within the federal agencies, tribes and the states. The site also provides a mechanism for identifying potential participants (state, tribal, and local governments) and serves as a link to environ

mental resource information (statistical trends and tracking data). The NEPAnet site also interfaces with other federal agencies' sites by providing links to their environmental planning information sites. guidance, and NEPA points of contact within the federal agencies, tribes and the states. The site also provides a mechanism for identifying potential participants (state, tribal, and local governments) and serves as a link to environmental resource information (statistical trends and tracking data). The NEPAnet site also interfaces with other federal agencies' sites by providing links to their environmental planning information sites.

Access to environmental datasets is provided on the "environmental statistics" page of the NEPAnet web site which provides a compilation of environmental statistics and trends, complemented with hot-links – or passageways – to the data compiled by EPA, Interior, and other government agencies. In addition, the "environmental impact analysis data links" page of NEPAnet provides access to online environmental datasets and libraries compiled by the United States Geological Survey. For example, the USGS site provides access to data sets such as the National Wetlands Inventory maps and data, the USGS maps and data tables for water data stations in the US, as well as to libraries such as the largest known collection of on-line publications related to forestry research maintained by the Forest Service.

Sec. 1506.9 Filing requirements.

(a) Environmental impact statements together with comments and responses shall be filed with the Environmental Protection Agency, attention Office of Federal Activities, EIS Filing Section, Ariel Rios Building (South Oval Lobby), Mail Code 2252-A, Room 7220, 1200 Pennsylvania Ave., NW., Washington, DC 20460. This address is for deliveries by US Postal Service (including USPS Express Mail).

(b) For deliveries in-person or by commercial express mail services, including Federal Express or UPS, the correct address is: US Environmental Protection Agency, Office of Federal Activities, EIS Filing Section, Ariel Rios Building (South Oval Lobby), Room 7220, 1200 Pennsylvania Avenue, NW., Washington, DC 20004.

(c) Statements shall be filed with the EPA no earlier than they are also transmitted to commenting agencies and made available to the public. EPA shall deliver one copy of each statement to the Council, which shall satisfy the requirement of availability to the President. EPA may issue guidelines to agencies to implement its responsibilities under this section and Sec. 1506.10.

[70 FR 41148, July 18, 2005]

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NEPA REGULATIONS - CEQ - OEQ

40 CFR 1501 - NEPA AND AGENCY PLANNING

- 1501.1—Purpose.
- 1501.2—Apply NEPA early in the process.
- 1501.3—When to prepare an environmental assessment.
- 1501.4—Whether to prepare an environmental impact statement.
- 1501.5—Lead agencies.
- 1501.6—Cooperating agencies.
- 1501.7—Scoping.
- 1501.8—Time limits.

Authority: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 et seq.), sec. 309 of the Clean Air Act, as amended (42 U.S.C. 7609, and E.O. 11514 (Mar. 5, 1970, as amended by E.O. 11991, May 24, 1977).

Source: 43 FR 55992, Nov. 29, 1978, unless otherwise noted.

40 CFR 1501.1 - Purpose.

The purposes of this part include:

(a) Integrating the NEPA process into early planning to insure appropriate consideration of NEPA's policies and to eliminate delay.

(b) Emphasizing cooperative consultation among agencies before the environmental impact statement is prepared rather than submission of adversary comments on a completed document.

(c) Providing for the swift and fair resolution of lead agency disputes.

(d) Identifying at an early stage the significant environmental issues deserving of study and deemphasizing insignificant issues, narrowing the scope of the environmental impact
statement accordingly.

(e) Providing a mechanism for putting appropriate time limits on the environmental impact statement process.

40 CFR 1501.2 - Apply NEPA early in the process.

Agencies shall integrate the NEPA process with other planning at the earliest possible time to insure that planning and decisions reflect environmental values, to avoid delays later in the process, and to head off potential conflicts. Each agency shall:

(a) Comply with the mandate of section 102(2)(A) to “utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decisionmaking which may
have an impact on man's environment,” as specified by § 1507.2.

(b) Identify environmental effects and values in adequate detail so they can be compared
to economic and technical analyses. Environmental documents and appropriate analyses
shall be circulated and reviewed at the same time as other planning documents.

(c) Study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of

available resources as provided by section 102(2)(E) of the Act.
(d) Provide for cases where actions are planned by private applicants or other non-Federal entities before Federal involvement so that:
(1) Policies or designated staff are available to advise potential applicants of studies or other information foreseeably required for later Federal action.
(2) The Federal agency consults early with appropriate State and local agencies and Indian tribes and with interested private persons and organizations when its own involvement is reasonably foreseeable.
(3) The Federal agency commences its NEPA process at the earliest possible time.

40 CFR 1501.3 - When to prepare an environmental assessment.

(a) Agencies shall prepare an environmental assessment (§ 1508.9) when necessary under the procedures adopted by individual agencies to supplement these regulations as
described in § 1507.3. An assessment is not necessary if the agency has decided to prepare an environmental impact statement.
(b) Agencies may prepare an environmental assessment on any action at any time in order
to assist agency planning and decisionmaking.

40 CFR 1501.4 - Whether to prepare an environmental impact statement.

In determining whether to prepare an environmental impact statement the Federal agency
shall:
(a) Determine under its procedures supplementing these regulations (described in § 1507.3) whether the proposal is one which:
(1) Normally requires an environmental impact statement, or
(2) Normally does not require either an environmental impact statement or an environmental assessment (categorical exclusion).
(b) If the proposed action is not covered by paragraph (a) of this section, prepare an environmental assessment (§ 1508.9). The agency shall involve environmental agencies,
applicants, and the public, to the extent practicable, in preparing assessments required by
§ 1508.9(a)(1).
(c) Based on the environmental assessment make its determination whether to prepare an
environmental impact statement.
(d) Commence the scoping process (§ 1501.7), if the agency will prepare an environmental impact statement.
(e) Prepare a finding of no significant impact (§ 1508.13), if the agency determines on the basis of the environmental assessment not to prepare a statement.
(1) The agency shall make the finding of no significant impact available to the affected public as specified in § 1506.6.
(2) In certain limited circumstances, which the agency may cover in its procedures under § 1507.3, the agency shall make the finding of no significant impact available for public review (including State and areawide clearinghouses) for 30 days before the agency makes its final determination whether to prepare an environmental

impact statement and before the action may begin. The circumstances are:
(i) The proposed action is, or is closely similar to, one which normally
requires the preparation of an environmental impact statement under the procedures
adopted by the agency pursuant to § 1507.3, or
(ii) The nature of the proposed action is one without precedent.

40 CFR 1501.5 - Lead agencies.

(a) A lead agency shall supervise the preparation of an environmental impact statement
if
more than one Federal agency either:
(1) Proposes or is involved in the same action; or
(2) Is involved in a group of actions directly related to each other because of their
functional interdependence or geographical proximity.
(b) Federal, State, or local agencies, including at least one Federal agency, may act as
joint lead agencies to prepare an environmental impact statement (§ 1506.2).
(c) If an action falls within the provisions of paragraph (a) of this section the potential
lead agencies shall determine by letter or memorandum which agency shall be the lead
agency and which shall be cooperating agencies. The agencies shall resolve the lead
agency question so as not to cause delay. If there is disagreement among the agencies,
the
following factors (which are listed in order of descending importance) shall determine
lead agency designation:
(1) Magnitude of agency's involvement.
(2) Project approval/disapproval authority.
(3) Expertise concerning the action's environmental effects.
(4) Duration of agency's involvement.
(5) Sequence of agency's involvement.
(d) Any Federal agency, or any State or local agency or private person substantially
affected by the absence of lead agency designation, may make a written request to the
potential lead agencies that a lead agency be designated.
(e) If Federal agencies are unable to agree on which agency will be the lead agency or
if
the procedure described in paragraph (c) of this section has not resulted within 45 days
in
a lead agency designation, any of the agencies or persons concerned may file a request
with the Council asking it to determine which Federal agency shall be the lead agency.
A copy of the request shall be transmitted to each potential lead agency. The request
shall
consist of:
(1) A precise description of the nature and extent of the proposed action.
(2) A detailed statement of why each potential lead agency should or should not
be the lead agency under the criteria specified in paragraph (c) of this section.
(f) A response may be filed by any potential lead agency concerned within 20 days after
a
request is filed with the Council. The Council shall determine as soon as possible but
not

later than 20 days after receiving the request and all responses to it which Federal agency
shall be the lead agency and which other Federal agencies shall be cooperating agencies.

40 CFR 1501.6 - Cooperating agencies.

The purpose of this section is to emphasize agency cooperation early in the NEPA process. Upon request of the lead agency, any other Federal agency which has jurisdiction by law shall be a cooperating agency. In addition any other Federal agency which has special expertise with respect to any environmental issue, which should be addressed in the statement may be a cooperating agency upon request of the lead agency.

An agency may request the lead agency to designate it a cooperating agency.

(a) The lead agency shall:

(1) Request the participation of each cooperating agency in the NEPA process at the earliest possible time.

(2) Use the environmental analysis and proposals of cooperating agencies with jurisdiction by law or special expertise, to the maximum extent possible consistent with its responsibility as lead agency.

(3) Meet with a cooperating agency at the latter's request.

(b) Each cooperating agency shall:

(1) Participate in the NEPA process at the earliest possible time.

(2) Participate in the scoping process (described below in § 1501.7).

(3) Assume on request of the lead agency responsibility for developing information and preparing environmental analyses including portions of the environmental impact statement concerning which the cooperating agency has special expertise.

(4) Make available staff support at the lead agency's request to enhance the latter's interdisciplinary capability.

(5) Normally use its own funds. The lead agency shall, to the extent available funds permit, fund those major activities or analyses it requests from cooperating agencies. Potential lead agencies shall include such funding requirements in their budget
requests.

(c) A cooperating agency may in response to a lead agency's request for assistance in preparing the environmental impact statement (described in paragraph (b)(3), (4), or (5) of this section) reply that other program commitments preclude any involvement or the degree of involvement requested in the action that is the subject of the environmental impact statement. A copy of this reply shall be submitted to the Council.

40 CFR 1501.7 - Scoping.

There shall be an early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action. This process shall be termed scoping. As soon as practicable after its decision to prepare an environmental impact statement and before the scoping process the lead agency shall publish a notice of intent (§ 1508.22) in the *Federal Register* except as provided in § 1507.3(e).

(a) As part of the scoping process the lead agency shall:

(1) Invite the participation of affected Federal, State, and local agencies, any affected Indian tribe, the proponent of the action, and other interested persons (including those who might not be in accord with the action on environmental grounds), unless there is a limited exception under § 1507.3(c). An agency may give notice in accordance with § 1506.6.
(2) Determine the scope (§ 1508.25) and the significant issues to be analyzed in depth in the environmental impact statement.
(3) Identify and eliminate from detailed study the issues which are not significant or which have been covered by prior environmental review (§ 1506.3), narrowing the discussion of these issues in the statement to a brief presentation of why they will not have a significant effect on the human environment or providing a reference to their coverage elsewhere.
(4) Allocate assignments for preparation of the environmental impact statement among the lead and cooperating agencies, with the lead agency retaining responsibility for the statement.
(5) Indicate any public environmental assessments and other environmental impact statements which are being or will be prepared that are related to but are not part of the scope of the impact statement under consideration.
(6) Identify other environmental review and consultation requirements so the lead and cooperating agencies may prepare other required analyses and studies concurrently with, and integrated with, the environmental impact statement as provided in § 1502.25.
(7) Indicate the relationship between the timing of the preparation of environmental analyses and the agency's tentative planning and decisionmaking schedule.
(b) As part of the scoping process the lead agency may:
(1) Set page limits on environmental documents (§ 1502.7).
(2) Set time limits (§ 1501.8).
(3) Adopt procedures under § 1507.3 to combine its environmental assessment process with its scoping process.
(4) Hold an early scoping meeting or meetings which may be integrated with any other early planning meeting the agency has. Such a scoping meeting will often be appropriate when the impacts of a particular action are confined to specific sites.
(c) An agency shall revise the determinations made under paragraphs (a) and (b) of this section if substantial changes are made later in the proposed action, or if significant new circumstances or information arise which bear on the proposal or its impacts.

40 CFR 1501.8 - Time limits.

Although the Council has decided that prescribed universal time limits for the entire NEPA process are too inflexible, Federal agencies are encouraged to set time limits appropriate to individual actions (consistent with the time intervals required by § 1506.10). When multiple agencies are involved the reference to agency below means lead

agency.
(a) The agency shall set time limits if an applicant for the proposed action requests them:
Provided, That the limits are consistent with the purposes of NEPA and other essential considerations of national policy.
(b) The agency may:
(1) Consider the following factors in determining time limits:
(i) Potential for environmental harm.
(ii) Size of the proposed action.
(iii) State of the art of analytic techniques.
(iv) Degree of public need for the proposed action, including the consequences of delay.
(v) Number of persons and agencies affected.
(vi) Degree to which relevant information is known and if not known the time required for obtaining it.
(vii) Degree to which the action is controversial.
(viii) Other time limits imposed on the agency by law, regulations, or executive order.
(2) Set overall time limits or limits for each constituent part of the NEPA process, which may include:
(i) Decision on whether to prepare an environmental impact statement (if not already decided).
(ii) Determination of the scope of the environmental impact statement.
(iii) Preparation of the draft environmental impact statement.
(iv) Review of any comments on the draft environmental impact statement from the public and agencies.
(v) Preparation of the final environmental impact statement.
(vi) Review of any comments on the final environmental impact statement.
(vii) Decision on the action based in part on the environmental impact statement.
(3) Designate a person (such as the project manager or a person in the agency's office with NEPA responsibilities) to expedite the NEPA process.
(c) State or local agencies or members of the public may request a Federal Agency to set
time limits.

40 CFR 1502--ENVIRONMENTAL IMPACT STATEMENT

Sec. 1502.1 Purpose.
1502.2 Implementation.
1502.3 Statutory requirements for statements.
1502.4 Major Federal actions requiring the preparation of environmental impact statements.
1502.5 Timing.
1502.6 Interdisciplinary preparation.
1502.7 Page limits.
1502.8 Writing.

1502.9 Draft, final, and supplemental statements.
1502.10 Recommended format.
1502.11 Cover sheet.
1502.12 Summary.
1502.13 Purpose and need.
1502.14 Alternatives including the proposed action.
1502.15 Affected environment.
1502.16 Environmental consequences.
1502.17 List of preparers.
1502.18 Appendix.
1502.19 Circulation of the environmental impact statement.
1502.20 Tiering.
1502.21 Incorporation by reference.
1502.22 Incomplete or unavailable information.
1502.23 Cost-benefit analysis.
1502.24 Methodology and scientific accuracy.
1502.25 Environmental review and consultation requirements.

Authority: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 et seq.), sec. 309 of the Clean Air Act, as amended (42 U.S.C. 7609), and E.O. 11514 (Mar. 5, 1970, as amended by E.O. 11991, May 24, 1977).

Source: 43 FR 55994, Nov. 29, 1978, unless otherwise noted.

Sec. 1502.1 Purpose.

The primary purpose of an environmental impact statement is to serve as an actionforcing device to insure that the policies and goals defined in the Act are infused into the ongoing programs and actions of the Federal Government. It shall provide full and fair discussion of significant environmental impacts and shall inform decisionmakers and the public of the reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the human environment. Agencies shall focus on significant environmental issues and alternatives and shall reduce paperwork and the accumulation of extraneous background data. Statements shall be concise, clear, and to the point, and shall be supported by evidence that the agency has made the necessary environmental analyses. An environmental impact statement is more than a disclosure document. It shall be used by Federal officials in conjunction with other relevant material to plan actions and make decisions.

Sec. 1502.2 Implementation.

To achieve the purposes set forth in Sec. 1502.1 agencies shall prepare environmental impact statements in the following manner:

(a) Environmental impact statements shall be analytic rather than encyclopedic.

(b) Impacts shall be discussed in proportion to their significance. There shall be only brief discussion of other than significant issues. As in a finding of no significant impact, there should be only enough discussion to show why more study is not warranted.

(c) Environmental impact statements shall be kept concise and shall be no longer than absolutely necessary to comply with NEPA and with these regulations. Length should vary first with potential environmental problems and then with project size.
(d) Environmental impact statements shall state how alternatives considered in it and decisions based on it will or will not achieve the requirements of sections 101 and 102(1)
of the Act and other environmental laws and policies.
(e) The range of alternatives discussed in environmental impact statements shall encompass those to be considered by the ultimate agency decisionmaker.
(f) Agencies shall not commit resources prejudicing selection of alternatives before making a final decision (Sec. 1506.1).
(g) Environmental impact statements shall serve as the means of assessing the environmental impact of proposed agency actions, rather than justifying decisions already
made.

Sec. 1502.3 Statutory requirements for statements.

As required by sec. 102(2)(C) of NEPA environmental impact statements (Sec. 1508.11)
are to be included in every recommendation or report.
On proposals (Sec. 1508.23).
For legislation and (Sec. 1508.17).
Other major Federal actions (Sec. 1508.18).
Significantly (Sec. 1508.27).
Affecting (Secs. 1508.3, 1508.8).
The quality of the human environment (Sec. 1508.14).

Sec. 1502.4 Major Federal actions requiring the preparation of environmental impact statements.

(a) Agencies shall make sure the proposal which is the subject of an environmental impact statement is properly defined. Agencies shall use the criteria for scope (Sec. 1508.25) to determine which proposal(s) shall be the subject of a particular statement. Proposals or parts of proposals which are related to each other closely enough to be, in effect, a single course of action shall be evaluated in a single impact statement.
(b) Environmental impact statements may be prepared, and are sometimes required, for broad Federal actions such as the adoption of new agency programs or regulations (Sec.
1508.18). Agencies shall prepare statements on broad actions so that they are relevant to
policy and are timed to coincide with meaningful points in agency planning and decisionmaking.
(c) When preparing statements on broad actions (including proposals by more than one agency), agencies may find it useful to evaluate the proposal(s) in one of the following ways:
1. Geographically, including actions occurring in the same general location, such as body of water, region, or metropolitan area.
2. Generically, including actions which have relevant similarities, such as common timing, impacts, alternatives, methods of implementation, media, or subject

matter.
3. By stage of technological development including federal or federally assisted research, development or demonstration programs for new technologies which, if applied, could significantly affect the quality of the human environment. Statements shall be prepared on such programs and shall be available before the program has reached a stage of investment or commitment to implementation likely to determine subsequent development or restrict later alternatives.
(d) Agencies shall as appropriate employ scoping (Sec. 1501.7), tiering (Sec. 1502.20), and other methods listed in Secs. 1500.4 and 1500.5 to relate broad and narrow actions and to avoid duplication and delay.

Sec. 1502.5 Timing.

An agency shall commence preparation of an environmental impact statement as close as possible to the time the agency is developing or is presented with a proposal (Sec. 1508.23) so that preparation can be completed in time for the final statement to be included in any recommendation or report on the proposal. The statement shall be prepared early enough so that it can serve practically as an important contribution to the decisionmaking process and will not be used to rationalize or justify decisions already made (Secs. 1500.2(c), 1501.2, and 1502.2). For instance:
(a) For projects directly undertaken by Federal agencies the environmental impact statement shall be prepared at the feasibility analysis (go-no go) stage and may be supplemented at a later stage if necessary.
(b) For applications to the agency appropriate environmental assessments or statements shall be commenced no later than immediately after the application is received. Federal agencies are encouraged to begin preparation of such assessments or statements earlier, preferably jointly with applicable State or local agencies.
(c) For adjudication, the final environmental impact statement shall normally precede the final staff recommendation and that portion of the public hearing related to the impact study. In appropriate circumstances the statement may follow preliminary hearings designed to gather information for use in the statements.
(d) For informal rulemaking the draft environmental impact statement shall normally accompany the proposed rule.

Sec. 1502.6 Interdisciplinary preparation.

Environmental impact statements shall be prepared using an inter- disciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts (section 102(2)(A) of the Act). The disciplines of the preparers shall be appropriate to the scope and issues identified in the scoping process (Sec. 1501.7).

Sec. 1502.7 Page limits.

The text of final environmental impact statements (e.g., paragraphs (d) through (g) of

Sec. 1502.10) shall normally be less than 150 pages and for proposals of unusual scope or
complexity shall normally be less than 300 pages.

Sec. 1502.8 Writing.

Environmental impact statements shall be written in plain language and may use appropriate graphics so that decisionmakers and the public can readily understand them.

Agencies should employ writers of clear prose or editors to write, review, or edit statements, which will be based upon the analysis and supporting data from the natural and social sciences and the environmental design arts.

Sec. 1502.9 Draft, final, and supplemental statements.

Except for proposals for legislation as provided in Sec. 1506.8 environmental impact statements shall be prepared in two stages and may be supplemented.

(a) Draft environmental impact statements shall be prepared in accordance with the scope
decided upon in the scoping process. The lead agency shall work with the cooperating agencies and shall obtain comments as required in Part 1503 of this chapter. The draft statement must fulfill and satisfy to the fullest extent possible the requirements established for final statements in section 102(2)(C) of the Act. If a draft statement is so inadequate as to preclude meaningful analysis, the agency shall prepare and circulate a revised draft of the appropriate portion. The agency shall make every effort to disclose and discuss at appropriate points in the draft statement all major points of view on the environmental impacts of the alternatives including the proposed action.

(b) Final environmental impact statements shall respond to comments as required in Part
1503 of this chapter. The agency shall discuss at appropriate points in the final statement
any responsible opposing view which was not adequately discussed in the draft statement
and shall indicate the agency's response to the issues raised.

(c) Agencies:

1. Shall prepare supplements to either draft or final environmental impact statements if:

(i) The agency makes substantial changes in the proposed action that are relevant to environmental concerns; or

(ii) There are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts.

2. May also prepare supplements when the agency determines that the purposes of the Act will be furthered by doing so.

3. Shall adopt procedures for introducing a supplement into its formal administrative record, if such a record exists.

4. Shall prepare, circulate, and file a supplement to a statement in the same fashion (exclusive of scoping) as a draft and final statement unless alternative procedures are approved by the Council.

Sec. 1502.10 Recommended format.

Agencies shall use a format for environmental impact statements which will encourage

good analysis and clear presentation of the alternatives including the proposed action. The following standard format for environmental impact statements should be followed unless the agency determines that there is a compelling reason to do otherwise:
(a) Cover sheet.
(b) Summary.
(c) Table of contents.
(d) Purpose of and need for action.
(e) Alternatives including proposed action (sections 102(2)(C)(iii) and 102(2)(E) of the Act).
(f) Affected environment.
(g) Environmental consequences (especially sections 102(2)(C)(i), (ii), (iv), and (v) of the
Act).
(h) List of preparers.
(i) List of Agencies, Organizations, and persons to whom copies of the statement are sent.
(j) Index.
(k) Appendices (if any).
If a different format is used, it shall include paragraphs (a), (b), (c), (h), (i), and (j), of this section and shall include the substance of paragraphs (d), (e), (f), (g), and (k) of this section, as further described in Secs. 1502.11 through 1502.18, in any appropriate format.

Sec. 1502.11 Cover sheet.

The cover sheet shall not exceed one page. It shall include:
(a) A list of the responsible agencies including the lead agency and any cooperating agencies.
(b) The title of the proposed action that is the subject of the statement (and if appropriate
the titles of related cooperating agency actions), together with the State(s) and county(ies)
(or other jurisdiction if applicable) where the action is located.
(c) The name, address, and telephone number of the person at the agency who can supply
further information.
(d) A designation of the statement as a draft, final, or draft or final supplement.
(e) A one paragraph abstract of the statement.
(f) The date by which comments must be received (computed in cooperation with EPA under Sec. 1506.10).
The information required by this section may be entered on Standard Form 424 (in items
4, 6, 7, 10, and 18).

Sec. 1502.12 Summary.

Each environmental impact statement shall contain a summary which adequately and accurately summarizes the statement. The summary shall stress the major conclusions, areas of controversy (including issues raised by agencies and the public), and the issues

to be resolved (including the choice among alternatives). The summary will normally not exceed 15 pages.

Sec. 1502.13 Purpose and need.

The statement shall briefly specify the underlying purpose and need to which the agency is responding in proposing the alternatives including the proposed action.

Sec. 1502.14 Alternatives including the proposed action.

This section is the heart of the environmental impact statement. Based on the information and analysis presented in the sections on the Affected Environment (Sec. 1502.15) and the Environmental Consequences (Sec. 1502.16), it should present the environmental impacts of the proposal and the alternatives in comparative form, thus sharply defining the issues and providing a clear basis for choice among options by the decisionmaker and the public. In this section agencies shall:

(a) Rigorously explore and objectively evaluate all reasonable alternatives, and for alternatives which were eliminated from detailed study, briefly discuss the reasons for their having been eliminated.

(b) Devote substantial treatment to each alternative considered in detail including the proposed action so that reviewers may evaluate their comparative merits.

(c) Include reasonable alternatives not within the jurisdiction of the lead agency.

(d) Include the alternative of no action.

(e) Identify the agency's preferred alternative or alternatives, if one or more exists, in the draft statement and identify such alternative in the final statement unless another law prohibits the expression of such a preference.

(f) Include appropriate mitigation measures not already included in the proposed action or alternatives.

Sec. 1502.15 Affected environment.

The environmental impact statement shall succinctly describe the environment of the area(s) to be affected or created by the alternatives under consideration. The descriptions shall be no longer than is necessary to understand the effects of the alternatives. Data and analyses in a statement shall be commensurate with the importance of the impact, with less important material summarized, consolidated, or simply referenced. Agencies shall avoid useless bulk in statements and shall concentrate effort and attention on important issues. Verbose descriptions of the affected environment are themselves no measure of the adequacy of an environmental impact statement.

Sec. 1502.16 Environmental consequences.

This section forms the scientific and analytic basis for the comparisons under Sec. 1502.14. It shall consolidate the discussions of those elements required by sections 102(2)(C)(i), (ii), (iv), and (v) of NEPA which are within the scope of the statement and as much of section 102(2)(C)(iii) as is necessary to support the comparisons. The discussion will include the environmental impacts of the alternatives including the proposed action, any adverse environmental effects which cannot be avoided should the

proposal be implemented, the relationship between short-term uses of man's environment
and the maintenance and enhancement of long-term productivity, and any irreversible or
irretrievable commitments of resources which would be involved in the proposal should it
be implemented. This section should not duplicate discussions in Sec. 1502.14. It shall include discussions of:
(a) Direct effects and their significance (Sec. 1508.8).
(b) Indirect effects and their significance (Sec. 1508.8).
(c) Possible conflicts between the proposed action and the objectives of Federal, regional,
State, and local (and in the case of a reservation, Indian tribe) land use plans, policies and
controls for the area concerned. (See Sec. 1506.2(d).)
(d) The environmental effects of alternatives including the proposed action. The comparisons under Sec. 1502.14 will be based on this discussion.
(e) Energy requirements and conservation potential of various alternatives and mitigation
measures.
(f) Natural or depletable resource requirements and conservation potential of various alternatives and mitigation measures.
(g) Urban quality, historic and cultural resources, and the design of the built environment,
including the reuse and conservation potential of various alternatives and mitigation measures.
(h) Means to mitigate adverse environmental impacts (if not fully covered under Sec. 1502.14(f)).
[43 FR 55994, Nov. 29, 1978; 44 FR 873, Jan. 3, 1979]

Sec. 1502.17 List of preparers.

The environmental impact statement shall list the names, together with their qualifications (expertise, experience, professional disciplines), of the persons who were primarily responsible for preparing the environmental impact statement or significant background papers, including basic components of the statement (Secs. 1502.6 and 1502.8). Where possible the persons who are responsible for a particular analysis, including analyses in background papers, shall be identified. Normally the list will not exceed two pages.

Sec. 1502.18 Appendix.

If an agency prepares an appendix to an environmental impact statement the appendix shall:
(a) Consist of material prepared in connection with an environmental impact statement (as distinct from material which is not so prepared and which is incorporated by reference
(Sec. 1502.21)).
(b) Normally consist of material which substantiates any analysis fundamental to the impact statement.

(c) Normally be analytic and relevant to the decision to be made.
(d) Be circulated with the environmental impact statement or be readily available on request.

Sec. 1502.19 Circulation of the environmental impact statement.

Agencies shall circulate the entire draft and final environmental impact statements except
for certain appendices as provided in Sec. 1502.18(d) and unchanged statements as provided in Sec. 1503.4(c). However, if the statement is unusually long, the agency may circulate the summary instead, except that the entire statement shall be furnished to:
(a) Any Federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved and any appropriate Federal, State or local agency authorized to develop and enforce environmental standards.
(b) The applicant, if any.
(c) Any person, organization, or agency requesting the entire environmental impact statement.
(d) In the case of a final environmental impact statement any person, organization, or agency which submitted substantive comments on the draft.
If the agency circulates the summary and thereafter receives a timely request for the entire statement and for additional time to comment, the time for that requestor only shall
be extended by at least 15 days beyond the minimum period.

Sec. 1502.20 Tiering.

Agencies are encouraged to tier their environmental impact statements to eliminate repetitive discussions of the same issues and to focus on the actual issues ripe for decision at each level of environmental review (Sec. 1508.28). Whenever a broad environmental impact statement has been prepared (such as a program or policy statement) and a subsequent statement or environmental assessment is then prepared on
an action included within the entire program or policy (such as a site specific action) the subsequent statement or environmental assessment need only summarize the issues discussed in the broader statement and incorporate discussions from the broader statement by reference and shall concentrate on the issues specific to the subsequent action. The subsequent document shall state where the earlier document is available. Tiering may also be appropriate for different stages of actions. (Section 1508.28).

Sec. 1502.21 Incorporation by reference.

Agencies shall incorporate material into an environmental impact statement by reference
when the effect will be to cut down on bulk without impeding agency and public review of the action. The incorporated material shall be cited in the statement and its content briefly described. No material may be incorporated by reference unless it is reasonably available for inspection by potentially interested persons within the time allowed for comment. Material based on proprietary data which is itself not available for review and comment shall not be incorporated by reference.

Sec. 1502.22 Incomplete or unavailable information.

When an agency is evaluating reasonably foreseeable significant adverse effects on the human environment in an environmental impact statement and there is incomplete or

unavailable information, the agency shall always make clear that such information is lacking.
(a) If the incomplete information relevant to reasonably foreseeable significant adverse impacts is essential to a reasoned choice among alternatives and the overall costs of obtaining it are not exorbitant, the agency shall include the information in the environmental impact statement.
(b) If the information relevant to reasonably foreseeable significant adverse impacts cannot be obtained because the overall costs of obtaining it are exorbitant or the means to
obtain it are not known, the agency shall include within the environmental impact statement:
1. A statement that such information is incomplete or unavailable;
2. a statement of the relevance of the incomplete or unavailable information to evaluating reasonably foreseeable significant adverse impacts on the human environment;
3. a summary of existing credible scientific evidence which is relevant to evaluating the reasonably foreseeable significant adverse impacts on the human environment, and
4. the agency's evaluation of such impacts based upon theoretical approaches or research methods generally accepted in the scientific community. For the purposes of this section, "reasonably foreseeable" includes impacts which have catastrophic consequences, even if their probability of occurrence is low, provided that the analysis of the impacts is supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason.
(c) The amended regulation will be applicable to all environmental impact statements for which a Notice of Intent (40 CFR 1508.22) is published in the Federal Register on or after May 27, 1986. For environmental impact statements in progress, agencies may choose to comply with the requirements of either the original or amended regulation.

Sec. 1502.23 Cost-benefit analysis.

If a cost-benefit analysis relevant to the choice among environmentally different alternatives is being considered for the proposed action, it shall be incorporated by reference or appended to the statement as an aid in evaluating the environmental consequences. To assess the adequacy of compliance with section 102(2)(B) of the Act the statement shall, when a cost-benefit analysis is prepared, discuss the relationship between that analysis and any analyses of unquantified environmental impacts, values, and amenities. For purposes of complying with the Act, the weighing of the merits and drawbacks of the various alternatives need not be displayed in a monetary cost-benefit analysis and should not be when there are important qualitative considerations. In any event, an environmental impact statement should at least indicate those considerations, including factors not related to environmental quality, which are likely to be relevant and important to a decision.

Sec. 1502.24 Methodology and scientific accuracy.

Agencies shall insure the professional integrity, including scientific integrity, of the discussions and analyses in environmental impact statements. They shall identify any methodologies used and shall make explicit reference by footnote to the scientific and other sources relied upon for conclusions in the statement. An agency may place

discussion of methodology in an appendix.

Sec. 1502.25 Environmental review and consultation requirements.

(a) To the fullest extent possible, agencies shall prepare draft environmental impact statements concurrently with and integrated with environmental impact analyses and related surveys and studies required by the Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.), the National Historic Preservation Act of 1966 (16 U.S.C. 470 et seq.), the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.), and other environmental review laws and executive orders.

(b) The draft environmental impact statement shall list all Federal permits, licenses, and other entitlements which must be obtained in implementing the proposal. If it is uncertain
whether a Federal permit, license, or other entitlement is necessary, the draft environmental impact statement shall so indicate.

40 CFR 1506 et seq.

40 CFR 1506.1 - Limitations on actions during NEPA process.

(a) Until an agency issues a record of decision as provided in § 1505.2 (except as provided in paragraph (c) of this section), no action concerning the proposal shall be taken which would:

(1) Have an adverse environmental impact; or

(2) Limit the choice of reasonable alternatives.

(b) If any agency is considering an application from a non-Federal entity, and is aware that the applicant is about to take an action within the agency's jurisdiction that would meet either of the criteria in paragraph (a) of this section, then the agency shall promptly notify the applicant that the agency will take appropriate action to insure that the objectives and procedures of NEPA are achieved.

(c) While work on a required program environmental impact statement is in progress and
the action is not covered by an existing program statement, agencies shall not undertake
in the interim any major Federal action covered by the program which may significantly affect the quality of the human environment unless such action:

(1) Is justified independently of the program;

(2) Is itself accompanied by an adequate environmental impact statement; and

(3) Will not prejudice the ultimate decision on the program. Interim action prejudices the ultimate decision on the program when it tends to determine subsequent development or limit alternatives.

(d) This section does not preclude development by applicants of plans or designs or performance of other work necessary to support an application for Federal, State or local
permits or assistance. Nothing in this section shall preclude Rural Electrification Administration approval of minimal expenditures not affecting the environment (e.g. long leadtime equipment and purchase options) made by non-governmental entities seeking loan guarantees from the Administration.

40 CFR 1506.2 (USFS 25.2) - Elimination of Duplication With State and Local
Procedures.

(a) Agencies authorized by law to cooperate with State agencies of statewide jurisdiction pursuant to section
102(2)(D) of the Act may do so.
(b) Agencies shall cooperate with State and local agencies to the fullest extent possible to
reduce duplication between NEPA and State and local requirements, unless the agencies
are specifically barred from doing so by some other law. Except for cases covered by paragraph (a) of this section, such cooperation shall to the fullest extent possible include:
(1) Joint planning processes.
(2) Joint environmental research and studies.
(3) Joint public hearings (except where otherwise provided by statute).
(4) Joint environmental assessments.
(c) Agencies shall cooperate with State and local agencies to the fullest extent possible to reduce duplication
between NEPA and comparable State and local requirements, unless the agencies are specifically barred
from doing so by some other law. Except for cases covered by paragraph (a) of this section, such
cooperation shall to the fullest extent possible include joint environmental impact statements. In such cases
one or more Federal agencies and one or more State or local agencies shall be joint lead agencies. Where
State laws or local ordinances have environmental impact statement requirements in addition to but not in
conflict with those in NEPA, Federal agencies shall cooperate in fulfilling these requirements as well as
those of Federal laws so that one document will comply with all applicable laws.
(d) To better integrate environmental impact statements into State or local planning processes, statements shall discuss any **inconsistency** of a proposed action with any approved State or local plan and laws **(whether or not federally sanctioned).** Where an
inconsistency exists, the statement should describe the extent to which the agency would
reconcile its proposed action with the plan or law. (40 CFR 1506.2)

40 CFR 1506.3 - Adoption.

(a) An agency may adopt a Federal draft or final environmental impact statement or portion thereof provided that the statement or portion thereof meets the standards for an adequate statement under these regulations.
(b) If the actions covered by the original environmental impact statement and the proposed action are substantially the same, the agency adopting another agency's statement is not required to recirculate it except as a final statement. Otherwise the adopting agency shall treat the statement as a draft and recirculate it (except as provided
in paragraph (c) of this section).

(c) A cooperating agency may adopt without recirculating the environmental impact statement of a lead agency when, after an independent review of the statement, the cooperating agency concludes that its comments and suggestions have been satisfied.
(d) When an agency adopts a statement which is not final within the agency that prepared
it, or when the action it assesses is the subject of a referral under part 1504, or when the
statement's adequacy is the subject of a judicial action which is not final, the agency shall
so specify.

Section 1508.4 Categorical exclusion.

“Categorical exclusion” means a category of actions which do not individually or cumulatively have a significant effect on the human environment and which have been found to have no such effect in procedures adopted by a Federal agency in implementation of these regulations (Sec. 1507.3) and for which, therefore, neither an environmental assessment nor an environmental impact statement is required. An agency
may decide in its procedures or otherwise, to prepare environmental assessments for the
reasons stated in Sec. 1508.9 even though it is not required to do so. Any procedures under this section shall provide for extraordinary circumstances in which a normally excluded action may have a significant environmental effect.

Section 1508.5 Cooperating agency.

“Cooperating agency” means any Federal agency other than a lead agency which has jurisdiction by law or special expertise with respect to any environmental impact involved in a proposal (or a reasonable alternative) for legislation or other major Federal action significantly affecting the quality of the human environment. The selection and responsibilities of a cooperating agency are described in Sec. 1501.6. A State or local agency of similar qualifications or, when the effects are on a reservation, an Indian Tribe,
may by agreement with the lead agency become a cooperating agency.

Section 1508.7 Cumulative impact.

“Cumulative impact” is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but
collectively significant actions taking place over a period of time.

Section 1508.8 Effects.

“Effects” include:
(a) Direct effects, which are caused by the action and occur at the same time and place.
(b) Indirect effects, which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land
use, population density or growth rate, and related effects on air and water and other

natural systems, including ecosystems.
Effects and impacts as used in these regulations are synonymous.
Effects includes ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative. Effects may also include those resulting from actions which may have both beneficial and detrimental
effects, even if on balance the agency believes that the effect will be beneficial.

Section 1508.9 Environmental assessment.

"Environmental assessment":
(a) Means a concise public document for which a Federal agency is responsible that serves to:
1. Briefly provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact.
2. Aid an agency's compliance with the Act when no environmental impact statement is necessary.
3. Facilitate preparation of a statement when one is necessary.
(b) Shall include brief discussions of the need for the proposal, of alternatives as required by section 102(2) (E), of the environmental impacts of the proposed action and alternatives, and a listing of agencies and persons consulted.

Section 1508.11 Environmental impact statement.

"Environmental impact statement" means a detailed written statement as required by section 102(2)(C) of the Act.

Section 1508.12 Federal agency.

"Federal agency" means all agencies of the Federal Government. It does not mean the Congress, the Judiciary, or the President, including the performance of staff functions for
the President in his Executive Office. It also includes for purposes of these regulations States and units of general local government and Indian Tribes assuming NEPA responsibilities under section 104(h) of the Housing and Community Development Act of
1974.

Section 1508.13 Finding of no significant impact.

"Finding of no significant impact" means a document by a Federal agency briefly presenting the reasons why an action, not otherwise excluded (Sec. 1508.4), will not have
a significant effect on the human environment and for which an environmental impact statement therefore will not be prepared. It shall include the environmental assessment or
a summary of it and shall note any other environmental documents related to it (Sec. 1501.7(a)(5)). If the assessment is included, the finding need not repeat any of the discussion in the assessment but may incorporate it by reference.

Section 1508.14 Human environment.

"Human environment" shall be interpreted comprehensively to include the natural and physical environment and the relationship of people with that environment. (See the definition of "effects" (Sec. 1508.8).) This means that economic or social effects are not

intended by themselves to require preparation of an environmental impact statement. When an environmental impact statement is prepared and economic or social and natural
or physical environmental effects are interrelated, then the environmental impact statement will discuss all of these effects on the human environment.

Section 1508.16 Lead agency.

“Lead agency” means the agency or agencies preparing or having taken primary responsibility for preparing the environmental impact statement.

Section 1508.18 Major federal action.

“Major federal action” includes actions with effects that may be major and which are potentially subject to federal control and responsibility. Major reinforces but does not have a meaning independent of significantly (Sec. 1508.27). Actions include the circumstance where the responsible officials fail to act and that failure to act is reviewable by courts or administrative tribunals under the Administrative Procedure Act or other applicable law as agency action.

(a) Actions include new and continuing activities, including projects and programs entirely or partly financed, assisted, conducted, regulated, or approved by Federal agencies; new or revised agency rules, regulations, plans, policies, or procedures; and legislative proposals (Secs. 1506.8, 1508.17). Actions do not include funding assistance solely in the form of general revenue sharing funds, distributed under the State and Local
Fiscal Assistance Act of 1972, 31 U.S.C. 1221 et seq., with no Federal agency control over the subsequent use of such funds. Actions do not include bringing judicial or administrative civil or criminal enforcement actions.

(b) Federal actions tend to fall within one of the following categories:

1. Adoption of official policy, such as rules, regulations, and interpretations adopted pursuant to the Administrative Procedure Act, 5 U.S.C. 551 et seq.; treaties and
international conventions or agreements; formal documents establishing an agency’s policies which will result in or substantially alter agency programs.

2. Adoption of formal plans, such as official documents prepared or approved by Federal agencies which guide or prescribe alternative uses of federal resources, upon which future agency actions will be based.

3. Adoption of programs, such as a group of concerted actions to implement a specific policy or plan; systematic and connected agency decisions allocating agency resources to implement a specific statutory program or executive directive.

4. Approval of specific projects, such as construction or management activities located in a defined geographic area. Projects include actions approved by permit or other
regulatory decision as well as federal and federally assisted activities.

Section 1508.20 Mitigation.

“Mitigation” includes:

(a) Avoiding the impact altogether by not taking a certain action or parts of an action.

(b) Minimizing impacts by limiting the degree or magnitude of the action and its implementation.

(c) Rectifying the impact by repairing, rehabilitating, or restoring the affected

environment.
(d) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.
(e) Compensating for the impact by replacing or providing substitute resources or environments.

Section 1508.22 Notice of intent.

"Notice of intent" means a notice that an environmental impact statement will be prepared and considered. The notice shall briefly:
(a) Describe the proposed action and possible alternatives.
(b) Describe the agency's proposed scoping process including whether, when, and where
any scoping meeting will be held.
(c) State the name and address of a person within the agency who can answer questions
about the proposed action and the environmental impact statement.

Section 1508.23 Proposal.

"Proposal" exists at that stage in the development of an action when an agency subject to
the Act has a goal and is actively preparing to make a decision on one or more alternative
means of accomplishing that goal and the effects can be meaningfully evaluated. Preparation of an environmental impact statement on a proposal should be timed (Sec. 1502.5) so that the final statement may be completed in time for the statement to be included in any recommendation or report on the proposal. A proposal may exist in fact as well as by agency declaration that one exists.

Section 1508.25 Scope.

"Scope" consists of the range of actions, alternatives, and impacts to be considered in an
environmental impact statement. The scope of an individual statement may depend on its
relationships to other statements (Secs.1502.20 and 1508.28). To determine the scope of
environmental impact statements, agencies shall consider 3 types of actions, 3 types of alternatives, and 3 types of impacts. They include:
(a) Actions (other than unconnected single actions) which may be:
(1) Connected actions, which means that they are closely related and therefore should be discussed in the same impact statement. Actions are connected if they:
(i) Automatically trigger other actions which may require environmental
impact statements.
(ii) Cannot or will not proceed unless other actions are taken previously or simultaneously.
(iii) Are interdependent parts of a larger action and depend on the larger
action for their justification.
(2) Cumulative actions, which when viewed with other proposed actions have cumulatively significant impacts and should therefore be discussed in the same impact statement.

(3) Similar actions, which when viewed with other reasonably foreseeable or proposed agency actions, have similarities that provide a basis for evaluating their environmental consequencies together, such as common timing or geography. An agency
may wish to analyze these actions in the same impact statement. It should do so when the
best way to assess adequately the combined impacts of similar actions or reasonable alternatives to such actions is to treat them in a single impact statement.
(b) Alternatives, which include:
(1) No action alternative.
(2) Other reasonable courses of actions.
(3) Mitigation measures (not in the proposed action).
(c) Impacts, which may be:
(1) Direct;
(2) indirect;
(3) cumulative.

Section 1508.27 Significantly.

“Significantly” as used in NEPA requires considerations of both context and intensity:
(a) Context. This means that the significance of an action must be analyzed in several contexts such as society as a whole (human, national), the affected region, the affected interests, and the locality. Significance varies with the setting of the proposed action. For
instance, in the case of a site-specific action, significance would usually depend upon the
effects in the locale rather than in the world as a whole. Both short- and long-term effects
are relevant.
(b) Intensity. This refers to the severity of impact. Responsible officials must bear in mind that more than one agency may make decisions about partial aspects of a major action. The following should be considered in evaluating intensity:
(1) Impacts that may be both beneficial and adverse. A significant effect may
exist even if the Federal agency believes that on balance the effect will be beneficial.
(2) The degree to which the proposed action affects public health or safety.
(3) Unique characteristics of the geographic area such as proximity to historic or cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas.
(4) The degree to which the effects on the quality of the human environment are
likely to be highly controversial.
(5) The degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks.
(6) The degree to which the action may establish a precedent for future actions
with significant effects or represents a decision in principle about a future consideration.
(7) Whether the action is related to other actions with individually insignificant
but cumulatively significant impacts. Significance exists if it is reasonable to anticipate a cumulatively significant impact on the environment. Significance cannot be avoided by terming an action temporary or by breaking it down into small component parts.

(8) The degree to which the action may adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places or may cause loss or destruction of significant scientific, cultural, or historical resources.
(9) The degree to which the action may adversely affect an endangered or threatened species or its habitat that has been determined to be critical under the Endangered Species Act of 1973.
(10) Whether the action threatens a violation of Federal, State, or local law or requirements imposed for the protection of the environment.

Section 1508.28 Tiering.

"Tiering" refers to the coverage of general matters in broader environmental impact statements (such as national program or policy statements) with subsequent narrower statements or environmental analyses (such as regional or basinwide program statements
or ultimately site-specific statements) incorporating by reference the general discussions
and concentrating solely on the issues specific to the statement subsequently prepared. Tiering is appropriate when the sequence of statements or analyses is:
(a) From a program, plan, or policy environmental impact statement to a program, plan, or policy statement or analysis of lesser scope or to a site-specific statement or analysis.
(b) From an environmental impact statement on a specific action at an early stage (such as need and site selection) to a supplement (which is preferred) or a subsequent statement
or analysis at a later stage (such as environmental mitigation). Tiering in such cases is appropriate when it helps the lead agency to focus on the issues which are ripe for decision and exclude from consideration issues already decided or not yet ripe.

Federal Register

Thursday
April 13, 1995

Part IV

Department of the Interior

Fish and Wildlife Service

50 CFR Part 17

Endangered and Threatened Wildlife and Plants; Red Wolves in North Carolina and Tennessee; Revision of the Special Rule for Nonessential Experimental Populations; Final Rule

DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

50 CFR Part 17

RIN 1018-AC03

Endangered and Threatened Wildlife and Plants; Revision of the Special Rule for Nonessential Experimental Populations of Red Wolves in North Carolina and Tennessee

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Final rule.

SUMMARY: The Service amends the special rule for the nonessential experimental populations of red wolves (*Canis rufus*) in North Carolina and Tennessee to; revise and clarify the incidental take provision; apply the incidental take provision to both reintroduced populations; revise the livestock owner take provision; apply the livestock owner take provisions to both reintroduced populations; add harassment and take provisions for red wolves on private property; revise and clarify the vaccination and recapture provision; and apply the same taking (including harassment) provisions to red wolves outside the experimental population area, except for reporting requirements.

EFFECTIVE DATE: April 13, 1995.

ADDRESSES: The complete file for this rule is available for inspection, by appointment, during normal business hours at the Asheville Field Office, U.S. Fish and Wildlife Service, 330 Ridgefield Court, Asheville, North Carolina 28806.

Requests for the summary report on the 5-year experimental reintroduction at the Alligator River National Wildlife Refuge (Alligator River) should be sent to the Alligator River National Wildlife Refuge, P.O. Box 1969, Manteo, North Carolina 27954.

FOR FURTHER INFORMATION CONTACT: Mr. V. Gary Henry, Red Wolf Coordinator, at the above Asheville, North Carolina, address (Telephone 704/665–1195, Ext. 226).

SUPPLEMENTARY INFORMATION

Effective Date

The usual 30-day delay between date of publication of a final rule and its effective date may be waived for good cause, as provided by 50 CFR 424.18(b)(1) and the Administrative Procedure Act (5 U.S.C. 553(d)(3)). The Service finds that this period be waived for this rule as its immediate promulgation is necessary to avoid potential conflict between Federal provisions for the taking of red wolves on private property and corresponding State of North Carolina provisions that become effective on January 1, 1995.

Background

A proposed rule to introduce red wolves into Alligator River National Wildlife Refuge (Alligator River), Dare County, North Carolina, was published in the Federal Register July 24, 1986 (51 FR 26564). A final rule making a determination to implement the proposed action with some modifications was published November 19, 1986 (51 FR 41790). The red wolf population in Dare County and adjacent Tyrrell, Hyde, and Washington Counties was determined to be a nonessential experimental population according to section 10(j) of the Endangered Species Act of 1973, as amended (Act). A revision published November 4, 1991, added Beaufort County to the list of counties where the experimental population designation would apply (56 FR 56325). The status of the population was to be reevaluated within 5 years, and the process was to include public meetings.

A proposed rule to introduce red wolves into the Great Smoky Mountains National Park (Park), Haywood and Swain Counties, North Carolina; and Blount, Cocke, and Sevier Counties, Tennessee, was published in the Federal Register August 7, 1991 (56 FR 37513). A final rule making determination to implement the proposed action with some modifications was published November 4, 1991 (56 FR 56325). This population was also determined to be a nonessential experimental population according to section 10(j) of the Act. Graham, Jackson, and Madison Counties, North Carolina; and Monroe County, Tennessee, were also included in the experimental designation because of the close proximity of these counties to the Park boundary. The reintroduction potential of the Park was to be assessed after a 10- to 12-month experimental phase. A positive assessment would result in initiation of a permanent reintroduction attempt.

The red wolf is an endangered species that is currently found in the wild only as experimental populations on the Service's Alligator River and Pocosin Lakes National Wildlife Refuges and adjacent private lands in Dare, Hyde, Tyrrell, and Washington Counties, North Carolina; and in the Park in Swain County, North Carolina, and Blount and Sevier Counties, Tennessee; and as an endangered species in three small island propagation projects located on Bulls Island, South Carolina; Horn Island, Mississippi; and St. Vincent Island, Florida. These five carefully managed wild populations contain a total of approximately 60 animals. The remaining red wolves are located in 31 captive-breeding facilities in the United States. The captive population presently numbers approximately 180 animals.

Following are summaries of the results from the two experimental reintroductions. A more detailed summary for Alligator River is available (see **ADDRESSES** section) as Progress Report No. 6, entitled ''Reestablishment of Red Wolves in the Alligator River National Wildlife Refuge, North Carolina, 14 September 1987 to 30 September 1992.''

Alligator River 5-Year Summary

The 5-year experiment to reestablish a population of red wolves in Alligator River in northeastern North Carolina ended October 1, 1992.

From September 14, 1987, through September 30, 1992, 42 wolves (adults—10 males, 9 females; yearlings—1 female; pups—12 males, 10 females) were initially released on 15 occasions. Four releases were conducted in 1987, two in 1988, five in 1989, two in 1990, one in 1991, and one in 1992. As of September 30, 1992, there were at least 30 free-ranging wolves in northeastern North Carolina.

Animals were initially released as members of seven adult pairs, an adult and a yearling, an adult and a pup, five families, and one sibling pair. Adults are defined as animals 24 months or greater in age, yearlings are between 12 and 24 months of age, and pups are 12 months or less in age. Released adults ranged in age from 2.25 years to 7.33 years.

Wide-ranging movements that created management situations or led to the death of some animals soon after release were common. Of the 31 releases of adults and 22 releases of pups, 18 adults and 10 pups either had to be returned to captivity or died within 2 months. Length of acclimation, release area, location of resident wolves, and type of social group released all affected a wolf's probability of successfully establishing itself in the wild.

Of the 42 wolves released, 22 died; 7 were returned to captivity for management reasons; 11 were free-ranging through September 30, 1992; and the fates of 2 are unknown. Length of time in the wild varied from 16 days to 3.5 years.

Reintroduced wolves were killed by one of at least seven mortality factors. Vehicles (n = 8), intraspecific aggression

(n = 5), and drownings (n = 4) were the most significant sources of mortality. It is a measure of the program's success that all but two of the deaths were natural or accidental, not as a result of any irresponsible action by a private citizen.

A minimum of 22 wolves were born in the wild. These animals were members of eight litters produced by 11 adults (6 males, 5 females). Two litters were produced in 1988, at least one in 1990, four in 1991, and at least one in 1992. No pups were born in the wild during 1989 because there were no adult pairs together during the breeding season.

Only two wild-born wolves died, and the fate of one is unknown. As of September 30, 1992, wild-born wolves accounted for 63 percent of the known population (19 of 30).

Of the 11 adults that bred in the wild, 1 was wild-born and 10 were captive-born. Wild-born offspring are evidence that captive-born-and-reared adults can make the transition from captivity to life in the wild.

As expected, wild-born pups exhibited wide-ranging movements as they dispersed from natal home ranges. These animals, with the exception of one female, traveled up to 192 km before establishing new home ranges on private land south or west of Alligator River. One female was killed by a vehicle before she established a new home range. Dispersal age ranged between 7 and 22 months. The youngest dispersers were siblings that left their natal home range after their parents were returned to captivity. Likewise, another female dispersed at a young age after her mother was returned to captivity. It is likely that some or all of these pups would not have dispersed had their families remained intact.

Twenty-four of the released wolves were recaptured 63 times, and 17 of the wild-born wolves were recaptured 39 times. Most recaptures were necessary in order to meet program objectives (replace radio collars, place a specific wolf with a mate, translocate an animal to a suitable site, etc.). Every management problem was resolved without inflicting significant long-term damage to animals and with little or no inconvenience to residents of the area.

Captive breeding was an integral component of the reintroduction. Since 1986, 79 wolves have been held in captivity at Alligator River for varying periods of time. As of September 30, 1992, 10 wolves were in captivity. During the 5-year experiment, 20 captive adult pairs produced 34 pups. With access to 12 pens, Alligator River will continue to be an important component of the red wolf captive-breeding program.

By almost every measure, the reintroduction experiment was successful and generated benefits that extended beyond the immediate preservation of red wolves to positively affect local citizens and communities, larger conservation efforts, and other imperiled species. During the last 5 years, four important points surfaced:

1. Since every management problem was resolved without inflicting long-term damage to animals and with little inconvenience to residents of the area, it is evident that red wolves can be restored in a controlled manner.

2. Significant land-use restrictions were not necessary in order for red wolves to survive. Indeed, hunting and trapping regulations for Alligator River remained unchanged or were further relaxed during the experiment. Additionally, no restrictions were needed in order for red wolves to survive on private land.

3. Red wolves and sportsmen can coexist. Many hunters and trappers expressed support, while others actively contributed to the success of the experiment by reporting sightings of red wolves.

4. The reintroduction area, which encompasses about 250,000 acres (111,750 hectares), probably cannot support 30 red wolves for an extended period of time. Dispersal outside the reintroduction area by wild-born red wolves has occurred and will continue. Efforts will be made to work with private landowners to allow wolves on private property. In addition to dispersal, the future of the red wolf population is threatened by its smallness; many events (e.g., disease outbreaks) can cause extinction of small populations.

Increasing the size of the wolf population minimizes threats to its survival. The primary factor limiting population size is the size of the reintroduction area. A larger reintroduction area would provide habitat for dispersing wolves and provide the Service with opportunities to release additional wolves. Fortunately, the reintroduction area can easily be enlarged by adding to the project the 112,000-acre (45,327-hectare) Pocosin Lakes National Wildlife Refuge (Pocosin Lakes). Purchased in 1990 and located in Washington, Tyrrell, and Hyde Counties, North Carolina, Pocosin Lakes is ideal for probably 15 to 25 wolves because of its large size, remoteness, abundant prey populations, and proximity to Alligator River.

Meetings with the public and local governments were held to present the results of the first 5 years and to solicit input on a proposal to maintain the current population and expand the reintroduction westward to encompass Pocosin Lakes beginning in 1993. The seven public meetings were held in the communities of Engelhard, Manteo, Stumpy Point, East Lake, Columbia, Swanquarter, Washington, and Plymouth. Attendance at these meetings ranged from 7 to 90 people at each and totaled 146 at all locations. Meetings were also held with the county commissioners in Washington, Dare, Beaufort, Tyrrell, and Hyde Counties.

Reintroductions are generally supported by local, State, and Federal agencies; elected officials; and the general public, except for some private landowners and the county boards of commissioners in Hyde and Washington Counties, North Carolina. Most people who commented supported the restoration project, although some expressed concern about the effect of red wolves on activities on private land. The Service assured them that, because free-ranging wolves are legally classified as members of an experimental nonessential population, the wolves would not negatively impact legal activities on private or Federal land.

Some citizens used the meetings to express frustration about other matters involving the Service. No significant complaints were voiced specifically about the red wolf reintroduction experiment. However, Hyde and Washington Counties did pass resolutions opposing red wolf project expansion. These resolutions seemed to be based on anti-government sentiment and a fear of prohibitions on private land use.

After consideration of the results from the 5-year experimental reintroduction and public input received in public meetings and meetings with State and local governments and agencies, the Service determined that it would maintain the present populations at Alligator River and has expanded this population with reintroductions at Pocosin Lakes beginning in 1993. The reintroductions at Pocosin Lakes are within counties previously designated for the experimental population and require no changes in the existing rule.

Park 1-Year Summary

On November 12, 1991, the Service, in cooperation with the National Park Service (Park Service), experimentally released a single family group of red wolves into the Cades Cove area of the Park. This release was designed to assess the feasibility of eventually establishing a self-sustaining red wolf population on Park Service and

surrounding U.S. Forest Service property. The experimental period ended in late September 1992 with the capture of the remaining three members of the release group.

Specific technical objectives of the experimental release were to document and respond to movements and activities of the wolves in mountainous terrain and in the presence of high human activity, livestock interests, and an increasing coyote population. However, another objective was to establish an informative and cooperative relationship with the involved agencies and local citizens. Through continuous telemetric contact, direct and relayed sightings, and the dedicated efforts of project personnel, valuable information was gathered with respect to all of these categories; some problems were encountered as well.

Cades Cove is unique within the Park; it possesses a great diversity and abundance of prey species, making it highly attractive to a large predator. As a result, the average home range for the four released wolves was 15 km^2 (3,700 acres), scarcely larger than Cades Cove itself. As yet, an accurate prediction of red wolf home ranges for habitat typical of the other 99.3 percent of the Park cannot be made. Wolves made exploratory movements up to 16 km (10 miles) from the release site. Individuals strayed off Park property (less than 5 miles or less than 8 km) four times. Twice they were recaptured within several hours, and twice they returned of their own accord within 24 hours. The primary prey species taken by the wolves were deer, rabbit, ground-hog, and raccoon. Samples are currently being analyzed for percentages and seasonal variation.

Wolves were sighted on numerous occasions by visitors and project personnel throughout the experiment. This was somewhat expected in an area where prey species are extremely visible and comfortable with the intense attention of as many as 15,000 visitors daily. However, the two adult wolves, especially the male, repeatedly tolerated people at close distances. This was attributed to the amount of time (e.g., 6 years for the male) that the adults had spent in captivity. The male was eventually recaptured and removed from the experiment in late January 1992. The female tolerated human presence to a lesser degree, but she presented no problems and was allowed to roam free for the duration of the experimental period. The two female pups were often sighted crossing roads or, at a distance, hunting in pastures. They developed an increasing wariness to human activity as they spent more time in the wild. The behaviors of these wolves support the theory that younger wolves, with minimal exposure to human contact, make better release candidates.

The private land surrounding the Park and throughout the Southern Appalachians supports a variety of livestock interests. The perceived potential economic threat of a large predator is perhaps the single greatest political barrier to establishing a self-sustaining red wolf population in the Southern Appalachians. The documentation and management of the wolves' interaction with domestic livestock is likely to be a major factor in deciding whether to expand the project. Thus, a $25,000 depredation account was established to compensate livestock owners for losses.

Throughout the experiment, the adult male was responsible for taking one chicken and three domestic turkeys in two separate incidents. The remaining three wolves took one of five injured or missing newborn calves. One additional depredation attempt occurred but did not result in injury to the calf. Reimbursements for the chicken and the calf totaled $253. Offers to reimburse for the turkeys were declined by the owner.

Cades Cove supports a 300-head black angus cattle-breeding operation, leased to a private stock owner. During the 6-month calving season, the wolves and calving operation were intensely monitored. The wolves were located disjunct from five of six attempted depredations. Day and night (using night-vision equipment) visual observations revealed cooperative hunting by small groups of coyotes. Nightly spotlight observations by the stock owner revealed continuous coyote activity in calving pastures. Accurate records of lost calves prior to the experimental release of wolves were not kept. Estimates by the stock owner indicated approximately five to ten calves per year were lost to bears, coyotes, and other predators/scavengers.

Of significance is that all of the six depredation attempts during the experimental release involved calves less than 1 week old, and all the events occurred along wood lines away from the main herd of cattle. Project personnel began assisting the stock owner in moving newborn calves into the main herd, and no further depredations by coyotes or wolves occurred.

Prior to the red wolf release, the Service contracted the University of Tennessee to conduct a census of coyotes in the Park and to study interactions between resident coyotes and released wolves. Seven coyotes were outfitted with telemetry collars and were monitored for 18 months, or until they permanently left the study area. Only one coyote remained ''on the air'' in Cades Cove by the time the wolves were released. This collar expired 3 months later. Interaction data was then gathered by direct observation.

Initial information indicated aggressive behavior between the adult wolves and resident coyotes, with the wolves apparently dominating. After the removal of the adult male wolf, greater numbers determined the dominating species.

In preparation for the experimental release, project and Park personnel met with area business, citizenry, and natural resource organizations for comment on the proposal. Modifications to the release plans included the addition of a ''non-injurious harassment clause'' to the experimental rule package, prevention of reproduction in the wild, immediate recapture of wolves straying off Park property, and recapture of all wolves at the end of the experiment.

To facilitate information exchange, an information committee (composed of representatives from Federal and State wildlife resource agencies, Farm Bureau Federations, and conservation organizations) was established. The Heartland Series, a local television environmental program, produced a documentary entitled ''Front Runner,'' focusing on the reestablishment effort in the Southern Appalachians. The ''Front Runner'' video, a teacher's guide, and an activity poster were distributed free to all requesting educational institutions. The project gained national television exposure on ''Zoo Life with Jack Hanna,'' a weekly public education broadcast. Presentations and workshops were given at wildlife exhibitions and to a variety of groups from elementary to college students and to senior citizens. Other media contact included interviews with local and regional newspapers, popular magazines, free-lance writers, and television news teams.

During the final weeks of the experimental period, the Service reviewed and presented their findings to the Park Service and members of the information committee. The decision was made to proceed with a full reintroduction effort at a very conservative pace, with two releases in the fall of 1992.

On October 9, 1992, a family of six red wolves (two adults, four pups) were released into Cades Cove. To date, these wolves have shown restricted movements and food habits very similar to the experimental group. Within

several weeks after release, the adult pair had taken a large European wild hog—an exotic species in the Park.

On December 9, 1992, a second group of six wolves (two adults, four pups) was released from a remote backcountry site several miles east of Cades Cove. It is expected that these animals will be more difficult to track. However, they will provide needed information about the home range requirements of red wolves in habitat that is typical of the vast majority of the Park and surrounding Federal lands.

All released wolves will wear transmitters and will be monitored as closely as the experimental group. There are no scheduled plans to recapture these animals, except to replace aging transmitters in approximately 2 to 3 years.

The possibility of expanding the Park reintroduction to include adjacent national forest lands within the Nantahala and Pisgah National Forests in North Carolina, the Cherokee National Forest in Tennessee, and the Chattahoochee National Forest in Georgia will be evaluated over the next few years. This evaluation will include meetings with congressional representatives, State wildlife and agriculture agencies, Farm Bureau Federations, local agriculture and hunting interests, conservation organizations, county commissioners, and a variety of local organizations. A final decision will be made after public meetings in the local areas where reintroductions are proposed.

Special Rule Changes for Both Reintroductions

In the period since publication of the special rules for the experimental population introduced on Alligator River and the Park, published in the Federal Register on November 19, 1986 (51 FR 41796) and November 4, 1991 (56 FR 56333), it has become apparent that changes are needed in the rule for these populations. These changes will also provide consistency by treating both reintroductions the same.

The provision for taking red wolves incidental to lawful recreational activities (50 CFR 17.84(c)(4)(ii)) is revised and clarified by this final rule. Current policy at Alligator River applies this provision to all lawful activities, not just to recreational activities. For example, 11 wolves (includes 8 within the 5-year experimental release) have been killed by vehicles not involved in recreational pursuits, but certainly otherwise lawful. No problems have been encountered at Alligator River in the application of a more liberalized provision. Therefore, the Service deletes the word ''recreational.'' In addition, incidental take was defined at Alligator River as ''unavoidable, unintentional, and not resulting from negligent conduct lacking reasonable due care.'' This definition is changed for clarification and is included in the incidental take provision of the special rule.

The Service revised the rule for the Park reintroduction, based on input by the North Carolina Farm Bureau Federation which stated that livestock owners should be allowed to take red wolves engaged in livestock depredation. The Tennessee Citizens for Wilderness Planning supported the revision. The final rule permitted private livestock owners to harass red wolves actually engaged in the pursuit or killing of livestock on private lands. Such conflicts must be reported to the superintendent of the Park. Service or State officials will respond to these conflicts within 48 hours and attempt to live-capture the offending animals. If an early response by the Service or State officials results in a failure to capture offending animals, the livestock owner will be permitted to take the offending animal.

These provisions worked well in all five depredation incidents recorded the first year. Offending animals were recaptured, when necessary, and in at least two of the instances, private landowners did harass the animals away but did not take offending animals. Including the experimental release in 1991, there have been 17 incidents of animals moving out of the Park onto private lands. In three incidents, they returned on their own; in the other 14 incidents, they were recaptured. No indication of abuse of these provisions were encountered in these incidents. However, experience with offending animals has indicated potential problems.

It is highly objectionable to owners of livestock and pets to be unable to kill a predator that is engaged in killing their livestock or pets. This, in turn, leads to the erosion of public support for predator reintroductions, which is essential if this effort is to be successful. Also, there may be a time lapse before offending animals settle into a predictable pattern whereby they can be recaptured. During this time period, private landowners will not be allowed to take the animals themselves. The Service will respond to reported incidents within 48 hours. However, the existing special rule (§ 17.84(c)(4)(iv)) does not establish a definitive time when Service or State attempts to recapture the animal are deemed unsuccessful and the private landowner is then permitted to take the offending animals. This is a decision that must be made by the Service project leader or biologist in the field at the depredation location. Therefore, a rule revision provides that private landowners will be permitted to take offending animals upon written approval by the Service project leader or biologist on site of the depredation. This approval will be provided when the Service abandons attempts to capture the offending animal and will specify the authorized personnel (landowner and a limited number of his agents), the number of animals, and the time period (not to exceed 6 months). Also, private landowners will be allowed to take red wolves in the act of killing livestock or pets on private lands without the need for Service approval.

Experience at Alligator River and the Park indicates a need to extend the harassment and take provisions now in place for private livestock owners to include all private landowners. Wolves that come in close proximity to private residences may cause property damage by killing pets or removing and/or physically defacing small property items. In addition, private individuals may not want the animals on their property because they fear them or consider them a nuisance. Although currently not covered by such rule provisions, these stipulations have been implemented as reasonable law enforcement procedures. To date, there have been at least 15 incidents where animals on private property were harassed by private individuals. The special rule is revised to provide the legal basis for a provision now being implemented as a reasonable procedure.

Currently, there are at least 12 red wolves once present at Alligator River whose fate is unknown. Three of these wolves were observed but never captured. Transmitters malfunctioned on the other eight wolves. One animal, whose transmitter malfunctioned in December 1989, would now be 7 years old. The remaining 11 animals are 1 to 3 years of age, and contact with them was lost in 1991, 1992, or 1993. As wolves are great wanderers, it is possible that some of these five animals may have dispersed outside the experimental population boundaries (which could also happen with future animals). There is no possibility of such dispersing wolves mixing with populations of red wolves that have been classified as endangered, because the only existing red wolves in the wild are those introduced as experimental populations (and offspring) or those introduced (and offspring) onto isolated islands for propagation purposes. As a

result, animals dispersing outside the experimental population boundaries will not contribute to the conservation of the species.

As other resident wild canid populations are hunted and trapped, it is possible for a dispersing red wolf to be taken incidental to such lawful activities. Dispersing red wolves could also enter upon private property or attempt to kill livestock or pets. Providing greater protection for dispersing red wolves than that provided for red wolves within the experimental population boundaries would seriously erode the public support that is so essential for the success of reintroductions. Therefore, the special rule is revised to apply the same taking provisions to red wolves outside the experimental population boundaries as within, with one exception. This exception is that taking does not need to be reported to the refuge manager or Park superintendent. Such reporting will be encouraged to the degree possible, but it will not be required. It is impractical to inform the general population of such requirements outside the localized experimental population boundaries, and red wolves taken are not likely to be recognized as red wolves, even after such taking occurs and an animal is in hand.

The proposed rule for Alligator River provided for any person to take red wolves incidental to lawful recreational activities (51 FR 26564). Objections to this provision from the Defenders of Wildlife, the National Audubon Society, the Humane Society of the United States, and the National Wildlife Federation, based on lack of necessity and risk of misinterpretation, resulted in its deletion from the final rule. Instead, the enforcement policy of the Service was clarified in the preamble to the final rule to the effect that there would be no penalty for taking incidental to otherwise lawful activity providing the taking was unavoidable, unintentional, and did not result from negligent conduct lacking reasonable due care, and providing the taking was immediately reported to the refuge manager. Experience at Alligator River did detect a need for this provision and did not detect any misinterpretation of the policy by private citizens. Eleven red wolves were killed by vehicles; one wolf was killed in a trapping incident; and two were shot, one close to a private residence. The vehicle deaths were interpreted as incidental to lawful activity, which required little investigation. The trapping and shooting incidents were investigated and settlements were reached in two cases. In addition, the incidental take provision originally proposed and then deleted at Alligator River was included in the final rule for the Park. No taking of red wolves has occurred despite several instances of wolves visiting and having been seen on private lands. Therefore, this is additional evidence that the provision is not being misinterpreted by private individuals in order to indiscriminately take red wolves. As now promulgated for Alligator River, the incidental taking provision is ambiguous. The language used for defining incidental take under § 17.84(c)(4)(i) used the terms ''unavoidable'', ''unintentional,'' and ''lack of reasonable due care,'' which are subject to differing legal interpretations. Therefore, for this final rule the Service changes the provisions by stating that only intentional or willful take will be prosecuted on private lands. The final rule does not change the standard for lands owned or managed by Federal, State, or local government agencies.

The basic premise is that a red wolf that is incidentally taken in any type of legal activity on private lands will not be a violation of the special rule. However, a higher standard of conduct is expected on public lands, where the conservation of red wolves is an objective.

This incidental taking provision places trust in the public to be responsible citizens by obeying the special rule. The Service intends to revisit this issue to determine if excessive taking of red wolves is occurring because of the revised special rule.

Extensive review of the special rule during preparation of proposed and final revisions detected additional needs for clarification. The current special rule (§ 17.84(c)(10)) provides for the close monitoring of reintroduced populations, vaccination against diseases prior to release, and immediate recapture of wolves that need special care or that move off of Federal lands. Early in the project all animals were vaccinated because the entire population consisted of released animals. As the project progressed, released wolves and their progeny reproduced and expanded their range and population.

Obviously, vaccination cannot be implemented for wild wolves that have never been captured. Therefore, the special rule is clarified by revising the statement to the effect that all ''released or captured'' wolves will be vaccinated. At present, most wolves are vaccinated because the majority of wolves born in the wild are eventually captured. However, as populations continue to expand, the percentage of wolves that have not been captured will increase. Rule modifications also recognize that it may be impossible to capture some wolves. However, other provisions provide for the control of wolves that are causing conflicts but cannot be captured.

The intent of the special rule regarding the recapture of wolves leaving Federal lands was that it would be implemented only when such wolves caused conflicts and/or the landowner wanted the wolves removed. This intent is not clear. Red wolves had established themselves on private lands within 2 years (1989) of the first reintroduction releases, and several private landowners have agreed to allow the wolves to inhabit their property. Obviously, there is no need to remove wolves from private lands when the landowner has no problem with the wolves being there. Therefore, the special rule is modified to provide that all landowner requests to remove wolves from their property will be honored, but wolves that inhabit lands where the landowner agrees to allow them to reside will not be recaptured unless they cause a conflict.

Special Rule Changes for Alligator River

Experiences at Alligator River indicate that a need exists for application of the private landowner harassment and take provisions to this population as well. Twenty-seven incidents have been reported at Alligator River, some of which probably did not involve red wolves. The provisions could have been utilized in some of these incidents and may have altered the final outcome in a positive manner with regard to reducing adverse impacts and increasing public support. As these provisions have worked well in incidents in the Park population, with no difficulties encountered in their interpretation or application, this rule will extend these provisions to the Alligator River population.

The proposed rule called for the addition of Martin and Bertie Counties as a buffer zone. However, after further consideration, the Service has determined that this addition lacks sufficient justification and the counties are not being added to the designated reintroduction area (see Issue 7 in the following section).

Summary of Comments and Recommendations

In the November 24, 1993, proposed rule (58 FR 62086), all interested parties were requested to submit comments or recommendations that might contribute to the development of a final rule. Appropriate county, State, and Federal agencies; scientific, environmental, and

land use organizations; and other interested parties were notified and requested to submit questions or comments on the proposed rule. On December 6, 1993, the Service mailed copies of the proposed rule to 270 persons and organizations. A 30-day comment period was provided. Nine comments were received, including three from individuals, three from State agencies and organizations, and three from national agencies and organizations. Six of the nine respondents took the opportunity to comment on the reintroductions; there were three who supported the reintroductions and three who did not. The three responses supporting the reintroductions were from two individuals and one national organization. The three responses not supporting the reintroductions were from one State agency (North Carolina Department of Agriculture), one State organization (North Carolina Farm Bureau Federation), and one individual.

Comments received are presented below as a series of issues, with each being followed by the Service's response.

Issue 1: The North Carolina Department of Agriculture and the North Carolina Farm Bureau Federation specifically addressed their nonsupport with regard to the expansion of the Alligator River reintroduction to Pocosin Lakes. Also, the one individual voicing nonsupport was located in the expansion area.

Service Response: Pocosin Lakes did not exist in 1986 when regulations were finalized for the reintroduction of red wolves at Alligator River. The final rule stated that the project would be reevaluated after 5 years and such reevaluation would include public meetings. The result of the reevaluation, which included public meetings, was to expand the reintroduction project to Pocosin Lakes. This was a logical decision based on the success of the reintroduction to that point in time, the establishment of Pocosin Lakes as one of our national wildlife refuges which are mandated to conserve and recover endangered species, and the location of Pocosin Lakes within the existing experimental population boundaries established in the final rule of November 19, 1986 (51 FR 41790). The reintroductions per se have previously been through the rulemaking process and are outside the scope of this revision to the existing rule.

Issue 2: One individual was opposed, in general, to classifying endangered animals as nonessential experimental and, within this designation, relaxing protection for them. This individual favored more, not less, protection and wondered why the provisions would be extended to animals outside the experimental population areas and if the provisions would apply in the future to the island propagation sites.

Service Response: The provisions for classifying listed species as nonessential experimental were provided by 1982 amendments to the Act. These provisions were designed to resolve the dilemma of significant local opposition to translocation efforts due to concerns over the rigid protection and prohibitions surrounding listed species under the Act. The resolution was to provide new administrative flexibility for selectively applying the prohibitions of the Act to experimental populations. Final regulations establishing procedures for designation of experimental populations, determination of such populations as ''essential'' or ''nonessential,'' and promulgation of appropriate protective regulatory measures were published in the Federal Register on August 27, 1984 (49 FR 33885). These provisions were necessary to obtain public support for attempts to reintroduce red wolves and were, therefore, an essential ingredient in success at reestablishment of the species. Prior to these provisions, attempts to reintroduce red wolves and other endangered species, particularly predators, were routinely unsuccessful because of local opposition.

The reasons for extending the provisions of this rule to animals outside the experimental population boundaries are believed to be adequately explained in the Background section of this rule. These provisions do not apply to the island propagation projects, and the Service has no intention of declaring these animals nonessential experimental in the future.

Issue 3: Responses from the North Carolina Wildlife Resources Commission (Commission), North Carolina Department of Agriculture (Department), and North Carolina Farm Bureau Federation (Federation) addressed the reporting requirements. The Department and Federation believe that livestock owners should be allowed to take red wolves engaged in depredation without notifying the Service and awaiting recapture attempts. At the other extreme, the Humane Society of the United States (Society) wants no provision for private citizens to take red wolves for any purpose. The Commission recommended that ''immediately'' be defined as 5 business days, and the Commission and Federation recommended that ''immediately'' be deleted from the provision for taking outside the designated experimental population area. The Commission also pointed out that local residents are more familiar with and are more likely to call the local State wildlife enforcement officer through an available toll free number.

Service Response: The Service agrees to delete the word ''immediately'' from the provision for taking outside of the designated experimental population area because the intent was to delete reporting requirements altogether. In addition, the term ''immediately'' has been replaced by ''within 24 hours'' for areas within the experimental population areas. It is important to report taking and harassment incidents quickly so that Service personnel can respond right away in order to minimize conflicts and retrieve any carcasses for necropsy before such carcasses deteriorate to the degree that necropsy results are compromised. Five days, as recommended by the Commission, would not allow such a quick response. Telephone access is such that reporting incidents within 24 hours should pose no burden on the public.

Changes are made to allow private landowners to take wolves that are in the act of killing livestock or pets prior to reporting such incidents to the Service.

The Service contacted the Tennessee Wildlife Resources Agency to obtain approval to also list the local State wildlife enforcement officer in that State as a contact for meeting the reporting requirements. Such approval was received, and this change, as recommended by the Commission, has been made. The State enforcement officer will, in turn, notify the Park superintendent or refuge manager so that Service personnel can respond to such incidents.

Issue 4: The Commission, Society, Federation, and American Sheep Industry Association (Association) commented on the incidental taking provision. The Federation supported the inclusion of lawful activities, other than recreational, in the provision. The Commission recommended that ''incidental'' be defined as ''unavoidable, unintentional, *or* not resulting from negligent conduct, taking reasonable due care'' in order to prevent the prosecution of well-intentioned citizens who may kill a red wolf, believing it to be a coyote. The Society, on the other hand, believes that the broad definition will invite abuse. The Association was concerned about whether the provision would be applied to livestock owners outside the Park, as well as inside, and who would make the decision on negligent conduct.

Service Response: The Service found it necessary to change the language in this provision to clarify the intent and to remove any ambiguity. Experience during the past several years indicates that direct human-induced red wolf mortality is rare. The Service has therefore determined that it is appropriate to modify the language of the special rule to implement section 9 provisions for the red wolf by limiting the section 9 prohibition on private lands to cover intentional and willful taking only. Unlike the protection afforded all endangered and most threatened species, this provision will make the taking of a red wolf on private lands a specific intent crime. This provision will apply to all private landowners. The concept of a general intent violation (i.e. avoidable take or take through mistaken identity) that was present in the earlier rule is now used only on lands owned or managed by Federal, State, or local government agencies.

Issue 5: In addition to comments addressed under reporting requirements, the Association's comments indicated overall support for the provision but recommended that a maximum of 48 hours Service response time be included and that the biologist ''on site of the depredation'' give approval in a reasonable time period. The Commission recommended that approval be given within 5 days and that takings be reported to the Service project leader or biologist. The Federation also supported expanding the harassment provisions to private individuals around residences. However, the Department and the Federation felt that the take provisions did not go far enough in protecting the interests of livestock owners and thought that a time period should be specified for approval of livestock owners to ''take'' offending animals. As indicated in the comments on reporting requirements, the Society recommends that private citizens not be allowed to take red wolves for any reason and that other provisions in the rule are sufficient to protect private residences without allowing the taking of animals by private citizens. The Society also believes private citizens should have the responsibility to protect pets and private property from wildlife.

Service Response: The Service has revised the provision to allow private landowners to harass wolves in an opportunistic manner at any time on their property and to take such animals with Service approval if the Service's attempts to take the animals are unsuccessful. Notification would allow the Service to remove the offending animals, which are still valuable to the recovery objectives as breeding animals. If unsuccessful in removing the animals, the Service will permit the landowner to take action to remove any returning animals. The provision has also been revised to make it clear that the Service project leader or biologist on site of the depredation will provide approval to the private landowner and has indicated in the previous sections explaining the rule changes that such approval will be provided when the Service abandons attempts to capture the offending animal. A definite time period for such approval cannot be provided because of the variation in individual wolf behavior; e.g., one wolf may stay in the vicinity or return daily, while others may not return for days. The Service also adopts the 48-hour Service response time to reported incidents, as recommended and indicated in the previous sections explaining the rule changes. The Service project leader or biologist has been added as a contact for reporting any taking, although it was intended that reports to this individual would meet the provision as previously stated, because the Service project leader or biologist serves as the representative of the Park superintendent or refuge manager.

While the position of the Society regarding responsibility of private citizens to protect pets and property is reasonable with regard to naturally occurring wildlife species, programs to purposely reintroduce predators, such as the red wolf, must be accompanied by provisions to protect private property from the presence of such reintroduced animals if the landowner does not want them on his property. Such protection is necessary in order to obtain local public support, which is essential to success. Without such support, reintroductions are doomed, because the animals can be efficiently eliminated, as evidenced by past history.

Issue 6: The Federation did not understand the need to list the North Carolina counties as part of the historic range of the species and stated that it should be presented in the information section unless it is absolutely necessary to establish the nonessential experimental use population designation.

Service Response: The Service believes that it is helpful to establish experimental population boundaries for reintroduction efforts.

Issue 7: The Commission objected to the addition of any counties to the experimental population area because (1) it would increase the public's perception of ''government land-grabbing'' and (2) it is unnecessary since the provisions for red wolves within the designated experimental population area will also be applied to red wolves outside the designated experimental population area, except for reporting requirements.

The Association expressed concerns that as red wolves continue to disperse from ''core areas,'' the areas will increase in size and more private property will be brought under the experimental population designation. The Association also expressed concerns that the provision for allowing the ''take'' of red wolves under certain circumstances on property outside the buffer zone will eventually be removed.

Service Response: The proposed addition of Martin and Bertie Counties was to provide a buffer around the release area. Although red wolves would not be released in these counties, their proposed addition, for management purposes, was because of their close proximity. The Service would expend efforts within these counties to provide information on the project and would quickly respond and handle any problems caused by dispersing red wolves. Such rapid response would necessitate the reporting of such problems to the Service as soon as possible. Because the Service will be monitoring the animals and will be contacting individual landowners regarding the capture of dispersing animals, the more intensive broad-scale management within the counties may not be necessary. Therefore, the Service agrees to not designate additional counties for the experimental population area.

The Service has no intention of removing the ''take'' provisions on property outside the buffer zone. Reintroduced red wolves will continue to be managed as experimental populations until the recovery objective of 220 red wolves in the wild is met. At that time, the species would be delisted and managed as a resident species by the State.

National Environmental Policy Act

Environmental assessments were prepared under the authority of the National Environmental Policy Act of 1969 and are available for inspection by the public at the Service's Asheville Field Office (see **ADDRESSES** section). These assessments formed the basis for a decision that these actions are not major Federal actions which would significantly affect the quality of the human environment within the meaning of section 102(2)(C) of the National Environmental Policy Act (implemented at 40 CFR Parts 1500–1508). These minor rule changes do not require

revision of the environmental assessments.

Executive Order 12866, Paperwork Reduction Act, and Regulatory Flexibility Act

This rule has been reviewed under Executive Order 12866. The Fish and Wildlife Service has determined that the rule would not have a significant economic effect on a substantial number of small entities as described in the Regulatory Flexibility Act (Pub. L. 96–354). No private entities will be affected by this action. The rule does not contain any information collection or recordkeeping requirements as defined in the Paperwork Reduction Act of 1980 (Pub. L. 96–511).

Author

The principal author of this final rule is V. Gary Henry (see **ADDRESSES** section).

List of Subjects in 50 CFR Part 17

Endangered and threatened species, Exports, Imports, Reporting and recordkeeping requirements, Transportation.

Regulation Promulgation

Accordingly, part 17, subchapter B of chapter I, title 50 of the Code of Federal Regulations is amended as set forth below:

PART 17—[AMENDED]

1. The authority citation for part 17 continues to read as follows:

Authority: 16 U.S.C. 1361–1407; 16 U.S.C. 1531–1544, 16 U.S.C. 4201–4245; Pub. L. 99–625, 100 Stat. 3500; unless otherwise noted.

2. Amend § 17.11(h) by revising the entries for red wolf to read as follows:

§ 17.11 Endangered and threatened wildlife.

* * * * *

(h) * * *

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Common name	Scientific name						
MAMMALS:							
*	*	*	* *		*		*
Wolf, red	*Canis rufus*	U.S.A. (SE U.S.A., west to central TX).	Entire, except where listed as Experimental Populations below	E	1, 248, 449, 579	NA	NA
do	do	do	U.S.A. (portions of NC and TN—see § 17.84(c)(9))	XN	248, 449, 579	NA	17.84(C)
*	*	*	* *		*		*

3. Section 17.84 is amended by revising paragraphs (c)(4), (c)(9)(i) and (c)(10) of the section to read as follows:

§ 17.84 Special rules—vertebrates.

* * * * *

(c) * * *

(4)(i) Any person may take red wolves found on private land in the areas defined in paragraphs (c)(9) (i) and (ii) of this section, *Provided* that such taking is not intentional or willful, or is in defense of that person's own life or the lives of others; and that such taking is reported within 24 hours to the refuge manager (for the red wolf population defined in paragraph (c)(9)(i) of this section), the Park superintendent (for the red wolf population defined in paragraph (c)(9)(ii) of this section), or the State wildlife enforcement officer for investigation.

(ii) Any person may take red wolves found on lands owned or managed by Federal, State, or local government agencies in the areas defined in paragraphs (c)(9) (i) and (ii) of this section, *Provided* that such taking is incidental to lawful activities, is unavoidable, unintentional, and not exhibiting a lack of reasonable due care, or is in defense of that person's own life or the lives of others, and that such taking is reported within 24 hours to the refuge manager (for the red wolf population defined in paragraph (c)(9)(i) of this section), the Park superintendent (for the red wolf population defined in paragraph (c)(9)(ii) of this section), or the State wildlife enforcement officer for investigation.

(iii) Any private landowner, or any other individual having his or her permission, may take red wolves found on his or her property in the areas defined in paragraphs (c)(9) (i) and (ii) of this section when the wolves are in the act of killing livestock or pets, *Provided* that freshly wounded or killed livestock or pets are evident and that all such taking shall be reported within 24 hours to the refuge manager (for the red wolf population defined in paragraph (c)(9)(i) of this section), the Park superintendent (for the red wolf population defined in paragraph (c)(9)(ii) of this section), or the State wildlife enforcement officer for investigation.

(iv) Any private landowner, or any other individual having his or her permission, may harass red wolves found on his or her property in the areas defined in paragraphs (c)(9) (i) and (ii) of this section, *Provided* that all such harassment is by methods that are not lethal or physically injurious to the red wolf and is reported within 24 hours to the refuge manager (for the red wolf population defined in paragraph (c)(9)(i) of this section), the Park superintendent (for the red wolf population defined in paragraph (c)(9)(ii) of this section), or the State wildlife enforcement officer, as noted in paragraph (c)(6) of this section for investigation.

(v) Any private landowner may take red wolves found on his or her property in the areas defined in paragraphs (c)(9) (i) and (ii) of this section after efforts by project personnel to capture such animals have been abandoned, *Provided* that the Service project leader or biologist has approved such actions in writing and all such taking shall be reported within 24 hours to the Service project leader or biologist, the refuge manager (for the red wolf population defined in paragraph (c)(9)(i) of this section), the Park superintendent (for the red wolf population defined in paragraph (c)(9)(ii) of this section), or the State wildlife enforcement officer for investigation.

(vi) The provisions of paragraphs (4) (i) through (v) of this section apply to red wolves found in areas outside the areas defined in paragraphs (c)(9) (i) and (ii) of this section, with the exception that reporting of taking or harassment to the refuge manager, Park superintendent, or State wildlife enforcement officer, while encouraged, is not required.

* * * * *

(9)(i) The Alligator River reintroduction site is within the historic range of the species in North Carolina, in Dare, Hyde, Tyrrell, and Washington Counties; because of its proximity and potential conservation value, Beaufort County is also included in the experimental population designation.

* * * * *

(10) The reintroduced populations will be monitored closely for the duration of the project, generally using radio telemetry as appropriate. All animals released or captured will be vaccinated against diseases prevalent in canids prior to release. Any animal that is determined to be in need of special care or that moves onto lands where the landowner requests their removal will be recaptured, if possible, by Service and/or Park Service and/or designated State wildlife agency personnel and will be given appropriate care. Such animals will be released back into the wild as soon as possible, unless physical or behavioral problems make it necessary to return the animals to a captive-breeding facility.

* * * * *

Dated: December 27, 1994

Mollie H. Beattie,

Director, Fish and Wildlife Service.

[FR Doc. 95–9291 Filed 4–12–95; 8:45 am]

BILLING CODE 4310–55–P



Red Wolf (*Canis rufus*) Recovery Program

U.S. Fish and Wildlife Service

March 22, 2017

History of Red Wolf Recovery

- Red wolf listed as endangered in 1967
- Captive breeding program initiated in 1973 at Point Defiance Zoo & Aquarium
- Red wolf declared extinct in the wild in 1980
- Non-essential, experimental populations established in North Carolina to reintroduce the red wolf in the wild
  - Eastern North Carolina in 1986
  - Great Smoky Mountains National Park in 1992 – terminated in 1998



Red Wolf Program Successes

Innovative conservation management techniques

- First successful wild carnivore reintroduction, 8 years before Yellowstone, leading to many of the management techniques used for Gray Wolf and Mexican Wolf Recovery including:
  - Use of island propagation sites pioneered
  - Maintenance of genetic diversity in what has grown to 42 captive breeding facilities, almost entirely volunteers, to form one captive population
  - Development of Pup fostering techniques
  - Demonstrated effective control of introgression of coyote DNA into the red wolf genome using Placeholder Strategy & Adaptive Management
  - Successful population management – exceeding recovery target for the NCNEP, peaking at an estimated 120-130 wolves in 2006



Recovery Challenges

Human Dimensions: Local landowner support for the NEP has largely eroded due to the Federal court injunction on coyote night hunting. However, public support for red wolf recovery outside the five-county NEP area exists.

Science: Uncertainty regarding the evolutionary origin and historical range of the red wolf species.

Management: Coyote introgression and hybridization with red wolves

Rule Implementation: Aspects of Service NEP management was inconsistent with 10j rule.

Legal: Red Wolf Coalition, Defenders of Wildlife and the Animal Welfare Institute have filed suit against the Service in 2015 alleging it illegally authorized a private landowners to take red wolves and failed to conduct a five-year status review.

Political: NCWRC issued resolutions calling for the termination of the NEP and for declaring the red wolf extinct in the wild. Congressional interest has resulted in oversight hearing of federal wolf management, including red wolf recovery actions.

Recent Management Actions

- Issued the first take authorization to a private landowner
- Signed MOU with NCWRC on collaborative conservation of red wolves and other canids
- Contracted Wildlife Management Institute (WMI) to conduct a program evaluation of the NEP
- Examined other 10(j) rules across the country for alternative approaches
- Convened a new Recovery Team, including sub-teams of geneticists and human dimensions experts, tasked with recommending a path forward for the Red Wolf Recovery Program



WMI Report Findings Specific to the NEP

- Recovery objectives can not be met on Federal land alone
- Program received inadequate Regional and National oversight
- Program lacked multi-disciplinary outreach approach
- The current 10(j) rule is poorly constructed
- Injunction on coyote hunting produced landowner and state anti-wolf sentiment
- USFWS/NCWRC 2013 MOU was a positive step



Key WMI Findings affecting the Recovery Program as whole

- Red wolf taxonomy remains unclear.
- The historical range of the red wolf is larger than the recovery plan outlined.
- Hybridization with coyotes is the greatest threat to red wolf recovery.
- Hybridization is far more likely to occur if a key breeder is lost at critical time.
- The placeholder technique is sound but labor intensive .
- Public support for red wolf recovery exists outside of the 5-County NEP in Eastern NC.



2015 Recovery Team

In October 2015, the Service convened a Recovery Team comprised of representatives from Federal and State agencies, universities, non-governmental organizations and county and landowner representatives.



The task: review the implementation of recovery actions, the human dimension challenges and the science behind red wolf conservation, including taxonomy, historical range and population viability, and provide findings to inform a Service recommendation on the future of the Red Wolf Recovery Program.

Recovery Team Findings

Genetics: Geneticists agreed that the red wolf is a “listable entity” although they do not agree on the taxonomy.

Captive Breeding: The captive breeding population needs to be increased to secure genetic diversity and allow for new NEPs.

Hybridization: Presents the greatest challenge to recovery.

Community Relations: Without private landowner support, recovery of the red wolf is impossible.



2016 Management Decision

On September 12, 2016, the Service announced the decision to continue to support the Red Wolf Recovery Program:

- ✓ Growing the captive population, with our private partners;
- ✓ Identifying other potential NEP locations with our state partners;
- ✓ Maintaining a smaller NCNEP, managed with the captive population as one population; and
- ✓ Keeping wolves in the wild to retain the “wild experience” and the influence of natural pressures on the wild population in the genetic pool.



Next Steps

- Completing a Species Status Assessment and five-year status review for the red wolf, to include a taxonomic determination. **Target Date: October 2017**
- Determining where potential new sites may exist for additional experimental wild populations. **Target Date: October 2017**
- Proposing a new rule to revise the scope, goals, and management of the existing experimental population. **Target Date: December 2017**
- Securing the captive red wolf population by working with partners to increase capacity. **Target Date: December 2017**




Questions?

***USFWS/USGS Structured Decision Making Workshops* (ALC 3159)**
Case Study Proposal, Instructions and Template

Red Wolf Reintroduction and Management

1. Decision: The Red Wolf Recovery Program will determine if/where there are areas suitable for reintroduction of red wolves within its historical range. We have committed to identifying potential reintroduction sites as part of a 5-year status review of the species. Our target for completion of the 5-year review is October 2017. We anticipate that at that time we will identify numerous potential reintroduction sites that will be very general in nature. However, following the 5-year review, we will need to determine which of those potential areas provide the best opportunity for successful reintroductions and the management strategy to reach set goals for these populations as well as the captive population. Ultimately, it will be the Regional Director(s) decision, but State wildlife agencies and other federal agencies will influence the decision. This is a one-time decision under the authority of the Endangered Species Act.
2. Background: In 2016, the Service determined that recovery of the red wolf in the wild is feasible with significant changes to management that must be implemented to secure the captive and wild populations. The only red wolves remaining in the wild is a nonessential experimental population in North Carolina; therefore, reintroduction of wolves to other areas is the only option to recover the species in the wild. However, reintroduction and maintenance of red wolves on the landscape is highly controversial. The presence and introduction of an apex predator usually incites strong opposition from the public, whether it is due to perceived or actual fears.
3. Decision Structure: The management objectives are to 1) identify the sites that will provide the best chance of successful reintroductions and, 2) identify the management strategy that will enable those populations to reach viability. Management actions may include maintenance of a set number of animals in the wild and captive population, maintenance of genetic diversity above certain levels, and number of animals released into the population over varying number of years. Population demographics and genetic diversity will need to be measured to ensure goals are met. At this time, key uncertainties include what constitutes viability for this species (to be determined in an SSA to be completed by August 2017), coyote introgression, prey density, and human dimension aspects.
4. Team Leadership: Emily Weller. Emily has taken some regional training on structured decision making. She is familiar with the general concept and process. She looks forward to applying a structured and well-documented process to this controversial decision.
5. Workshop Participation: GIS-expertise, SSA participants that determine viability for the species, human dimensions, Federal and State partner representation, population viability analysis, and Species Survival Plan (captive population) representation.

Submit your proposal by email to:
Christy Coghlan, NCTC course leader, christy_coghlan@fws.gov

II. Summary: Did the red wolf historically exist?

a. **Was there historically a wolf present in the southeast?**

i. Pre-1600s

- Archaeological records contain evidence of primitive wolf species in southeastern United States from Late Blancan (2.5-2 million ybp, Irvingtonian (1 million-600,000 ybp), Rancholabrean (300,000-130,000 ybp), and Pleistocene (130,000-10,000 ybp) (Nowak 2002, pp. 104-106?).
- Small wolves seem to disappear (for approximately 1 million years) from eastern North America between the middle Irvingtonian (700,000 – 1 million ybp) and the late Rancholabrean (130,000-10,000 ybp) (extinction of C. priscolatrans) (Nowak 2002, p. 106).
- Late Rancholabrean (130,000-10,000 ybp), small wolf reappears in eastern North America and persists until the 20th century when it was extirpated (Nowak 2002, p. 106).
    - The small wolf that reappeared differed from *C. dirus*, *C. armbrusteri*, and *C. latrans* (Nowak 2002, p. 109); was intermediate in size to *C. dirus* and *C. latrans*; considered to be *C. rufus* (Nowak 2002, p. 106).
- The small wolf was the only canid in the east/southeastern U.S. after late Rancholabrean Age (130,000-10,000 ybp).
    - *C. dirus* extinct by end of Pleistocene/late Rancholabrean (~ 10,000 ybp) (Nowak 2003, p. 241).
    - *C. latrans* was absent from the southeast at the end of Pleistocene (late Rancholabrean) until mid-20th Century, (Nowak 2002, p. 118).
- Small coyote and large wolf (C. dirus) occupied the east until end of the Pleistocene (10,000 ybp) with the influx of a small wolf, but new small wolf persisted until the 20th Century (Nowak 2002, pp. 117, 118?)
- Genetic studies corroborate presence of a wolf in the southeast during this time.

ii. 1600 – Early 1900's

- Evidence of a wolf in southeastern United States in travel journals, personal writings, and bounty records. WMI (2016) notes evidence from 1632 to 1900 in VA, SC, NC, GA, and FL.
- Evidence is less from scientific and museum specimens likely due to the fact that early settlers extirpated most of the red wolves in VA, SC, NC, GA, and FL before there was an opportunity for naturalists and biologists to obtain specimens for study (Nowak IN WMI 2016, p. 15).
- Although they cannot state with certainty the species of wolf that was present in these states, it seems likely that wolves existed historically across the southeast from VA to FL, likely in abundance (WMI 2016, p. 16).
- Genetic studies corroborate presence of a wolf in the southeast during this time period

FACT: There was a wolf in southeastern U.S.

b. Was the wolf inhabiting the southeastern U.S. different/distinguishable from other canids?

i. Pre-1600s

- The small wolf that reappeared was intermediate in size to *C. dirus* and *C. latrans*, (Nowak 2002, p. 106).
- Samples of the small eastern wolf, including paleontological fragments dating about 10,000 ybp, archeological fragments dating 2,000-200 ybp, and complete, mostly modern skulls, were significantly different from western *C. lupus* and *C. latrans* (Nowak 2002, p. 109) (Identified as *C. rufus*).

ii. 1600 – Early 1900's

- Samples of the small eastern wolf, including paleontological fragments dating about 10,000 ybp, archeological fragments dating 2,000-200 ybp, and complete, mostly modern skulls, were significantly different from western *C. lupus* and *C. latrans* (Nowak 2002, p. 109). Identified as red wolf *C. rufus*
    - 6 whole, fully developed male *Canis* skulls taken prior to 1918 were statistically separate from *C. lupus* and *C. latrans*; identified as red wolf *C. rufus* (Nowak 2002, pp. 118-119)(East of Mississippi River and south of Prairie Peninsula, Lakes Erie and Ontario and St. Lawrence River).
    - 7 additional complete male skulls from northeastern LA, taken between 1898 and 1905, and 1 collected in south-central OK in 1869 also identified as red wolf *C. rufus* (Nowak 2002, p. 119).
- Catesby (1771), writing of FL and the Carolinas noted "The wolves in America are like those of Europe, in shape and colour, but are somewhat smaller" (Nowak 1979, p. 16?).
- Travel writer Charles Lanman (Camuto 1997) "routinely distinguished between the black (red) and gray wolf and… encountered them in the southern Appalachian backcountry" in the mid 1800's (WMI 2016, p. 15).
- Audubon and Bachman (1851) first suggested that in the southern U.S. there existed wolves structurally different from those in other regions (Nowak 1979, p. 24).
    - Black American wolf (FL, SC, NC, KY, southern IN, southern MO, LA, and northern TX)
    - Red Texan wolf (northern Arkansas through Texas and into Mexico)
        - Mentioned long legs, pointed nose, and slender proportions (id).
- Bailey's (1905) detailed biological survey of TX included reports/references to *C. lupus*, *C. latrans*, and *C. rufus* (Nowak 1979, p. 37).
    - *C. rufus* – definite range can be assigned; does not overlap with *C. lupus*; ranchmen invariably distinguished between them and coyotes; ranchman usually pay $10 or $20 bounty for red wolves (as opposed to $1 or $2 for coyotes) (Nowak 1979, p. 38).
- In reference to Bailey (1905), Nowak (1979, p. 38) states that the important fact is that the presence of both this larger species of *Canis* (now referred to as the red wolf) and a distinct smaller species (*C. latrans*) was generally recognized.

- Bailey (1905) referred to *C. rufus* as a large coyote or a small wolf (Nowak 1979, p. 24).

Information indicates that people were able to visually distinguish between coyotes and wolves; although in personal accounts, not a lot of information is provided on distinguishing features. By late 1800s/early 1900s they were referring to the small wolf as "red wolf."

c. What was this entity in the southeast called?

i. <u>Pre-1600s</u>

- Contemporary debate/studies on the correct classification and origin for the wolf/wolf-like entity in the southeast have resulted in several proposals for this time period:

Distinct Origin Theory

  - *Canis rufus* (e.g. Ferrell 1980; Nowak 1979, 2002; Bertorelle and Ecoffier 1998 in Hedrick 2002, p. 1906)
  - *Canis lycaon* (e.g., Wilson et al. 2000; Rutledge et al. 2010, p. 1278)
  - *Canis lupus rufus* (e.g., Audubon and Bachman 1851; Lawrence and Bossert 1967, p. 228; Wayne 1995, p.11)

Hybrid Origin Theory

  - Ancient (depending on timeframe)
    - *Canis rufus* (possibly *C. lycaon*) (Speciation through hybridization)
    - *Canis lupus* subspecies (e.g. Wayne and Jenks 1991, p. 566; Hohenlohe et al. 2016, p. 1)
  - Recent
    - *Canis lupus* (e.g., Roy et al. 1994, p. 565; Wayne 1995, p. 9; Roy et al. 1996, p. 1421; Reich 1999, p. 143; von Holdt et al. 2011, 2016).

ii. <u>1600s – Early 1900s</u>

Chronology of scientific names for red wolf (Nowak 1979, pp. 24-25)

- 1791 - Bartram
  - *Canis niger* (black wolves seen in FL)
- 1825 – Harlan
  - *Canis lycaon* (black wolves in FL, but also black wolves in mountainous areas of North America and Europe)
- 1851 - Audubon and Bachman
  - *Canis lupus* var. *Ater* (Black American Wolf – FL, SC, NC, KY, southern IN, southern MO, LA, and northern TX
  - *Canis lupus* var. *Rufus* (Red Texan Wolf – northern AR through TX, and Mexico)

End of 19th Century finer taxonomic splitting became "more fashionable"

- 1898 - Bangs *Canis ater* (designated FL wolf as full species)
- 1905 – Bailey
  - *Canis ater* (questionably referred to the large, dark wolf of east Texas as *C. ater*)
  - *Canis rufus* (recognized Audubon and Bachman's red wolf as a full species)
- 1912 – Miller
  - *Canis floridanus* (name *ater* was unavailable, designated FL wolf – became generally accepted for wolves in the forested areas of southeastern U.S.).
  - *Note: C. rufus continued to be recognized in central and southern TX.*
- In the 18th and 19th centuries, residents of the American Southeast often described encounters with creatures they called red wolves: longlegged, cinnamon-colored animals (Wayne and Gittleman 1995, p. 1).
- Although the scientific name changed, there is consistency in using "red wolf" to refer to those wolves in central and southern TX since 1851 (also possible northern AR based on Audubon and Bachman (1851)).
- Contemporary debate/studies on the correct classification and origin for the wolf/wolf-like entity in the southeast have resulted in several proposals for this time period:

Distinct Origin Theory

- *Canis rufus* (e.g., Ferrell 1980; Nowak 1979, 2002; Bertorelle and Ecoffier 1998 in Hedrick 2002, p. 1906)
- *C. lycaon* (e.g., Wilson et al. 2000, Rutledge et al. 2010, p. 1278)
- *C. lupus rufus* (e.g., Audubon and Bachman 1851; Lawrence and Bossert 1967, p. 228; Wayne 1995, p.11)

Hybrid Origin Theory

- Ancient
  - *C. rufus* (possibly *C. lycaon*) (Speciation through hybridization)
  - Hybrid (historic hybridization between coyote and gray wolf that then backcrossed extensively with coyotes)
- Recent
  - Hybrid cross of coyote and gray wolf (e.g., Roy et al. 1994, p. 565; Wayne 1995, p. 9; Roy et al. 1996, p. 1421; Reich 199, p. 143; von Holdt et al. 2011, 2016).

Depending on the Theory of Origin, the entity occupying the southeastern United States could be one of various scientific names/proposed taxonomic classification; however, there is consistency, especially since observation first began, of this entity being referred to as the red wolf.

Nowak 1992, p. 594

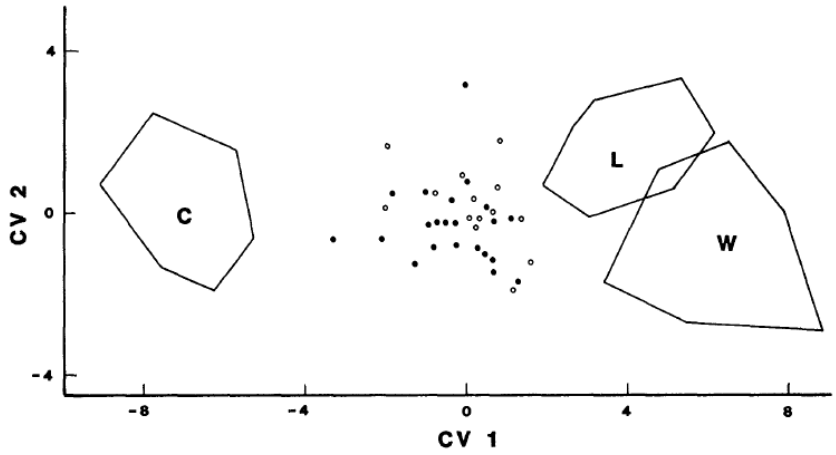


Figure 1. Plot of first and second canonical variables (CV 1 and CV 2) of a canonical discriminant analysis of skulls of Canis. *Letters indicate mean positions of known groups: coyote (C), Minnesota and Isle Royale gray wolf (L) Alaska gray wolf (W). Solid lines show boundaries of distributions of known groups. Dots indicate positions of 22 specimens of red wolf collected before 1940. Open circles indicate positions of 9 individuals used to found existing captive and reintroduced population of red wolf, and 5 individuals that had been released in North Carolina.*

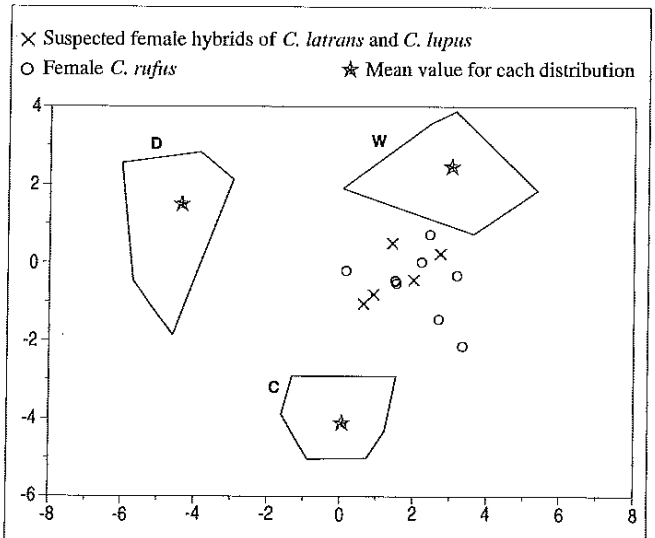


Figure 1. *Multistatistical distribution of five groups of Canis, based on the first (horizontal axis) and second (vertical axis) canonical variables. D shows the limits for C. familiaris, C shows limits for female C. latrans, and W shows limits for female C. lupus. The mean for each distribution is given by a star. Data points for female C. rufus (circles) and suspected female hybrids of C. latrans and C. lupus (crosses) are also shown.*

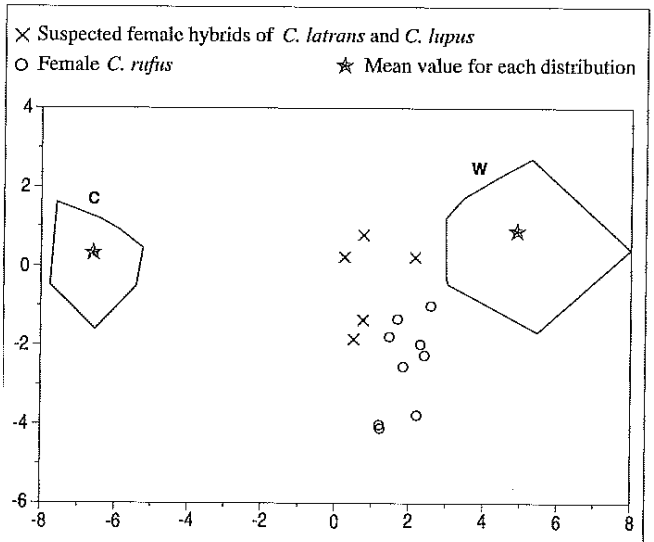


Figure 2. *Multistatistical distribution of four groups of female Canis, based on the first (horizontal axis) and second (vertical axis) canonical variables. C shows the limits for C. latrans and W shows limits for C. lupus. The mean for each distribution is given by a star. Data points for female C. rufus (circles) and suspected female hybrids of C. latrans and C. lupus (crosses) are also shown.*

Brzeski et al. 2016, p. 288

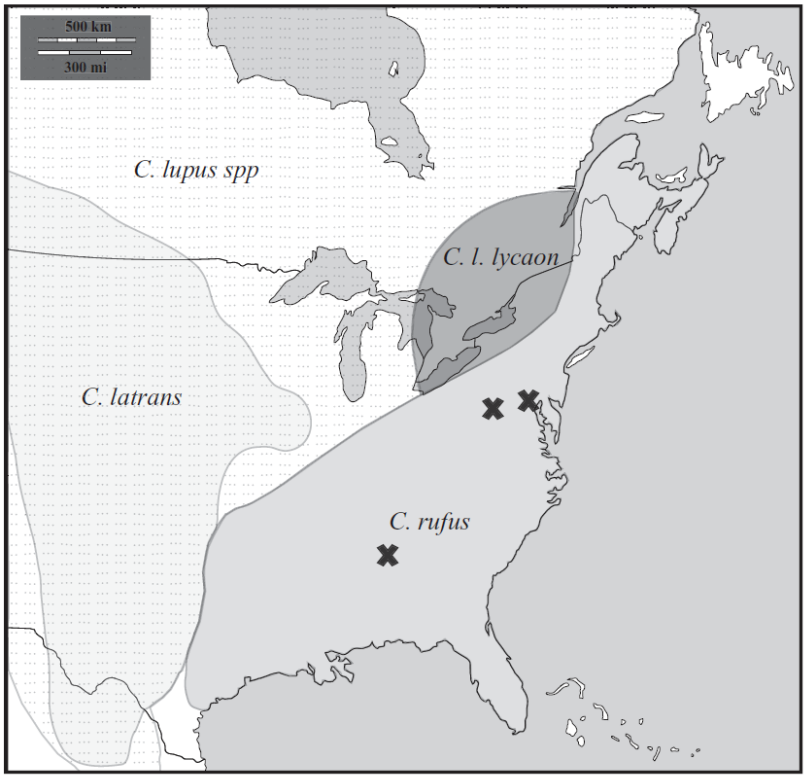


Figure 1. Historic map of North American *Canis* species and approximate sampling locations (Xs) for ancient DNA samples. Distributions are based on Parker (1995), Nowak (2002), and Chambers et al. (2012); for alternative range distributions see Kyle et al. (2006) and Rutledge et al. (2010).

Chamber et al. 2012, p. 9 (*C. latrans* added)

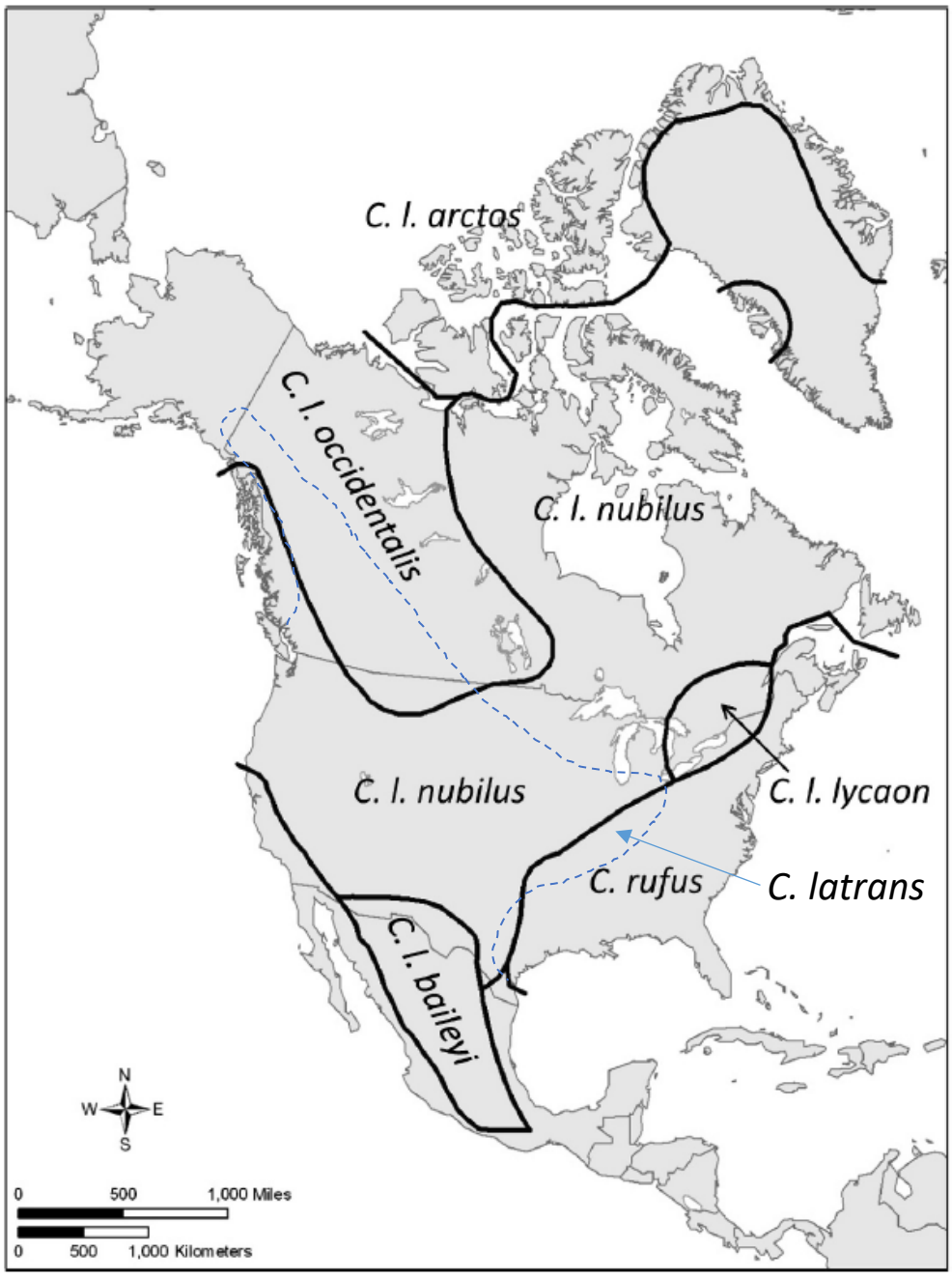


Figure 3. Ranges of North American *Canis lupus* subspecies recognize by Nowak (1995, 2002) and of *C. rufus* (after Nowak 2002).

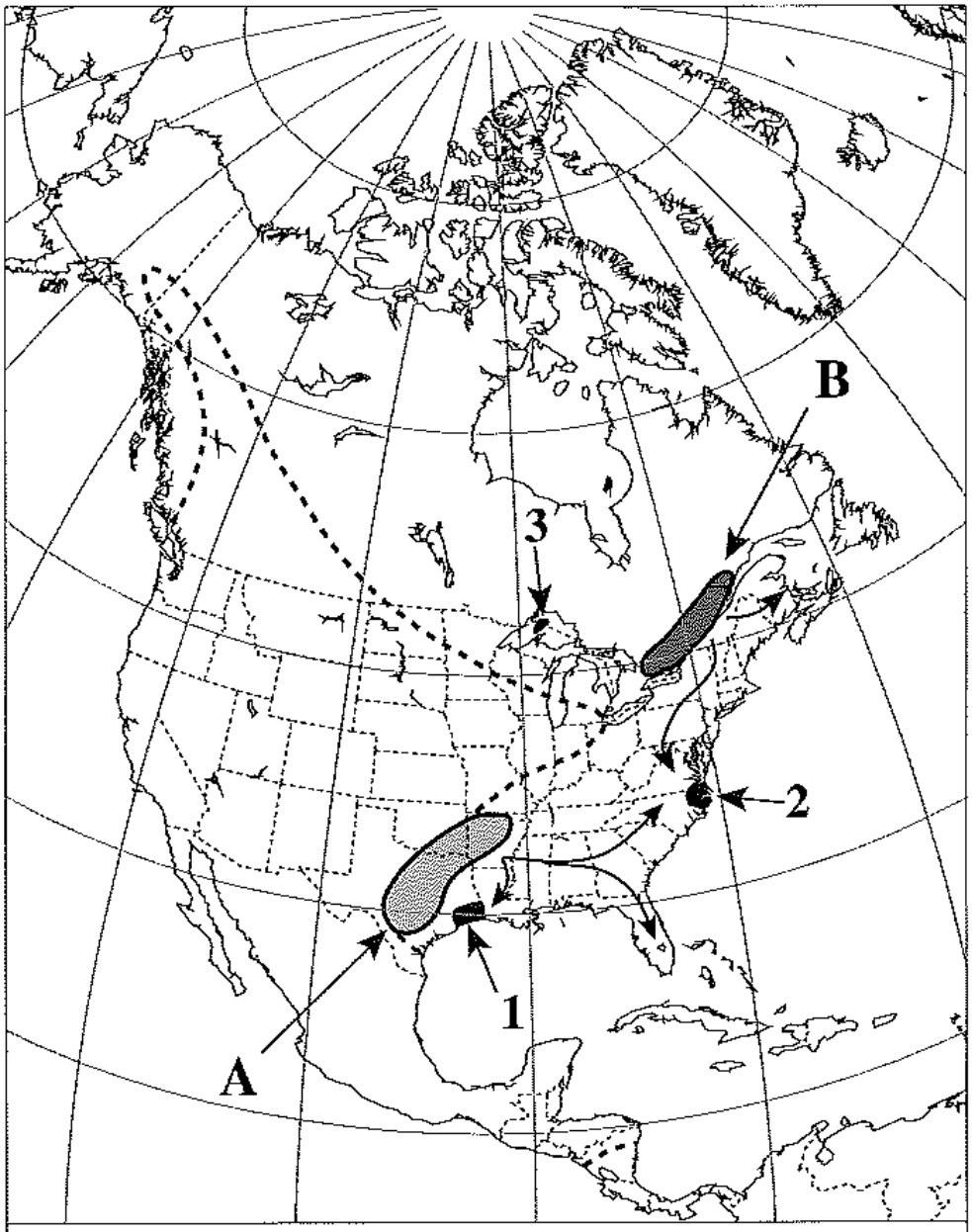


Figure 6. *Map showing original geographical range of the coyote (limits shown by dashed lines), area where coyote and red wolf hybridized c. 1890–1930 (A), and area where grey wolf and coyote hybridized shortly thereafter in southeastern Canada (B). Arrows indicate subsequent expansion of modified coyote populations. Also shown are the last relatively pure wild red wolf population c. 1970 (1), the reintroduced red wolf population 1987 to present (2), and Isle Royale (3).*

Nowak 2002, p. 97

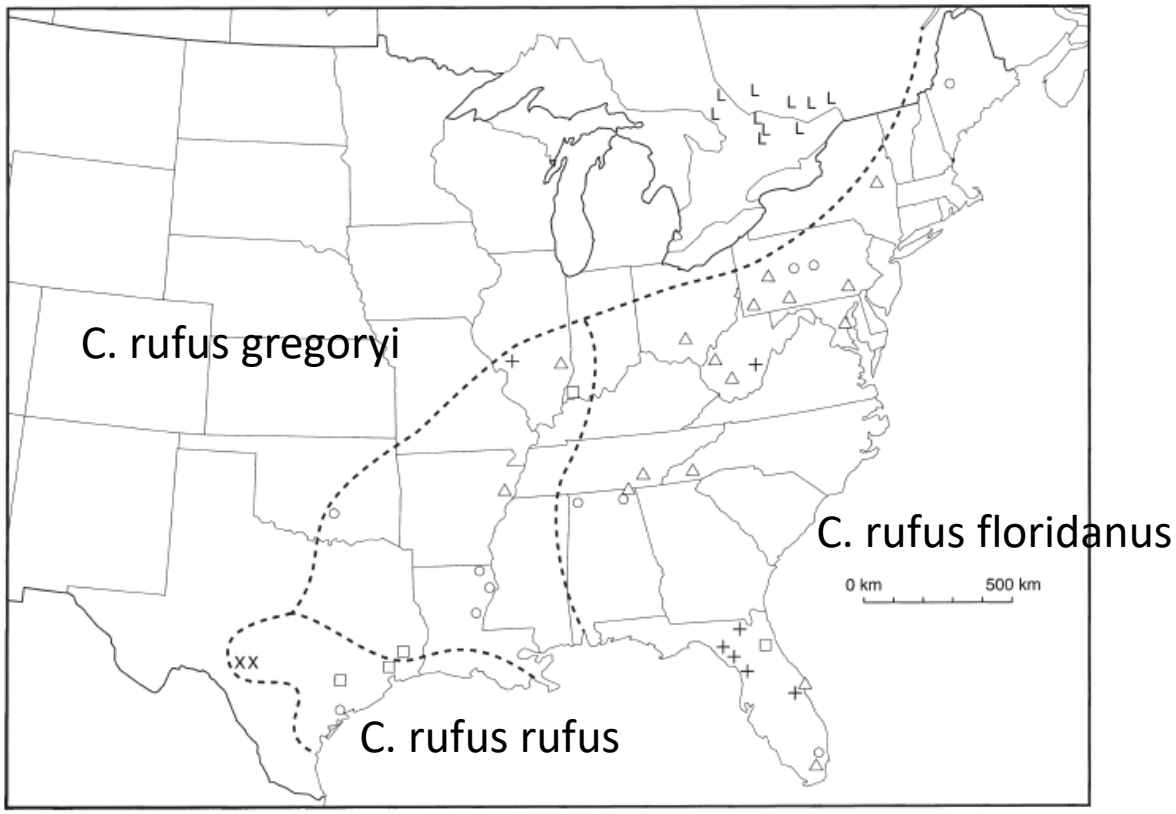


Figure 2. Distribution of eastern *Canis*. Open circles, pre-1918 complete skulls of male *C. rufus* used in multivariate analyses (precise localities of Pennsylvania specimens are unknown); squares, pre-1918 complete skulls of female *C. rufus*; triangles, archeological fragments (2,000-200 ybp) referable to *C. rufus*; crosses, paleontological fragments (c. 10,000 ybp) referable to *C. rufus*; X's, apparent hybrids of *C. rufus* x *C. latrans*, 1899-1906; L's, *C. lupus lycaon*, 1905-1933; dashed lines, subspecific ranges: *C. rufus floridanus* (east), *C. rufus gregoryi* (central), *C. rufus rufus* (southwest).

Nowak 2002, p. 111

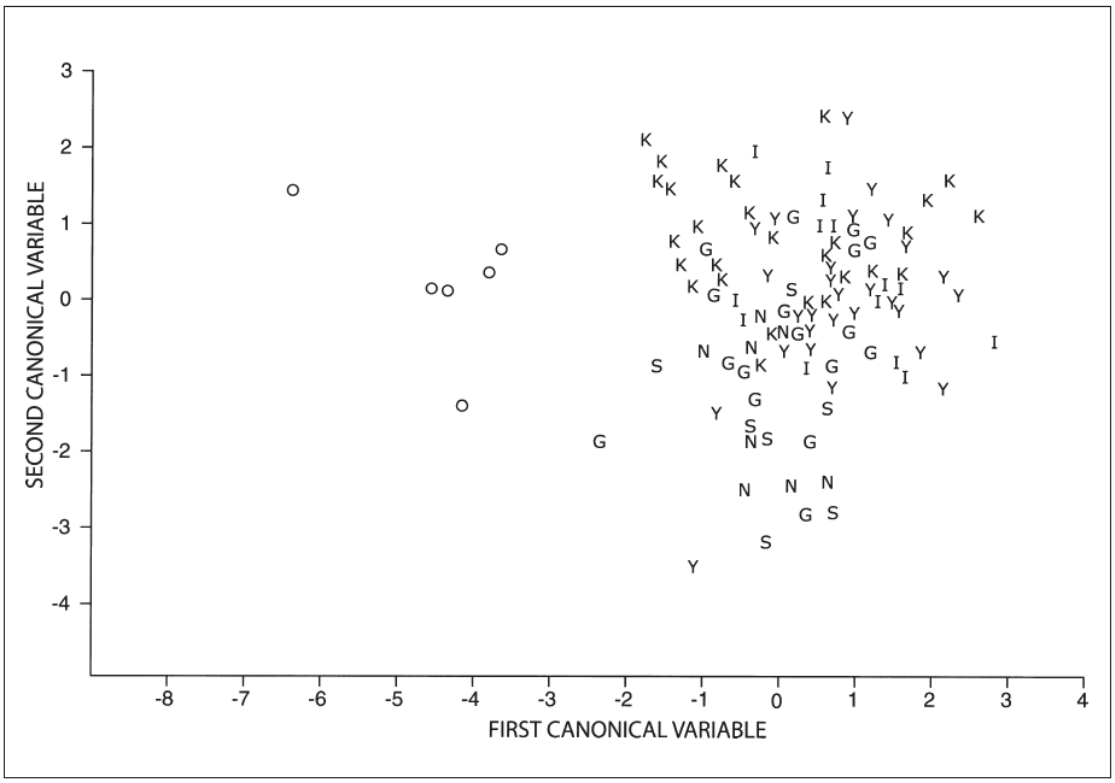


Figure 6. Statistical distribution of seven groups of North American male *Canis*, plotted on the first and second canonical variables. G's, *C. lupus* from southern Rocky Mountains; I's, *C. lupus* from northern Rocky Mountains; K's, *C. lupus* from Minnesota; N's, *C. lupus* from Nebraska, Kansas, and Oklahoma; S's, *C. lupus* from central and western Texas; Y's, *C. lupus* from central Rocky Mountains); open circles, pre-1918 *C. rufus* from east of Mississippi River.

Nowak 2003, p. 240

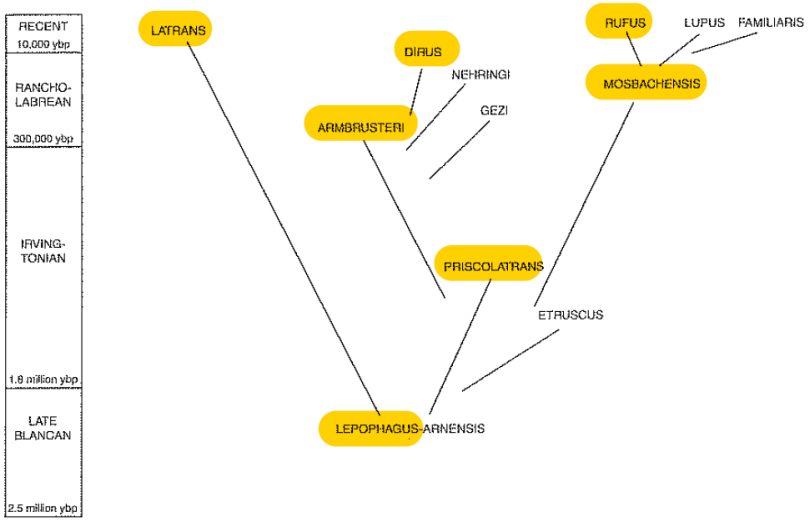


FIGURE 9.1. Hypothetical evolution and branching of the genus *Canis*. North American Land Mammal ages are shown to left (see also table 9.2).

Nowak 2003, p. 241

TABLE 9.2. Chronological development of wolves

Epoch	North American Land Mammal Age	Years ago	Major events
Holocene	Recent	0 – 10,000	Extinction of *dirus*, dominance of *lupus*, retreat of *rufus*
Late Pleistocene	Late Rancholabrean	10,000 – 130,000	Dominance of *dirus*, modern wolves enter New World
Middle Pleistocene	Early Rancholabrean	130,000 – 300,000	Emergence of modern wolves, extinction of *armbrusteri*
	Late Irvingtonian	300,000 – 700,000	Dominance of *armbrusteri* and *mosbachensis*
Early Pleistocene	Middle Irvingtonian	700,000 – 1 million	Emergence of larger wolves
	Early Irvingtonian	0 – 1.8 million	Dominance of *priscolatrans* and *etruscus*
Pliocene	Late Blancan	1.8 – 2.5 million	Divergence of wolf and coyote lineages
	Early Blancan	2.5 – 4.5 million	Emergence of small coyotelike forms
Miocene	Hemphillian	4.5 – 9 million	Origin of *Canis*

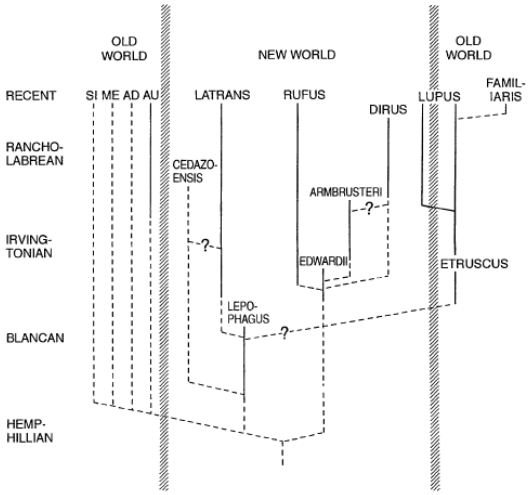


Figure 1. Phylogeny of species in the genus Canis *from Nowak (1979). Dashed lines indicate possible lineages lacking fossil evidence. Species names are placed at the latest known occurrence. Horizontal and vertical distances are not to scale and do not indicate degree of affinity. Abbreviations: SI,* C. simensis*; ME,* C. mesomelas*; AD,* C. adustus*; and AU,* C. aureus*. Question marks show alternative lineages.*

rized objectively Nowak's (1979) data and other historical records. Subsequent publications by Nowak were

Table 1. Review of literature that presents new data, new analysis, or explicit statements about red wolf systematics.

*Hypotheses**	*Reference*
D	Audubon & Bachman 1851
D	Goldman 1937
D, H	Young & Goldman 1944
D, H, HS	McCarley 1962
D, H, HS	Lawrence & Bossert 1967
D, H	Paradiso 1968
D, H	Pimlott & Joslin 1968
D, HS	Mech 1970
D	Atkins & Dillon 1971
D, H	Paradiso & Nowak 1972
D, H	Gipson et al. 1974
D, H, HS	Lawrence & Bossert 1975
D, H	Riley & McBride 1975
D, H	Elder & Hayden 1977
D, H, HS	Van Gelder 1978
D, H, HS	Nowak 1979
D, H	Ferrell et al. 1980
D, H, HS	Wayne & Jenks 1991
D, H, HS	Dowling et al. 1992*a*
D, H, HS	Dowling et al. 1992*b*
D, H, HS	Phillips & Henry 1992
D, H, HS	Wayne 1992
D, H, HS	Roy et al. 1994
D, H, HS	Wayne & Gittleman 1995
D, H, HS	Roy et al. 1996

**Three general hypotheses have been suggested for the origin of the red wolf in the southcentral United States, the area sampled by Roy et al. (1996): D, it has not hybridized and/or is fully distinguishable from closely related North American* Canis*; H, it is a distinct species or subspecies that hybridized with gray wolves, coyotes or both, at least in a significant portion of its range; or HS, it is possibly a hybrid species derived from hybridization between gray wolves and coyotes.*

Rutledge et al. 2010, p. 1274

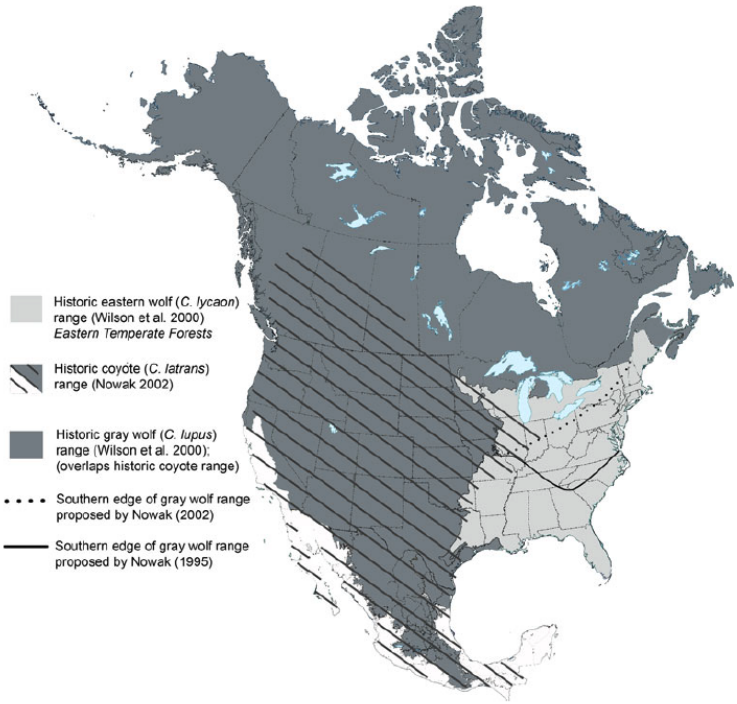


Fig. 1 Map of historic distribution of *Canis* spp. based on various taxonomic treatments. Historic eastern wolf (*C. lycaon*) range is in the Eastern Temperate Forest ecoregion and includes the red wolf (*C. rufus*) range shown south of the *thin solid line* (Wilson et al. 2000; Kyle et al. 2006); historic coyote (*C. latrans*) range shown in central and western North America (Nowak 2002; Sacks et al. 2004); historic gray wolf range overlapped historic coyote range (Nowak 2002); two suggested southern limits of *C. lupus lycaon* are also shown (*solid thin line* (Nowak 1995) and *dotted line* (Nowak 2002)). Current coyote (*C. latrans*) distribution is continent-wide (Moore and Parker 1992)

Does the red wolf meet the definition of a "species" under the ESA?

II. Did the red wolf historically exist? (Beginning of time to European settlement?)
  a. Was there a wolf historically present in the southeast?
    i. Pre-1600s
      - Late Blancan (2.5-2 million ybp)
        - C. lepophagus known mainly from western United States, but also recorded in FL. Small coyote-like species. Seem to be near the stem line from which arose the later coyotes and wolves
      - Irvingtonian (1 million – 600,000 ybp)
        - By Irvingtonian, primitive small wolves, perhaps identical with modern C. rufus, were widespread in southern North America. A branch probably entered the Old World where it gave rise to C. lupus (id).
        - C. priscolatrans present in FL (early Irving. From FL decidedly larger than C. lepophagus).
        - C. armbrusteri abundance at several other eastern sites (middle Irving.) – larger
        - This progression from small, generalized canid to a large wolf represents a single evolutionary sequence; there is no evidence of another lineage, a smaller wolf continuing into the late Irvingtonian and early Rancholabrean (Nowak 2002, p. 104).
        - Small wolves seem to disappear from eastern North America following extinction of C. priscolatrttans and do not reappear until the terminal Pleistocene (15,000-10,000 ybp) (Nowak 2002, p. 106).
        - This wolf could have been a direct descendant of the Eurasian C. mosbachensis (Nowak 2002, p. 117). Possible that C. mosbachensis gave rise to small wolves that entered North America, became isolated by glaciation, and developed into modern eastern wolves (id).
      - Rancholabrean (300,000 – 130,000 ybp)
        - C. armbrusteri abundance at several other eastern sites (early Ranch.) Larger
        - C. dirus (late Ranch. (130,000-10,000 ybp) Even Larger, no overlap with armbrusteri
        - Late Ranch specimens represent 3 species: C. dirus, substantially larger; far smaller is eastern form of C. latrans; intermediate size wolf most likely the emergence of a modern species, considered to be C. rufus (Nowak 2002, p. 106).

    - As New World wolf line grew larger from priscolatrans to the very large early Ranch form of armbrusteri, a niche opened for the coyote. A few specimens indicate widespread sympatry with the huge dire wolf (Nowak 2003, p. 251).
    - Late Rancholabrean (130,000-10,000 ybp), small wolf reappears in eastern North America and persists until the 20th century when it was extirpated (Nowak 2002, p. 106).
        - The small wolf that reappeared differed from C. dirus, C. armbrusteri, and C. latrans (Nowak 2002, p. 109); was intermediate in size to C. dirus and C. latrans; considered to be C. rufus (Nowak 2002, p. 106).
        - Small coyote and large wolf (C. dirus) occupied the east until end of the Pleistocene (10,000 ybp) with the influx of a small wolf, but new small wolf persisted until the 20th Century (Nowak 2002, pp. 117, 118?)
    - Late Ranch records of eastern C. latrans are from WV, MS, and AL, FL (Nowak 2002, p. 118).
    - The small wolf was the only canid in the east/southeastern U.S. after late Rancholabrean Age (130,000-10,000 ybp).
    - Influx of a small wolf, late in Ranch may have been factor in the ultimate disappearance of the coyote from most of the east (id).
- Pleistocene (130,000 ybp)
    - Line culminated in dirus. Progressive increase in size of that line seems to have allowed reopening of the niche for a smaller kind of Canis. Initially just C. latrans by late Irving. but also another wolf at the end of the Pleistocene.
    - C. dirus extinct by end of Pleistocene/late Rancholabrean (~ 10,000 ybp) (Nowak 2003, p. 241).
    - C. latrans was absent from the southeast at the end of Pleistocene (late Rancholabrean) until mid-20th Century, (Nowak 2002, p. 118).
    - By terminal Pleistocene, the east had been reoccupied by a wolf differing from C. dirus, C. armbrusteri, and C. latrans (Nowak 2002, p. 109).
        - Assessment of later specimens indicate continuity of this small eastern wolf (no difference in size of m1 of paleontological fragments dating about 10,000 ybp, archeological fragments dating 2,000-200 ybp, and complete, mostly modern skulls. But there is significant difference between those samples and western C. lupus and C. latrans (id)).

- Different theories also in Nowak 2003

- Although we (WMI 2016, p. 16) cannot state with certainty the species wolf present in these states, it seems likely that wolves existed historically across the southeast based on this range of accounts.
- How far back is there evidence?
  - Wolves in southeastern U.S.: Blancan Age (2.5-2 million ybp)
  - What is considered to be Canis rufus: Late Rancholabrean Age (130,000-10,000 ybp).

ii. 1600-Early 1900s

- Evidence of a wolf in southeastern United States in travel journals, personal writings, and bounty records.
- WMI (2016) notes evidence from 1632 to 1900 in VA, SC, NC, GA, and FL.
- Evidence of a wolf in SE United States - Evidence that red wolves existed in the southeastern United States (Virginia to Florida) derived less from scientific literature and museum specimens and more so from historical accounts, including travel journals, bounty records, and personal writings.
- Nowak (personal communication, December 14, 2015) hypothesized that this was likely due to the fact that early settlers extirpated most of the red wolves in Virginia, North Carolina, South Carolina, Georgia, and Florida. Thus, there was no opportunity for naturalists and biologists to obtain specimens from those states for study (WMI 2016, p. 15).

- Red wolf has existed in southeastern North America, in much the same form as now, for at least 700,000 years (Nowak 1995, p. 2).
  - Only 6 whole, fully developed male Canis skulls prior to 1918 – all are statistically separate from C. lupus and C. latrans (Nowak 2002, pp. 118-119). Taken from east of MS and south of Prairie Peninsula, Lakes Erie and Ontario, and the St. Lawrence River.
  - This species, as defined by these eastern skulls, has diagnostic measurements statistically identical to two series of fragmentary specimens collected from the same region and dating from around 10,000 ybp and from 2,000-200 ybp.
  - Supports view that C. rufus has continuously occupied the east since terminal Pleistocene and that it was the only

Commented [WE1]: This is referring to a similarly sized wolf that pre-dates red wolf.

species of wild Canis that was present in most of the region (Nowak 2002, p. 119).
    - Seven additional complete skulls of males from northeastern LA, taken 1898-1905, and one prior to 1896 in south-central OK have about the same statistical distribution as the 6 above, when compared to C. lupus and C. latrans (Nowak 2002, p. 119).
    - These argue for recognition as distinct species that is appropriately named C. rufus (Nowak 2002, p. 119).
- Archaeological records demonstrate that the red wolf was likely in southern IN, southern MO, and northwestern AR at some point in time (Paradiso and Nowak 1971) (WMI 2016, p. 17).
- Nowak (2002) observed the morphology of modern red wolves to be consistent with fossilized remains of small wolves in the eastern U.S. dating back to Pleistocene (Hinton et al. 2014, p. 856).
    a. East of Mississippi River
        - 9 known complete skulls dating from the end of Pleistocene to AD 1917
        - 5 skulls known to date from before 1870, one probably does
        - 7 specimens taken 1898-1905
- Journal/personal writings, literature
    a. WMI (2016, p. 15) review of historical records, including bounty records and laws, make it apparent that wolves were historically present in the southeastern states from VA to FL, and were likely abundant). <u>However, documents did not state the species of wolf and little descriptive information was provided.</u>
    b. Except for travel writer Charles Lanman (In Camuto 1997) who "routinely distinguished between the black (red) and gray wolf and… encountered them in the southern Appalachian backcountry" in the mid 1800's (WMI 2016, p. 15).
    c. Camuto (1997) also cited explorer John Lawson's account of wolves in his 1709 *A New Voyage to Carolina* and Mark Catesby's account of wolves in his 1731 *The Natural History of Carolina, Florida, and the Bahama Islands*. Both noted the presence of wolves in "Carolina," and Catesby stated they were "very numerous" (WMI 2016, p. 15).
    d. Bartram noted the early presences of wolves in Florida in 1774, and although he called it a black wolf, it was the only

official documentation of red wolves in the southeastern U.S. at this early time (Camuto, 1997) (WMI 2016, p. 15).

- Wolf bounty laws and records
    a. Documents did not state the species of wolf and little descriptive information was provided (WMI 2016, p. 16).
    b. VA (WMI 2016, p. 15):
        - State library contained reference to hardcopies of all wolf bounty laws enacted from 1776-1928.
        - VA was one of earliest states to establish a bounty on wolves, likely at the time of settlement and at least before 1632 (Bailey 1907; Hampton 1997).
        - Under later laws, Native Americans were required to bring in wolf pelts (Hampton 1997).
    c. SC (WMI 2016, pp. 15-16)
        - 1695 law, An Act for Destroying Beasts of Prey required Native American bowman to bring in a variety of animals skins, including wolves (Hampton 1997)
        - Landrum (1897) noted the historic presence of wolves in SC based on historian Dr. David Ramsey's writings.
        - Hampton (1997) noted that wolves were gone from SC by about 1860.
    d. NC (WMI 2016, p. 16)
        - Established a bounty in 1748
        - Several accounts of wolves based on letters and personal account recorded in a diary (Letter from William Byrd; McPherson 1915; Spangenberg, 1704-1792).
    e. GA and FL (WMI 2016, p. 16)
        - Camuto 1997 documented the historic presence of wolves in both FL and GA.
        - Bailey (1907) stated wolves were in FL in 1888, and specifically in Bradford County as late as 1895.
        - Noted last remaining wolf documented in GA in 1908, and FL and SC in 1920.

b. Was the wolf inhabiting southeastern U.S. distinguishable from other Canids?
    i. Pre-1600s
        - The small wolf that reappeared was intermediate in size to C. dirus and C. latrans, (Nowak 2002, p. 106).
            - Samples of the small eastern wolf, including paleontological fragments dating about 10,000 ybp,

archeological fragments dating 2,000-200 ybp, and complete, mostly modern skulls, were significantly different from western C. lupus and C. latrans (Nowak 2002, p. 109) (Identified as C. rufus).

ii. 1600s – early 1900s

b. Physical features

- Samples of the small eastern wolf, including paleontological fragments dating about 10,000 ybp, archeological fragments dating 2,000-200 ybp, and complete, mostly modern skulls, were significantly different from western C. lupus and C. latrans (Nowak 2002, p. 109). Identified as red wolf C. rufus.
  - 6 whole, fully developed male Canis skulls taken prior to 1918 were statistically separate from C. lupus and C. latrans; identified as red wolf C. rufus (Nowak 2002, pp. 118-119)(East of Mississippi River and south of Prairie Peninsula, Lakes Erie and Ontario and St. Lawrence River).
    - 7 additional complete male skulls from northeastern LA, taken between 1898 and 1905, and 1 collected in south-central OK in 1869 also identified as red wolf C. rufus (Nowak 2002, p. 119).
- Catesby (1771), writing of FL and the Carolinas noted "The wolves in America are like those of Europe, in shape and colour, but are somewhat smaller" (Nowak 1979, p. 16?).
- Travel writer Charles Lanman (Camuto 1997) "routinely distinguished between the black (red) and gray wolf and… encountered them in the southern Appalachian backcountry" in the mid 1800's (WMI 2016, p. 15).
- Audubon and Bachman (1851) first suggested that in the southern U.S. there existed wolves structurally different from those in other regions (Nowak 1979, p. 24).
  - Black American wolf (FL, SC, NC, KY, southern IN, southern MO, LA, and northern TX)
  - Red Texan wolf (northern Arkansas through Texas and into Mexico)
    - Mentioned long legs, pointed nose, and slender proportions (id).
- Bailey (1905) referred to C. rufus as a large coyote or a small wolf (Nowak 1979, p. 24).
  - In reference to Bailey (1905), Nowak (1979, p. 38) states that the important fact is that the presence of

both this larger species of Canis (now referred to as the red wolf) and a distinct smaller species (C. latrans) was generally recognized.

- Ranchmen invariably distinguished between them and coyotes; ranchman usually pay $10 or $20 bounty for red wolves (as opposed to $1 or $2 for coyotes) (Nowak 1979, p. 38).

c. Habitat
   - *C. lupus* – common over most of the plains and mountain country of western Texas (Bailey 1905 In Nowak 1979, p. 37)
     - At the time of the first white settlers in North America, coyotes were confined to open plains and more arid regions, mainly in the western half of the continent (Young 1951 and Seton 1929 IN Nowak 1979, p. 14).
   - *C. latrans* – more or less common over at least middle and southern Texas and apparently eastward on strips of prairie as far as Gainesville and Richmond (Bailey 1905 In Nowak 1979, p. 37). East of the semiarid mesquite region coyotes are rare. They do not enter the timbered country, but are at home in the scrub oak, juniper, mesquite, and chaparral, as well we other open prairies (Bailey 1905 In Nowak 1979, p. 38)
   - *C. rufus* – East of the plains where scrub oak and mequite country begins (Bailey 1905 In Nowak 1979, p. 38)
     - Share range with coyote, but ranchmen able to distinguish red wolf from coyote.

d. Range
   - Bailey's (1905) detailed biological survey of TX included reports/references to *C. lupus*, *C. latrans*, and *C. rufus* (Nowak 1979, p. 37).
     - *C. rufus* – definite range can be assigned; does not overlap with *C. lupus*; (Nowak 1979, p. 38).
     - Animal now referred to as red wolf was originally common only along the Texas coast above Nueces Bay (Bailey1905 in Nowak 1979, p. 38).
   - Red wolf progressively diminished in numbers farther inland in the more arid parts of southern Texas, whereas the coyote became more abundant (Bailey1905 in Nowak 1979, p. 38).
   - Observations and/or literature references suggested that red wolves possibly ranged as far south as southern Florida

(Dade County), extended into the Edwards Plateau region of Central Texas (Edwards, Sutton, Tom Green, and Sterling Counties); southern Illinois (Hancock, Montgomery, and Crawford Counties), Indiana (Posey County), Ohio (Ross County); and as far north as Pennsylvania (Green, Indiana, Bedford, Lancaster, and Montgomery Counties).

- Although several specimens were identified with locations in Maine (Piscataquis County) and Texas (Brewster and Pecos Counties), they fell outside the ecoregional overlay performed by this review and were considered to be dispersing or transient individuals (WMI 2016).

c. What was this wolf called?
   i. Pre-1600s
      - Contemporary debate/studies on the correct classification and origin for the wolf/wolf-like entity in the southeast have resulted in several proposals for this time period:
      - Distinct Origin Theory
        a. *Canis rufus* (e.g. Ferrell 1980; Nowak 1979, 2002; Bertorelle and Ecoffier 1998 in Hedrick 2002, p. 1906)
        b. *Canis lycaon* (e.g., Wilson et al. 2000; Rutledge et al. 2010, p. 1278)
        c. *Canis lupus rufus* (e.g., Audubon and Bachman 1851; Lawrence and Bossert 1967, p. 228; Wayne 1995, p.11)
      - Hybrid Origin Theory
      - Ancient (depending on time frame)
        - *Canis rufus* (possibly C. lycaon) (Speciation through hybridization)
        - *Canis lupus* subspecies (e.g. Wayne and Jenks 1991, p. 566; Hohenlohe et al. 2016, p. 1)
      - Recent (since settlement)
        - *Canis lupus* (e.g., Roy et al. 1994, p. 565; Wayne 1995, p. 9; Roy et al. 1996, p. 1421; Reich 1999, p. 143; von Holdt et al. 2011, 2016).

   ii. 1600s – Early 1900s

      - Foundational Sources - Classification by various authors
        - Bartram 1791: noted in his travel journal a black colored wolf in FL. One of the earliest records of the wolf in FL. Called it *Canis niger* (WMI 2016, p. 11).

- Harlan 1825: *Canis lycaon* (black wolves in FL, but also black wolves in mountainous areas of North American and Europe.

b. Audubon and Bachman 1851: noted the species *Canis lupus rufus* as the red wolf of TX. Account noted a description, color, size, and habits. Did not believe it inhabited the more northern prairies or Mississippi bottoms, but was likely present in northern Arkansas and Mexico (WMI 2016, p. 11).
    - Wolves they described were varieties of one species (C. lupus), except coyotes (Nowak 1979, p. 24).
    - Canis lupus var. Ater (Black American Wolf – FL, SC, NC, KY, southern IN, southern MO, LA, and northern TX
    - Canis lupus var. Rufus (Red Texan Wolf – northern AR through TX, and Mexico)

c. Bangs 1898: designated FL wolf as full species – *Canis ater*

d. Bailey 1905: Work was based on specimens collected by C. Hart Merriam in Texas and field reports from the Bureau of Biological Survey. Bailey provided a number of city and county red wolf locations. He noted there was no evidence of them in the plains area and do not overlap with the "lighter colored 'lobo' of the plains." (WMI 2016, p. 11) (Referring to Great Plains wolf C. l. nubilus?)
    - Canis ater (questionably referred to the large, dark wolf of east Texas as C. ater) (Nowak 1979, p. 24).
    - Canis rufus (recognized Audubon and Bachman's red wolf as a full species) (Nowak 1979, p. 24).

e. Goldman 1937: described subspecies. Noted that specimens primarily collected through predatory animal control provide a satisfactory basis for determining species and subspecies. He noted specifically:
    - "More than 150 skins and skulls from the lower part of the Mississippi River Valley, referred to *C. r. gregoryi*, represent a still living form connecting typical *rufus* and *floridanus*, both of which now may be extinct" (WMI 2016, pp. 11-12).
    - Goldman (1937) combined wolves of south-central and southeastern U.S. in to *C. rufus*, distinct from all other North American wolves, which he combined into C. lupus (Nowak 1979, p. 25).
        - *C. r. rufus* – TX

        - *C. r. floridanus* – eastern
        - *C. r. gregoryi* – lower MS Valley
    f. Paradiso and Nowak 1971: Reviewed all museum Canis specimens, including 213 *C. rufus*. Found in TX, LA, OK, AR, MO, FL, and AL (WMI 2016, p. 12).
    g. Nowak 1979: Examined 5,000 Canis skulls. Provided most comprehensive review of specimens and discussion on historic range, expansion of coyote, hybridization, and origin (WMI 2016, p. 12).
    h. Nowak 2002: Reviewed all available Canis material dated prior to invasion of coyote east of the MS River.
        - Nowak found the morphology of modern red wolves to be consistent with the fossilized remains of small wolves in the eastern U.S. dating back to Pleistocene (Hinton et al. 2014, p. 856).
        - The small wolf that reappeared, intermediate in size to C. dirus and C. latrans, considered to be C. rufus (Nowak 2002, p. 106).
        - Assessment of specimens indicate continuity of this small eastern wolf as there was no difference in size of m1 of paleontological fragments dating about 10,000 ybp, archeological fragments dating 2,000-200 ybp, and complete, mostly modern skulls. However, those samples were significantly different from western *C. lupus* and *C. latrans* (Nowak 2002, p. 109).
- Other sources
    a. Miller (1912a) found *ater* to be unavailable and designated FL wolf as *C. floridanus*, which then became generally accepted for wolves in forested areas of SE U.S. which *rufus* continued to be recognized in central and southern TX (Nowak 1979, pp. 24-25).
    b. Goldman (1944) observed that the 2 eastern subspecies of *C. rufus* exhibited remarkable approach in size and general proportions to the eastern gray wolf, *C. lupus lycaon*, but there existed several specific cranial differences (Nowak 1979, p. 25).
    c. One theory/explanation for the results of Brzeski's (2016, p. 290) results is that the sequences came from coyotes (ancient Canid samples (teeth) from 350-1900 years).
        - However, the size of the teeth samples analyzed was more wolf-like than coyote-like (Nowak 2002, Brzeski et al. 2016, p. 290).

- Additionally, Paleontological records suggests presence of a wolf-like canid, distinct from coyote and gray wolf, and continuously present in SE U.S. since terminal Pleistocene (Nowak 2002)
- Archaeological record suggest coyotes were absent from SE U.S. between 10,000-100 years ago (Parker 1995; Nowak 2002)

d. In the 18th and 19th centuries, residents of the American Southeast often described encounters with creatures they called red wolves: long-legged, cinnamon-colored animals (Wayne and Gittleman 1995, p. 1).

e. Lawrence and Bossert (1975, p. 230) concluded that the early pre-1930 population of red wolves in AR were no more than subspecifically distinct from gray wolves and differed less from northern gray wolves than did an Old World subspecies of gray wolf (Wayne et al. 1998, p. 727).
   - Lawrence and Bossert (1967, p. 223) refer to red wolves as *Canis niger*

- Contemporary debate/studies on the correct classification and origin for the wolf/wolf-like entity in the southeast have resulted in several proposals for this time period:

a. Distinct Origin Theory
   - *Canis rufus* (e.g., Ferrell 1980; Nowak 1979, 2002; Bertorelle and Ecoffier 1998 in Hedrick 2002, p. 1906)
   - *C. lycaon* (e.g., Wilson et al. 2000, Rutledge et al. 2010, p. 1278)
   - *C. lupus rufus* (e.g., Audubon and Bachman 1851; Lawrence and Bossert 1967, p. 228; Wayne 1995, p.11)

b. Hybrid Origin Theory

c. Ancient
   - *C. rufus* (possibly *C. lycaon*) (Speciation through hybridization)
   - Hybrid (historic hybridization between coyote and gray wolf that then backcrossed extensively with coyotes)

d. Recent (since settlement)
   - Hybrid cross of coyote and gray wolf (e.g., Roy et al. 1994, p. 565; Wayne 1995, p. 9; Roy et al. 1996, p. 1421; Reich 199, p. 143; von Holdt et al. 2011, 2016).

Commented [WE2]: Counter Statements:

Ancient:

-The gray wolf once occurred in all of North America except for parts of the southeastern U.S. (Nowak 1979, p. 7).

-All available specimens – paleontological, archeological, and modern – indicate that neither C. lupus nor C. latrans was present in the southeastern U.S. at a time that would have allowed formation of a hybrid population (Nowak and Federoff 1996, 1198 IN Nowak 2003, p. 251).

-No evidence that C. lupus existed in the southeastern U.S. in the 20th Century (Nowak 1979, p. 33).

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-Gray wolf x coyote hybrid origin is not supported by the fossil record. The red wolf, in much the same form as now, was present in North America though the Irvingtonian and Rancholabrean ages (Nowak 1979; Nowak 1992, p. 594).

-Fossil evidence (Nowak 1979, Kurten and Anderson 1980) indicate that the wolf group separated from the coyote line in the early Pleistocene (perhaps about 1 million years ago) (Nowak 1995b, p. 396).

-Discovery of a new specimen of a wolf that lived long before the disruption of the environment by man, and far from the range of the coyote, but which demonstrates the same morphological characteristics as the 20th century population known as rufus, indicates that rufus was not derived from introduction of genes from latrans into lupus populations (Paradiso and Nowak 1973, p. 508).

-No instances of interbreeding between gray wolf and coyote in the western half of the continent have been reported.

-Therefore, it is reasonable to consider these two species of the western and northern parts of the U.S. as consisting of natural unmodified populations that may confidently be used as a basis on which to test other more questionable populations (Nowak 1979, p. 7).

-Hybridization generally was considered a modern phenomenon that contributed to the demise, not the origin of the red wolf (Nowak 1979, p. XX; Nowak 2002, p. 98).

-Hybrid derivation of rufus not supported by morphometric analysis, observation of living animals, or by some geneticists (Nowak 2002, p. 98).

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Recent:

-The gray wolf once occurred in all of North America except for parts of the southeastern U.S. (Nowak 1979, p. 7).

-No evidence that C. lupus existed in the southeastern U.S. in the 20th Century (Nowak 1979, p. 33).

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-All available specimens – paleontological, archeological, and modern – indicate that neither C. lupus nor C. latrans was present in the southeastern U.S. at a time that wou...

- Notes on Theories of Origin
    a. Hybrid origin
        - What is "recent"?
            - Last 250 years (Reich et al. 1999, p. 143; Roy et al. 1996, Wayne et al. 1998 IN Nowak 2002, p. 119).
            - 10,000 ybp (Nowak 2003, p. 240; fig 9.1)
        - Until 1991, there was only one published suggestion of a hybrid origin (Mech 1970) (Nowak 1992, p. 593).
        - Gray wolf and coyote populations moved into the southeast and interbred to form the red wolf. Unlikely for a separate species to exist in the southeast, especially since there were no barriers to prevent entry of the large and mobile gray wolf (Jenks and Wayne 1992, p. XX; Nowak 1995, p. 2).
        - Only *C. latrans* (recent samples) and *C. lupus* (older samples) DNA genotypes found in red wolf.
            - Viewed as indicative of hybrid origin; however another interpretation exists (Nowak 2003, p. 253).
            - Great Lakes region – only coyote DNA found in all C. lupus from southeastern Ontario and Isle Royale and in most lupus from MN and western Ontario.
            - Interpreted to mean that limited hybridization with C. latrans did occur and did introduce a coyote genotyoe that somehow spread through most of the wolf population without otherwise affecting it.
            - Perhaps hybridization occurred between red wolf and coyote, thus the spread of coyote genotypes.
            - A more plausible explanation for the presence of genotypes of C. lupus in specimens of red wolves taken in the south-central United States in the early twentieth century might be that the two species underwent limited hybridization when they were still in contact but coming under intense pressure from hunting and ecological disturbance. Such interaction would be closely comparable to what may have

Commented [WE3]: Notes from the fossil record

o Red wolf has existed in southeastern North America, in much the same form as now, for at least 700,000 years. C. lupus did not arise until much later and never penetrated far into the southeast (occurred in TX). C. latrans did not enter the southeast during this entire period except for a brief incursion about 10,000 years ago and again within the last few decades (Nowak 1995, p. 2).

occurred more recently between C. lupus and lycaon in the western Great Lakes region (Nowak 2009, p. 244).

- No species-specific DNA has been found for C. rufus. May be that they were found in earlier studies (Ferrel et al. 1980), but were lost with near total extirpation (Nowak 2003, p. 253).
-

- Distinct Lineage
  - All available early morphological material from east of the Mississippi consistently demonstrates the presence of a small wolf, with no coyote influence (Nowak and Federoff 1996 in Nowak and Federoff 1998, p. 723).
  - Had the red wolf always represented nothing more than a hybrid zone between gray wolf and coyote, we would expect a complete blend of all three species throughout the range of the red wolf (Nowak 1979 IN Nowak 1992, p. 594).
  - If a hybrid of gray wolf and coyote, would expect red wolf to blend morphologically into its parental species and the statistical break that separates C. rufus from adjacent c. lupus populations would not be possible (Nowak 1995b, p. 397).
  - Only in central TX was there a substantial hybrid zone (Nowak 1992, p. 594).
  - Hybridization generally was considered a modern phenomenon that contributed to the demise, not the origin of the red wolf (Nowak 1979, p. XX; Nowak 2002, p. 98).
  - Nowak (1995b, p. 391) claims that the existence of a small wolf, statistically comparable to C. rufus, far beyond the range where it could be influenced by hybridization with C. latrans is further evidence against Wayne and Jenks (1991) suggestion that red wolf originated as a gray wolf-coyote hybrid (C. lupus pallipes – Israel).
  - Many of the genes found in red wolf and lycaon were not found in either western coyote or gray wolf populations (Wilson et al. 2000 In Nowak 2009, p. 240).

Commented [WE4]: Counter statements
No species-specific DNA has been found for C. rufus. May be that they were found in earlier studies (Ferrel et al. 1980), but were lost with near total extirpation (Nowak 2003, p. 253).

Most authors have accepted specific status since the studies of Goldman (1937, 1944) (Nowak 1992, p. 593).
Minority view that the red wolf is a subspecies of gray wolf (Lawrence and Bossart 1967, 1975) (Nowak 1992, p. 593)
Until 1991, there was only one published suggestion of a hybrid origin (Mech 1970) (Nowak 1992, p. 593).

- Genetic material from two wolf skins (NE U.S. – NY and Maine) – Maine samples found to have a genotype of the kind previously found in lycaon and rufus. NY sample was like that of western coyote populations. Results interpreted to be conducive to designation of original eastern wolves as an independent species with affinity to C. latrans (Wilson et al. 2003 in Nowak 2009, p. 241).
- Nowak (2002, 2003) noted that small wolves disappeared entirely from eastern North America for a period of about a million years, from the middle Irvingtonian to the late Rancholabrean. He suggested that the species C. priscolatrans (= C. edwardii) of the early Irvingtonian, previously thought to be the ancestor of rufus , actually gave rise to an archaic line of large New World wolves, culminating in C. dirus of the late Rancholabrean. He thought that rufus had arisen in the Old World from the same ancestral stock as C. lupus . Meanwhile, C. latrans had a separate history in North America since the early Irvingtonian.
- Fossils show the wolf and coyote lines well separated by the early Pleistocene (about 1.5 million years ago) (Nowak 2003, p. 240) See Fig 9.1 And Evidence of…Notes
- Wilson et al. 2000: On the basis of divergence of genetic sequences, Wilson et al. (2000) concluded that the eastern wolf (including red wolf) is a close relative of C. latrans , the two species separating only 150,000–300,000 years ago, while their common ancestor would have split from the line leading to C. lupus 1–2 million years ago (In Nowak 2009, p. 244).
- An alternative was offered by Kurten (1974), who considered C. priscolatrans not a small wolf but part of a Holarctic group of coyotes that sometimes attained substantial size and preceded modern C. latrans . C. priscolatrans disappeared well before the division of C. latrans and lycaon/rufus hypothesized by Wilson et al. (2000), but a small Eurasian wolf, C. mosbachensis , may have persisted from the early Irvingtonian to the early Rancholabrean (Nowak 2003) . Sotnikova (2001) suggested affinity

Commented [WE5]: • Nowak referred to the wolf (red wolf) in southeastern U.S. as C. rufus. Since he found the morphology of ancient remains to be consistent with modern red wolves, he identified those samples as C. rufus.
• Nowak found the morphology of modern red wolves to be consistent with the fossilized remains of small wolves in the eastern U.S. dating back to Pleistocene (Hinton et al. 2014, p. 856).
o The small wolf that reappeared, intermediate in size to C. dirus and C. latrans, considered to be C. rufus (Nowak 2002, p. 106).
o Assessment of specimens indicate continuity of this small eastern wolf as there was no difference in size of m1 of paleontological fragments dating about 10,000 ybp, archeological fragments dating 2,000-200 ybp, and complete, mostly modern skulls. However, those samples were significantly different from western C. lupus and C. latrans (Nowak 2002, p. 109).

among mosbachensis , latrans , pallipes , and rufus . However, while mosbachensis or priscolatrans might not be an unreasonable progenitor of a lycaon / rufus group, we still are left with the million-year gap in the fossil history of small wolves in eastern North America (Nowak 2002). 15 Taxonomy, Morphology, and Genetics of Wolves in the Great Lakes Region 245

III. Is the current wolf representative of the historic wolf?

a. Status of wolf post-European settlement
    i. Eradication and habitat loss
        - Man played a major role in the decline of the red wolf. Among detrimental factors were cutting of forest habitat, construction of wolfproof fences, extensive hunting by ranchers and farmers, the bounty system, and State and Federal predator control operations (Paradiso and Nowak 1971, p. 11).
            a. These factors reached a peak in 1930s
            b. Nearly all museum specimens from TX, OK, AR, and MO from the first 2 decades are large red wolves.
            c. Specimens after 1930 are much smaller and different kind of canid.
        - Perhaps numbering in the hundreds of thousands (Parker 1984), the red wolf, like the gray wolf, was subject to the persecution and loss of habitat that accompanied the movement of European settlers west, until by about 1930s it had been extirpated east of the Mississippi (Nowak 1979, Cohn 1987; Peek et al. 1991 in Brownlow 1996, p. 391).
        - The small population that remained in the 1960s in the coastal areas of SE TX/SW LA was subject to further stress in the forms of heavy parasite loads and hybridization with expanding coyote population (Brownlow 1996, p. 391).
    ii. Coyote expansion
        - Coyote was found throughout most of the western half of the continent, and its range in the northeast extended as far as the upper Great Lakes (Nowak 1979, p. 7).
        - After the mid-19th Century, coyotes began appearing to the N, S, and E of the prairies, and by mid-20th Century existed in large numbers beyond their original range (De Vos 1964, Mech 1959, 1961, Young 1951 IN Nowak 1979, p. 14).
        - Coyotes apparently moved north and east, then down Appalachian Mountains (Nowak 1979, p. 16). Range extension, maybe moving

into areas where wolves had previously been exterminated (Nowak 1979, p. 16).

- Edwards Plateau was a mix of densely forested river valleys to arid stony slopes; in this area, red wolves and coyotes maintained themselves as distinct species. However, arrival of man brought killing of predators, with larger red wolf getting hit hardest, clearing of river forests, cultivation of livestock, and construction of wolf proof fences. Over grazing led to decline of grasslands and spread of mesquite. Breakdown led to unprecedented contact between species (Paradiso and Nowak 1971, p. 12).

iii. Impacts

- Population decline/ Range reduction
  - Red wolves likely gone from MO by mid-1930s (Paradiso and Nowak 1971, p. 11)
  - Same for OK (id).
  - Large red wolves present in 1920s were gone by 1940, replaced by coyotes (id).
  - Not a gradual dilution of a gene pool through hybridization from long-term ecological changes; rather there was extermination of a dominant carnivore followed by an influx of another species to fill its ecological niche (Paradiso and Nowak, pp. 11-12).
  - Replaced by coyotes in MO and OK; replaced by hybrid swarm in TX, LA and maybe parts of AR (Paradiso and Nowak 1971, p. 18).
- Introgression
  - Once man altered the environment and at the same time attacked the wolves and coyotes, ecological and behavioral isolation might have broken down, and large-scale hybridization began (Nowak 1979, p. 43).
  - Available evidence favors the theory that hybridization between *C. rufus* and *C. latrans* was of relatively short-term occurrence, and probably began in the latter part of the 19th Century in response to man's disruption of the habitat and persecution of native wild canid populations (Nowak 1979, p. 43).
  - By the time the red wolf received the attention of the scientific community in the early 1960s, it had hybridized extensively with the coyote and a hybrid swarm was threatening the species with extinction (McCarley 1962, p. 232; IN Adams 2003, p. 2176).

    - Extensive hybridization limited to Edwards Plateau, whereas other areas experienced limited hybridization (Paradiso and Nowak 1971, p. 12).
    - Hybrid swarm formed first in central TX and then spread east, a geographic expansion of the hybrid animals. However, no indication that hybridization occurred to a large extent anywhere except in central TX where natural conditions of "eastern" and "western" habitat types supported this phenomenon (Paradiso and Nowak 1971, pp. 14-15).
    - Morphological diversity in TX, LA, and parts of AR indicate that hybridization must have played a major role in its formation; caused by extreme habitat changes and decimation of pure red wolf populations (Paradiso and Nowak 1971, p. 12).
- Evidence of unmodified red wolf
    - 8 skulls taken in 1900 and 1904 near the Texas coast in Calhoun, Colorado, and Libery counties all have close affinity with the standard red wolf sample taken farther east and ID'd as *C. rufus gregoryi*, but are smaller and more narrowly proportioned (Nowak 1979, p. 39).
        - Although there is suggestion of limited hybridization, early specimens taken from south TX may be separated into 2 distinct groups (*C. rufus and C. latrans*).
    - Evidence of hybridization between C. rufus and C. latrans at certain localities in Arkansas and eastern OK, genetic exchange appears to have remained very limited before 1930 (Nowak 1979, p. 37).
    - Nearly all specimens from lower Mississippi Valley taken then (before 1930) and ID'd as *C. rufus* are statistically separate from western coyotes and from coyotes taken in the south-central U.S. Hence, the sum of available evidence indicates that the species *C. rufus* in essentially unmodified form, survived through the 1920's in this region (Nowak 1979, p. 37).
        - By that time, species was under heavy pressure from man and already making its last stand in the Ozark-Oachita uplands (p. 37).
    - In LA, pure red wolves persisted up until about 1940. By 1950, pure populations were restricted to the eastern bottomlands and coastal marshes (Paradiso and Nowak 1971, pp. 15-16).

Commented [WE6]: Some have hypothesized that C. rufus rufus is a hybrid between coyotes and C. r. gregoryi.

Commented [WE7]: True, but an unmodified form of what? A species, a hybrid between coyote and subspecies of red wolf?

    - Small number of red wolves thought to survive in southwestern LA, Cameron Parish around 1968 (Paradiso and Nowak 1971, pp. 17-18).
    - Pure populations of red wolf existed, as of 1969, in certain sections of extreme southeastern TX: Chambers Co, Brazoria, Galveston, Liberty, Jefferson, and Orange counties (Paradiso and Nowak 1971, p. 16).
- Evidence of introgression
    - Material collected after 1930 shows the spread of hybridization between red wolf and coyote, and the steady reduction of unmodified red wolf populations (Nowak 1979; Nowak 1992, p. 594).
    - Original canid population of the States from which the red wolf sample was drawn had been replaced by a different type of Canis within comparatively recent years. This replacement occurred in AR, MO, and eastern OK sometime during the 1930s and in Louisiana during the 1940s (Paradiso and Nowak 1971, p. 2).
    - Goldman (1944) stated that the C.r.r of TX and OK was so small and in general characters agreed closely with coyotes, he suggested the possibility of hybridization between C.r.r. and C. latrans in some localities in TX (Nowak 1979, p. 25).
    - About 1949, hybrid swarm from TX began filling void left in LA by intensive control of red wolf. This wasn't a gradual takeover by a smaller animal; it was extermination of red wolves and invasion of the area (Paradiso and Nowak 1971, p. 16).

b. Texas-Louisiana Roundup

By mid-1975, it became apparent that the only way the red wolf could be saved from extinction was to capture as many wild animals as possible and place them in a secured captive breeding program (USFWS 1989, p. 1).

i. Standards used to distinguish entities

- Side note for Emily - How do those standards line up with morphology studies
- Paradiso and Nowak (1971) state that two or the three subspecies occur in the present range: C. r. rufus in Brazoria, Harris, and Galveston counties and C. r. gregoryi in Liberty, Chambers, and Jefferson counties and Cameron Parish (Riley and McBride 1972, p. 1).
- Material collected after 1930 shows the spread of hybridization between *C. rufus* and *C. latrans* and the steady reduction of unmodified red wolf populations. By the 1960s, such groups had

largely disappeared, though available skulls from 1963-1970 in extreme southeastern Texas indicate the population there was still predominantly like original *C. rufus* (Nowak 1992, p. 594).
    - Animals were subsequently captured from that area and adjacent southwestern LA to form a breeding pool and eventual reintroduction (Nowak 1992, p. 594).
- A number of indicators were used to determine whether an animal was a wolf, coyote, or hybrid. The following morphological measurements were used (specific standards for males and females listed in USFWS 1989, p. 11).
    - Skull length
    - Zygomatic breadth
    - Weight
    - Total length
    - Hind foot length
    - Ear length
    - Shoulder height
    - Brain/skull ratio

ii. Selection of Founders

- Animals determined to be possible wolves were placed in the breeding/certification program (USFWS 1989, p. 11).
    - From fall of 1973-July 1980, over 400 wild canids were examined (USFWS 1989, p. 12).
- Of those, only 43 wild canids were admitted to the breeding/certification program as probable red wolves.
    - Only 40 of 400 canids trapped were considered "pure" enough for breeding purposes (Cauley in Cohn 1987; Jenks and Wayne 1992 in Brownlow 1996, p. 391).
- Final proof of genetic integrity was determined through captive-breeding process itself (USFWS 1989, p. 12).
    - 15 became founding stock.
    - 12 are represented in the wild/captive wolves today

iii. Are founders/descendants representative of the historical entity?

- Multiple studies indicate that the captive animals appear to be morphologically and genetically similar to historic red wolves (Nowak 1979, p. X; Wayne and Jenks 1991, pp. 567-568; Nowak 1992, pp. 594-595; Wayne 1995, p. 10; Nowak 2002, p. 121; Roy 1994 In Hailer and Leonard 2008, p. 8; Chambers et al. 2021, p. 12; Hinton et al. 2014, p. 856)
- The captive and reintroduced red wolf stock has statistical distribution close to that of the original *C. rufus* (Nowak 1992, p. 595).

- Captive animals appear similar to historic red wolves in morphology (Nowak 2002) and autosomal microsatellites (Roy 1994) (Hailer and Leonard 2008, p. 8).
- Nowak (2002) observed the morphology of modern red wolves to be consistent with fossilized remains of small wolves in the eastern U.S., dating back to Pleistocene (Hinton et al. 2014, p. 856)
- The population of wild *Canis* that persisted in southeastern TX and southern LA until the 1970s, as well as those removed from that area and used to found the existing captive/reintroduced population were similar to the original red wolf (Nowak 1979, 1992 in Nowak 2002, p. 121).
- The captive population of red wolves seems to be morphologically and genetically representative of the canid that existed in the southeastern U.S (Wayne and Jenks 1991, pp. 567-568).
- All surviving individuals are descendants of red wolves captured within the historical range of the subspecies C. r. rufus, so that nearly all genetic data on C. rufus are derived from individuals attributable to that subspecies (Chamber et al. 2012, p. 12).
- Historic wolves shown to differ little from captive; captive red wolf is excellent representation of existing gene pool (Wayne 1995, p. 10).
- North Carolina retains the morphometric characterization of *C. rufus rufus* (Nowak 2002, p. 121).
- Specimens assigned C. r. rufus by Goldman collected before 1930 from Texas, OK, and northwestern Arkansas were on the whole smaller and more narrowly proportioned, and hence more coyote-like than most specimens of *gregoryi*.

c. How relevant is representation of historical entity to the "species" question?

IV. Does the wolf we have today meet the definition of a "species" under the ESA?

- Shaw (1975) evaluated data on behavior, ecology, vocalizations, allelic frequency, and morphology of *C. r. gregoryi* in SE TX and concluded the population represented a species distinct from both *C. lupus* and *C. latrans* (Nowak 1979, p. 26).
- Once man altered the environment and at the same time attacked the wolves and coyotes, ecological and behavioral isolation might have broken down, and large-scale hybridization begun (Nowak 1979, p. 43, see also Behavioral Notes).

a. Morphology
Red wolf is distinct species

Commented [WE8]: Using the criteria established…
Is it a hybrid or a listable entity? What do we mean by hybrid?
If it's not a hybrid, it's a species.
If it had a hybrid origin, is it a "species" today?

From this section, we may eliminate 1 alternative (not a "species/hybrid)

Information was gathered before criteria established; therefore, information here has been focused on how the red wolf is different/similar to other Canid species with consideration given to different theories of origin.

- Strongest evidence that red wolves are a separate species comes from Nowak (1979) (Wayne and Gittleman 1995, p. 3).
- Statistical distances separating red wolf samples and gray wolf samples are relatively great. This distinction and lack of any clinal approach, in the region where the southeastern range of *C. lupus* met the western edge of *C. rufus* is perhaps the best argument for maintaining each as a full species (Nowak 1995b, p. 389).
- Questions about species definition seem to be increasing, though complete lack of morphological intergradation, where two populations approach without physical barriers, argues for specific distinction (Nowak 1995b, p. 394)(referring to *C. rufus* and *C. lupus*).
    - There is less consensus on what constitutes a subspecies (id).
- Significant morphometric difference between populations that are geographically proximal and not isolated would most likely result from true phylogenetic distinction (Nowak 2002, p. 99) (referring to *C. rufus* and *C. lupus*).
- Whether *C. rufus* is considered a full species or a subspecies, it is the most distinctive kind of wolf in the world (Nowak 1995b, p. 397). Except for small overlap with *pallipes*, red wolf is statistically separate from all series of *C. lupus*.
- Nowak (2002) observed the morphology of modern red wolves to be consistent with fossilized remains of small wolves in the eastern U.S. dating back to Pleistocene (Hinton et al. 2014, p. 856).

Different from C. latrans

- 1919-1925, series of *C. latrans* collected in and around southeastern MO, along with a large series representing an isolated wolf population. Previous study showed no morphometric overlap, demonstrating that each represented a separate species and that hybridization had not developed in that area yet (Nowak 2002, p. 118).
- Nowak (1979, 2002) found the red wolf to be intermediate to coyotes and gray wolves; before 1930, there is no overlap with coyotes except in central TX; after 1930 show increasing amounts of overlap with coyotes as hybridization progressed (Chamber et al. 2012, p. 26).
    - Gipson, Sealander, and Dunn (1974), Freeman (1976), and Elder and Hayden (1977) all found that red wolf fell statistically intermediate to *C. lupus* and *C. latrans* (Nowak 1979, p. 26).
- Series taken from southern Missouri prior to 1930 show that red wolf and coyote were sympatric, but completely distinguishable from one another; no intermediate specimens known (Nowak 1995b, p. 388).
- Series taken from FL, AL, MS, LA, southeastern TX before 1940, and those taken from 1930 (above) compared with main southern group of *C.*

Commented [WE9]: If intermediate position is support for hybrid, how do you explain the overlap when hybridization is known to have started to occur?
Is it that a C x GW hybrid would be intermediate, but then backcrossed with coyote would result in more overlap with coyotes?

lupus and with the series of the two smallest North American gray wolf, *baileyi* and Algonquin *lycaon*. *C. rufus* does not statistically overlap any of the series of *C. lupus*. (Nowak 1995b, p. 389).

- By the 1960's, unmodified red wolf populations had largely disappeared, though available skulls from 1963-1970 in extreme southeastern TX indicate the population there was still predominately like original red wolf (Nowak 1992, p. 594).
- 9 Founders and 5 of their descendants, as well as 22 red wolves (FL, AL, MS, LA, TX; before 1940) compared with coyote (before 1925; ID), 2 gray wolf subspecies from Alaska, 1 subspecies of gray wolf from Isle Royale and MN (1960s and 1970s). RESULTS: Three species (*latrans*, *rufus*, and *lupus*) are distinct (Fig 1; Nowak 1992, p. 594). Red wolf falls between coyote and gray wolf, but does not overlap.
- Multi-statistical analysis shows that red wolf and gray wolf-coyote hybrid may overlap if the sample is large enough, but that the two do not have identical characteristics (Fig 2) (Nowak 1995, pp. 3-4).

- Paradiso and Nowak (1972) compared data on 213 *rufus* skulls, 214 *lupus*, and 336 *latrans* and concluded that the red wolf was a distinct species. In size and proportion it fell between *latrans* and *lupus*, but was nearer *lupus*.
- Atkins and Dillon (1971), on the basis of a morphological study of cerebellum, considered red and gray to be in the same group, distinct from other *Canis*, but that *rufus* was a valid species (Paradiso and Nowak 1972, p. 2; Nowak 1979, p. 26).
- Paradiso and Nowak (1971, p. 6) found the red wolf to be a much less massive animal than the gray, with lighter, more narrowly spreading zygomata, relatively flat frontals, more delicate dentition, and considerably weaker rostrum reflected by a lighter maxillary and premaxillary development. These difference are in most instances readily apparent to the eye and a majority of specimens can be separated on this basis alone. See also note under taxonomic classification.
- Paradiso and Nowak (1971, p. 6) found the red wolf to be a much less massive animal than the gray, with lighter, more narrowly spreading zygomata, relatively flat frontals, more delicate dentition, and considerably weaker rostrum reflected by a lighter maxillary and premaxillary development. These difference are in most instances readily apparent to the eye and a majority of specimens can be separated on this basis alone. See also note under taxonomic classification.
- *C. rufus* differs more from western subspecies of *C. lupus* than it does from *C. lupus lycaon*. There's even more difference between *C. rufus* and *C. l. nubilus* of the Great Plains – No intergrade between series of *nubilus*

Commented [WE10]: Genetically, it is closer to coyote (Coyote clade)

from OK, KA, CO, NE, SD, and MN and large red wolf series from MO, AR and OK (Paradiso and Nowak 1971, p. 7).
    - In animals as large and as mobile as wolves, it would be rather surprising to have such a substantial shift in characters over so small a distance with no geographic barrier if only 1 species were involved (Paradiso and Nowak 1971, p. 7).
- *C. rufus* resembles *C. latrans* more than it does *C. lupus*, the two (*rufus* and latrans) are sufficiently distinct to warrant a full specific recognition (Paradiso and Nowak 1971, p. 8).
    - Differ greatly in size; easier to differentiate between them than between *lupus* and *rufus*.
    - Quickly apparent that *rufus* has heavier bone structure and dentition.
    - Skull is relatively broader and much more pronounced sagittal crest.
- As late as 1920s, there is clear separation between C. rufus and C. latrans in most areas where their ranges approached or overlapped. With few questionable skulls, long after settlement, suggests that a hundred years earlier the two species were completely distinct throughout their ranges (Paradiso and Nowak 1971, p. 10).
-
- Differences between coyote and red wolf are far greater than any variation exhibited by any recognized subspecies of C. latrans over its entire range; even large series from Texas, adjacent to red wolf range, show no shift toward C. rufus (Paradiso and Nowak 1971, p. 8).
    - Because of this and the fact that specimens indicate they occurred sympatrically in some places, Paradiso and Nowak (1971, p. 8) conclude that C. rufus is specifically distinct from C. latrans.
- Differentiating todays red wolves, coyotes, and hybrids:
    - Body-size measurements of red wolves and coyotes are distinct from one another. Findings are consistent with Nowak (1979, 2002) who demonstrated that little to no overlap in red wolf and coyote cranial and dental measurements (Hinton et al. 2014, pp. 857, 858, 859).
        - Measurements differed among all 3; hybrids intermediate in all measurements (Hinton et al. 2014, p. 857), red wolves clearly the largest canid (p. 859).
        - F1 and F2 hybrids are incapable of reaching body sizes of adult red wolves (Hinton et al. 2014, p. 859).

- This suggests that red wolves represent a unique Canis phenotype in the southeastern U.S.
- Differences in body-size measurements are highly suggestive of differences in ecological requirements, and this is particularly true for carnivores regarding diet, space use, and interspecific interactions (citations)
- Using body measurements, coyotes correctly classified 99%, red wolves 98 %, hybrids 13% (more likely to be misclassified as coyotes than as red wolves, 61% vs. 35%)(Hinton et al. 2014, p. 858). Overall, canids correctly id'd 86% (Hinton et al. 2014, p. 857).

Red wolf is a gray wolf-coyote hybrid

- Figures from Nowak (1979, p. 22, 32) show that 5 suspected female hybrids of gray and coyote from southeastern Canada fall within the graphical range of red wolf. Used by Jenks and Wayne (1992) and Wayne (1992) to argue that red wolf is essentially the same as gray wolf-coyote hybrid (Nowak 1995, pp. 2-3).
  - *Nowak's counter*: Two original figures (referenced by Wayne and Jenks) were based on a procedure that was not intended to distinguish red wolves and gray-coyote hybrids, but to show individuals of each group compared to 3 known samples. Because red wolf is a primitive wolf, representing a stage in the evolution of *Canis* intermediate to *latrans* and *lupus*, its position on the graph is not surprising. Likewise, hybrids could reasonably be expected to fall between their parent species (Nowak 1995, p. 3).
  - Ran additional analyses: red wolf and hybrids separate from coyote, gray, and domestic, but overlap extensively (Fig 1). Removing domestic, results show red wolf and hybrids form distinct clusters. Larger samples may have overlapped, but multi-statistical analysis does show that the two do not have identical characteristics (Fig 2) (Nowak 1995, pp. 3-4).
    - Populations of C. lupus in southeastern Canada do show a morphological approach toward C. rufus; however, available specimens from eastern U.S. are too scarce and too fragmentary to allow determination of whether the red and gray wolves intergraded in that region (Nowak 1995b, p. 389)
    - Some specimens of *C. lupus lycaon* fall very near *C. rufus*, but there is possibility that those specimens have been

affected by hybridization with *C. latrans* (Nowak 1995b, p. 389).

- McCarley (1962, p. 229) – analysis of all measurements show a gradation in size of skulls from presumed specimens of *niger* and *latrans*: largest assigned to *C. n. gregoryi*, smallest to *latrans frustror*. Those intermediate were not easily assignable to either species.
    - Majority of skulls examined were of unknown sex, therefore males (generally larger) and females were treated together (p. 229).
    - *Canis* skulls from AR, LA, OK, and TX: in general, skull size was the most reliable trait for separating 2 species; however, based on total length of skull and zygomatic breadth, following conclusions were reached: *Canis niger* only extant in few places in eastern and southern LA, all current population samples of *Canis* in AR, OK, and TX were referable to *C. latrans frustror* (p. 234).
    - Extirpation of red wolves in latter states was the result of either:
        - Non-adaptability of red wolves to changing environmental conditions, including competition with coyote populations, and
        - *Canis niger rufus* was not a valid taxon, but represented the result of a natural hybridization between *Canis latrans* and *Canis niger gregoryi* (pp. 233, 234).
        - Possibility supported by Young and Goldman (1944) and Young and Jackson (1951) (p. 233).

Commented [WE11]: How would this explain extirpation of red wolves from AR, OK, and TX?

Red wolf is a subspecies of gray wolf

- If the study of small wolves in southern states had begun with *niger* in FL, and been based on adequate series, it is highly unlikely that *niger* ever would have been separated as a species from *lupus* (Lawrence and Bossert 1967, p. 228).
    -

COUNTER TO MORPHOLOGY STUDIES

- In reality, fragmentary fossil remains of wolf-like canids and the conservative nature of canid dentition makes the interpretation of the sparse fossil record difficult (Wayne 1995, p. 8).
    - Efforts to use morphological criteria as a basis to classify red wolf as a distinct species are problematic. (Wayne 1995, p. 7).
        - Multivariate analysis of morphological measurements (like that in Nowak 1979), express an overall similarity in cranial and dental form of red wolves to other canids (p. 7).
            - Nowak acknowledge hybrid origin for the red wolf as a possibility, Nowak suggests that the most reasonable explanation is that

C. rufus represents a primitive line of wolves that has undergone less change than C. lupus and has retained more characters found in ancestral stock from which both wolves and coyotes arose (p. 7).

- Quantitative differences alone to define species status is controversial (p. 7 – other citations).
    a. Emily notes that genetics only would be too.
- Phenotypic argument may be circular because hybrids between gray wolves and coyotes are expected to be intermediate in morphology; thus the phenotype of red wolf may reflect either:
    a. Recent hybridization between gray wolf and coyotes in southeast, or
    b. Ancient origin and long distinct evolutionary heritage (p. 7)
    c. Emily notes that Nowak plotted hybrids or that hybrids would be expected to show a larger range/intergrading between species than what found with red wolf.
- Nowak's cranial data are consistent with the possibility that the red wolf is a hybrid of the gray wolf and the coyote (Wayne and Gittleman 1995, p. 4).
    a. Coyotes and gray wolves have been observed to mate in certain parts of Canada, resulting animals had skull dimensions resembling those Nowak found for red wolf (p. 4).
- Position of hybrid overlaps with position of red wolves (p. 7) – see figure here and Nowak 1979 (fig 10 and 15), and Wayne 1992).
- Because of hybrid possibility, discrete character state differences uniquely shared with red wolves is needed to define them as a separate taxon. Molecular data provide such data (p. 7). See genetics

b. Phenotype

Commented [WE12]: Ancient hybrid origin seems to come up as a possibility in both morphology and genetic studies.

Commented [WE13]: W and G 1995 starts page 36.

Commented [WE14]: Great Lakes wolves = Lycaon

Commented [WE15]: If BSC difficult to apply, some investigators use phenotype as a surrogate – two groups that have evolved separately are likely to display measurable differences in their traits. If the distribution of measurements from one group does not overlap those of another group, the two groups might be considered distinct species (Wayne and Gittleman 1995, p. 3).

- Most available specimens of "red wolves" exhibit a typical wild canid color pattern, consisting of agouti gray or brown interspersed with black hairs (Nowak 1979, p. 25).
- Disproportionately long legs and large ears are the two most obvious external features separating the species from coyote and gray wolf (Phillips and Henry 1992, p. 597).
- C. n. rufus and C. latrans frustror are particularly similar in size, morphology (McCarley 1962, p. 228).
- Most accounts of external characteristics of red wolf give the impression that it closely resembles the coyote except in size and color variations; however there are certain definite characteristics which we (Riley and McBride 1972, pp. 3, 12, 14) believe are so pronounced that the two species can be readily distinguished in the field.
    - Color: facial color patterns resemble gray wolf: Muzzle tends to be very light, area of white around the lips may extend well up on the sides of the muzzle, leaving only the bridge of the nose a tawny to cinnamon coloration
        - In contrast, in coyotes area of white around the lips of coyotes is thin and sharpky demarcated (, p. 4).
    - Coloration around eyes: many red wolves light areas around the eyes, a light tan spot may be present over each eye adding to the almond or slanted eye effect (p. 4).
    - Facial appearance is more massive than the more fox-like coyote.
        - Almond-shped eyes, broad muzzle, and wide nose pad (p. 4).
    - Weight: 40-60lbs (p. 6)
    - Legs: long legs are one of the most striking external characteristics; ranchers differentiate between red wolves and coyotes based on this (p. 6).
    - Ears: proportionately large ears and the angle at which they are normally carried.
        - May equal the size of gray wolf ears, but because the head is smaller, they are more prominent (p.6).
        - The angle creates an accentuated triangular facial appearance markedly different from gray and coyote (p. 6).

Commented [WE16]: In Wayne and Gittleman 1995 (p. 3) Audubon and Bachman (1851) had difficulty distinguishing the red wolf from the physically similar coyote and gray wolf.

Young and Goldman (1944) – there appear to be no dependable characters distinguishing in all cases small specimens of rufus from large ones of the coyote (McCarlley 1962, p. 228).

This seems weird given this from Riley and McBride.

Implicit in McCarley's interpretation of his data is the fact that while closely related species usually differ most from each other where their ranges meet or overlap, the opposite is true in south-central states. Here, at the western edge of niger, the small C. n. rufus is often difficult to tell from latrans, while the eastern end of its range, the larger C. n. niger is said to resemble C. lupus lycaon (Lawrence and Bossert 1967, p. 227).

- Red wolf tracks are larger (3.5-5in) than coyote (2.25-2.85) (Riley and McBride 1972, p. 8).
- This suggests that red wolves represent a unique Canis phenotype in the southeastern U.S. (Hinton et al. 2014, p. X).
- The absence of a red wolf-like individuals in the present hybrid zone in MN and Canada suggest that unique environmental and genetic conditions are required for the genesis of a red wolf phenotype (Wayne and Jenks 1991, p. 568).
- Roy et al. (1994, p. 566) claim that their analyses of microsatellite data support the hypothesis that the intermediate phenotype of the red wolf is derived from historic hybridization between gray wolves and coyotes. More recently, extensive hybridization with coyotes has caused red wolves to become more similar, in allele frequency, to coyotes than to recently hybridizing populations of gray wolves.
- McCarley 1962 (p. 227) states that latrans and niger show a considerable amount of geographic variation and morphological overlap of both skeletal and pelage characteristics.

c. Ecology
    - In terms of behavior, ecology, and morphology red wolves have never exhibited the variability one would expect if the species originated from interbreedings of gray wolves and coyotes (Phillips and Henry 1992, p. 597).
    - Diet
        - Diets of red wolves and coyotes in NC were similar. White tailed deer was an important component to both; rabbits, white-tailed deer, and rodents were the prey most frequently eaten by both (McVey et al. 2013, pp. 1144, 1146).
        - Red wolf: primarily white-tailed deer and raccoons were primary year round food items; gray wolves also rely heavily on ungulates and make use of med-sized mammals (Phillips and Henry 1992, p. 597).
        - In contrast, deer and raccoons were of tertiary or lesser importance to coyotes in southern U.S.; use of deer tends to be seasonal and adult deer eaten as carrion (Phillips and Henry 1992, p. 597).

    - Slender proportions of red wolf indicate that is prey averaged smaller than that of gray wolf (Nowak 1979, p. 30).
    - Indications that red wolf is not as serious a predator on cattle as were gray wolves (Riley and McBride 1972, p. 10).
- Habitat preference
    - Coyotes – mostly agriculture, coastal bottomland forest, and pine forest (Hinton et al. 2015, p. 7, 11).
        - Territories centered on edges of agricultural fields and forests with higher percentages of agriculture in the interior (core areas) as forest habitat increased in outer fringes.
        - During harvest (autumn through winter) coyotes typically loafed in forest habitats within 50-300 m of edges adjacent to ag fields and roads.
        - As winter wheat reached heights of appx 0.5m during growing season (spring through summer), coyotes abandoned forest habitats to loaf in wheat fields when available, then shifted to corn later as wheat was harvested (pp. 11-12).
    - Coyotes – indicate general selection for open, treeless environments (cited)(Hinton et al. 2015, p. 11).
    - Biologically difficult problem of reconciling the existence of 2 similar sized forms of wolf in one continuous habitat (Lawrence and Bosert (1967))(Nowak 1979, p. 30).
        - Ecological niche may have approached that of the coyote, which did not occur in the eastern forests when settlers first arrived (Nowak 1979, p. 30).
    - Central Texas – exact ranges of red wolf and coyote are unknown as hybridization obscured the picture; however, the red wolf is considered a species of eastern forests. The area under discussion in central Texas falls just within the extreme western boundary of eastern forest elements (Nowak 1979, p. 43).

- C. rufus is essentially a warmth-adapted species in contrast to the more cold-adapted C. lupus (Paradiso and Nowak 1971, p. 8).
- Coyote and red wolf were primarily allopatric species (Paradiso and Nowak 1971, p. 9).
  - Coyote range included drier regions and grasslands of the west, along the edge of the eastern forested zone. Range extended as far east as IN, but never far from prairies.
  - Red wolf was found mainly in more humid regions of predominantly forest type (southeastern forests, swamps, and coastal marshes, and extended some distance up the wooded river valleys and through the broken woodlands of TX and OK.

- Territory size
  - Upper limit of coyote home-range size approximately 47 km2 - limit to area they can effectively exploit and defend as territories (13.4-47.3 in eastern NC) (Hinton et al. 2015, pp. 6, 9). Throughout North America, range from 2.5-70km2.
  - Transient ranges ranged from 64.5 km2-633.4km2 (greater during harvest season) (Hinton et al. 2015, p. 6).
  - Riley and McBride (1972, p. 9) found home range to be 25-50 sq.mi; Shaw (1972) estimated average of 35 sq. mi.

d. Behavior
- Reproduction (tendency to exclude coyotes in right numbers, litter size)
  - Red wolf specimen: diploid chromosome number was 78 and only X chromosome was biarmed. The karyotype of this specimen is thus indistinguishable from those of latrans, lupus, and familiaris, and chromosomal factors would not inhibit interbreeding (Paradiso and Nowak 1972, p. 3).
  - Available evidence favors the theory that hybridization between C. rufus and C. latrans was of relatively short-term occurrence, and probably began in the latter part of the 19th Century in response to man's disruption of the habitat and persecution of native wild canid populations (Nowak 1979, p. 43).

    - Once man altered the environment and at the same time attacked the wolves and coyotes, ecological and behavioral isolation might have broken down, and large-scale hybridization begun (p. 43).
    - Red wolf series collected before 1930 compared with standard (base) western samples of coyote. Results demonstrate clear separation (Nowak 1979, p. 34).
        - Direct evidence that, as pointed out by Paradiso and Nowak (1972a), C. rufus and C. latrans occurred sympatrically in area (southeastern Missouri), without intergradation or hybridization (Nowak 1979, p. 36).
    - Despite being primarily allopatric, there were some areas in western part of red wolf range where it overlapped with coyote, yet in these areas there is evidence that they maintained themselves as distinct species without extensive interbreeding; no evidence of intermediate forms (Paradiso and Nowak 1971, pp. 9-10).
    - It is not clear whether the red wolf interbred historically with the coyote where their ranges overlapped or whether there were biological or behavioral barriers to breeding that broke down as European settlement spread across the southern U.S. (Nowak 1979 In Adams 2003, p. 2176).
- Pack/family groups
    - Red wolves maintain group structure throughout year, but no reason to hunt in packs since food is small (Riley and McBride 1972, p. 9).
    - Reintroduced and wild-born red wolves were very social, belonging to packs (extended families) that occupied territories. It was not unusual for yearling or 2-year old to associate with parents, assist with pup-rearing, and restrict movements to natal home ranges. Red wolves relatively intolerant to strange conspecifics, and intraspecific aggression led to death of 7 wolves – similar to gray wolves (Phillips and Henry 1992, p. 596).
        - Conversely, coyotes are often more asocial; animals belong to breeding pairs or small family groups, home ranges of groups often

show considerable overlap, pups often disperse before second summer, and intraspecific aggression is not thought to be an important source of mortality (Phillips and Henry 1992, pp 596-597).

- Dispersal time
- Defense of territories (wolf always displaces coyote, not the other way around)
- Threat behavior
    - Trapped red wolves are more aggressive than trapped coyotes or gray wolves (Riley and McBride 1972, p. 8).
    - Tail upright and canine teeth bared, frequently bark or howl
        - Coyotes bark, but rarely howl
        - Gray wolves seldom bark or howl
        - Wolves bare canine teeth and raise fur along their neck and back
        - Coyotes assume a wide-mouthed posture with teeth showing, back arched, and tail between the legs; fur along neck and back may or may not be raised (p.8).
- Howling?
    - Howling pays a role in both in territorial advertising and group cohesion. Thought to mediate much of canid social behavior like maintaining dominance relationships (Kershenbaum et al. 2016, p. 149).
    - Early description in Riley and McBride (1972, p. 7) indicates it is similar to coyote; harmony more controlled and deliberate than coyotes, but not blended as well as vocalizations of gray wolves.
    - Red wolf found to have a species-specific pattern of howl type usage and could be identified using howl type histograms (25% correct; coyote 50% correct) (Kershenbaum et al. 2016, pp. 152, 154).
    - Coyote and red wolf howl type usage differs significantly, but red wolf howling was similar to eastern timber wolves (Kershenbaum et al. 2016, p. 154).
    - Red wolves and coyotes share their most commone howl type (type 3), but red wolves will often use howl type 6, which coyotes and timber wolves almost never use (Kershenbaum et al. 2016, p. 154

        - Intermediate nature of howl type 6 may provide potential evidence of hybridization (Kershenbaum et al. 2016, p. 155)

e. Genetics

- Very few of the reviewed studies were designed to address taxonomic questions (Chambers et al. 2012, p. 3).
- Species
    - An allele only known in red wolves has been identified (letter, p. 2). Ferrell et al. (1980, p. 47) found a second allele at the LDH A locus (Lactate Dehydrogenase) LDH^{2}_{A},
        - Observed throughout the wolf-range sample (TX) but absent in domestic dogs and pure coyote populations – suggestive of the survival of a gene originating in the red wolf population (Ferrel et al. 1908, p. 47).
        - Gene frequency distribution of this gene is congruent with the distribution of surviving red wolves found in the 1972 survey of Riley and MvBride and in more recent unpublished work (p. 47)
        - LDH^{2}_{A}, has not been observed in any published report on the biochemical genetics of either wild or domestic canids (p. 47).
    - Morizot (1981 in Parker 1989, p.8) found substantial genetic variation at three enzyme loci in red blood cell samples in comparison of dogs, coyotes, red wolves and an allele not seen in any other Canis (letter, p. 2).
        - Few biochemical-genetic differences among living Canis species have been discovered (Morizot 1981 in Parker 1989, p. 8).
    - Concluded that the red wolf was genetically more similar to coyote than gray wolf, but possess an allele unknown in coyotes.
        - In combination with data derived from skull measurements of red wolves and coyotes in early collections, convinced him of the integrity of the red wolf as a separate form (pp. 8-9) (letter, p. 2).
    - Additionally, study found substantial genetic variatioin at three enzyme loci LDH-A, GPI, and GOT-S:

Commented [WE17]: Studies done on "ancient" samples? Yes, Brzeski et al. 2016

Use Chamber et al. 2012 to structure/compare

Commented [WE18]: Carley on this paper

Commented [WE19]: This is referring to Ferrell 1980

Commented [WE20]: Also von Holdt et al. 2011, p. 8. Analysis infers substantial coyote ancestry for red wolves. Although founder effect and inbreeding as well as small effective population size may inflate the probability of a cluster being defined in Structure (p. 8).

        - Domestic dogs – exhibit no variability at LDH-A and only very rare variants at GPI and GOT-S (letter, p. 1)
        - Coyotes from 3 geographically distant areas in TX exhibit considerable variability at GPI and GOT-S, but not at LDH-A (letter, p. 1).
        - Red wolves – possess variability at all 3 loci (p. 1)
        - Studies of gray wolves – no variability has been demonstrated at any of these 3 loci. In fact gray wolf genetically is identical to all but a few (<1%) domestic dogs with respect to these genes (letter, p. 2).
        - Red wolf is more like a coyote that a gray wolf or dog (letter, p. 2).
        - Frequency of this allele is in inverse proportion geographically to the presumed extent of coyote hybridization – a west to east cline in red wolf LDH-A is observed in Brazoria County, TX to Cameron Parish, LA (letter, p. 2).
        - This finding (gene frequency data at the 3 loci) agree with Nowak and Kurten and Anderson evolutionary schemes/fossil record of a probably derivation of the red wolf from a coyote-red wolf ancestor and a more distant separation from the gray wolf (letter, p. 2).
    - Wilson et al (2000 in Mech et al. 2014, p. 1 – double check) based findings on the fact that haplotypes have not been found in extant non-hybridizing coyote populations. Others whose work was challenged agreed the new interpretations should be further tested.

- Hybrid
    a. Roy et al. (1994, p. 566) claim that their analyses of microsatellite data support the hypothesis that the intermediate phenotype of the red wolf is derived from historic hybridization between gray wolves and coyotes. More recently, extensive hybridization with coyotes has caused red wolves to become more similar, in allele frequency, to coyotes than to recently hybridizing populations of gray wolves.

Commented [WE21]: Hybridization is only successful between Male gray wolf and female coyote, not vice versa (wayne 1995, p. 10).

Curent and historic red wolf samples showed surprisingly high levels of genetic variability (captive showed >60% heterzygosity) and several alleles discovered at most loci; however small populations tend to be characterized by low levels of variability. This is incongruous with dwindling population which resulted in just 14 “pure” individuals, but wholly consistent with a population representing a hybrid swarm (Wayne 1995, p. 10).
Other explanations???

b. Wayne and Jenks (1991, p. 566)proposed that the red wolf is a hybrid between coyotes and gray wolves or were once a distinct taxon that hybridized with coyotes and gray wolves over much of its previous geographic range.
    a. Based ONLY on red wolf genotypes falling within coyote and gray wolf genotypes (p. 566).
    b. Captive red wolf mtDNA genotypes are indistinguishable from that found in coyotes from Louisiana (source population) (Wayne and Jenks 1991, p. X); Coyote mtDNA in red wolf reflects prior hybridization (Wayne and Jenks 1991, p. X).
        i. Indicates that ancestor of captive red wolves paired with female coyote, potentially some time before the captive breeding effort (Wayne 1995, p. 8).
    c. Source population – found mtDNA genotypes of southern coyotes and gray wolves (p. X).
        i. Lack of discernable red wolf genotype may be due to:
        ii. Sample failed to include red wolves with unique genotypes, or
        iii. Three centuries of human settlement gave rise to gray wolf-coyote zone at least as large as red wolf range (Wayne and Jenks 1991, p. X; Wayne 1995, p. 9).
            1. It's not a distinct species, but a zone of various crosses or intergrades between gray and coyote (Wayne 1995, p. 9)
    d. 1905-1930 samples: 6 specimens from TX, OK, LA, MO, and AR (2) – taken before hybridization was thought to be widespread. All 6 were either coyote or gray wolf genotypes, supporting hybrid swarm hypothesis (Wayne and Jenks 1991, p. X; Wayne 1995, p. 9).
    e. LIMITATIONS:
    f. Pre-1930s samples limited (Wayne 1995, p. 9)
    g. Although mtDNA has advantages, it is uniparental and clonal mode of inheritance promote rapid loss of diversity and provide

Commented [WE22]: Similar to RW, wolves from MN/Canada exhibit high frequency (over 50%0 of coyote mtDNA; however, mtDNA from other wolves in northern and western areas were grouped in distinct cluster or clade (Wayne 1995, p. 8)

Emily notes: Why do coyotes and gray wolves only hybridize in east, not in west or north (what is north – more northern than MN and Canada?). Is it a size issue (different size of gray wolves?); if so, is there a hybrid swarm of MX wolf (a smaller subspecies?) and coyotes?

Is there another explanation?

Commented [WE23]: Just prior? 1700s? Pleisotcene?

Commented [WE24]: What's the likelihood of one versus the other?

Commented [WE25]: Didn't Nowak not find intergrading, but rather a distinct range intermediate to gray and coyote?

Commented [WE26]: Cross check this with accounts of hybridization and extirpation in these states.
Nowak (1979): presence of red wolf-coyote hybrid in central TX between 1890-1920; hybridization in MO, OK, and AR between 1920 and 1940. (In Nowak and Federoff 1998, p. 723).

Samples taken in part of the range most likely to have been affected through introgression from the coyote (Nowak and Federoff, p. 723).

Almost no extant specimens of C. lupus lycaon from the southeastern states (Lawrence and Bossert 1967, p. 227).

biased representation of gene flow (Wayne 1991, p. 9).

h. COUNTER STATEMENTS
i. They also say that red wolf-like individuals are NOT present in MN/Canada hybrid area (C and GW) and suggest that unique environmental and genetic conditions are required for red wolf phenotype (568).
j. The authors also state that even if red wolf is entirely a hybrid, it filled a role as a top predator throughout its geographical range and was an integral part of the ecosystem (567).
k. Wolf colonization of mid-latitude NA in the Late Rancholabrean and the simultaneous appearance of a small wolf in the fossil record in eastern NA (Nowak 2002) provide a plausible background for ancient wolf-coyote hybridization giving rise to a novel canid type (Sefc and Kobmuller 2016, p. 1).
    i. Nowak's analysis, while thorough, is insufficient to assess ancestry in a system complicated by ancient hybridization followed by widespread extirpation and habitat alteration leading to contemporary admixture (Rutledge et al. 2016, p. 1).

c. RECENT – Roy et al. (1994, p. 565) hypothesize that the red wolf phenotype may represent a phenotype resulting from several-hundred-year period of hybridization between coyote and gray wolf in south-central U.S., which began with arrival of settlers circa 1700. Results of their microsatellite analysis is consistent with this theory of origin (p. 565)
    a. Red wolf share microsatellite alleles with coyote (p. 565).
    b. After extermination of gray wolves, hybrids (red wolves) became rare and phenotype more influenced by hybridization with coyote (p. 565).
        i. Phenotype seems distinct from coyote – See phenotype notes

ii. What was the med/small wolf from fossil record – Nowak did not find that it was a gray wolf due to lack of grading.

c. If red wolf was a species distinct as coyote and gray wolf, then unique alleles should have been found, even considering small founding size of captive population (p. 565)
   i. It should have unique genetic attributes like coyotes and gray wolves (Wayne 1995, pp. 7-8).

- What about Ferrell 1980?
  - Lack of unique allele is not favorable to ancient origin hypothesis (Wayne 1995, p. 10).
- Should have had time to produce unique alleles; however, this is not Conclusive (Wayne 1995, p. 10).
  a. Red wolf captive stock descended from a few finders, unique alleles could have been lost (Wayne 1995, p. 10).

b. Intermediate phenotype of red wolf is derived from historic (1700) hybridization between gray wolf and coyote. Recent extensive hybridization between hybrids and coyotes has caused those hybrids (red wolf) to become more similar in allele frequency to coyote that to recent hybridized populations of gray wolves (p. 566).
   a. In allele frequency, red wolf is similar to coyote and wolf-hybrid populations – a result not expected to be simple consequences of population bottleneck in otherwise distinct species (p. 566).

d. Roy et al. (1996, p. 1414) used historic specimens (pre1940) (skins) and analyzed mtDNA and microsatellites – no unique mtDNA genotype or microsatellite alleles (pp. 1417, 1420; Wayne 1995, p. 10).

e. Reich et al. (1999, p. 143), based on microsatellite allele length distributions estimate that hybridization originated less than 12,800 years ago, likely within 2,500 years ago – lends support to the hypothesis of a

Commented [WE27]: Founder also taken when hybridization had already begun – would that have had an effect?

Mexican wolves have only 4 founders, but have a unique mtDNA genotype and unique microsatellite alleles (Wayne 1995, p. 10).

Commented [WE28]: What years?

recent hybridization between coyotes and gray wolves associated with extensive agricultural cultivation by European settlers around 250 years ago.

f. Von Holdt et al. (2011, p. 8) found that red wolves appear to have an admixed ancestry with 75-80% of their genomes attributed to coyotes and the remainder to gray wolves
    a. Von Holdt et al. (2011, p. 8) estimate admixture initiated 144 generations (287-430 years ago), placing it approximately in a period when the Southeast U.S. was being converted and predators were intensely hunted.
    b. A component of the phenotypic distinction of red wolves may be attributed to historic hybridization of distinct populations of gray wolves and coyotes (von Holdt 2011, p. 8).
    c. Show that red wolves and GL wolves have a DISTINCT but admixed evolutionary history (p. 9).
    d. Supports admixed or ancient origin hypothesis (von Holdt et al. 2016, p. 1).
        i. Reanalysis of data (by Rutledge et al. 2012) found evidence for a genetic cluster in central Ontario representing eastern wolf and concluded that the SNP array data may suffer from ascertainment bias
        ii. Rutledge et al. 2015 showed through simulation that admixture alone cannot explain the unique positions of the eastern wolf (von Holdt 2016, p. 3).
    e. Red wolves are more similar to coyotes, but somewhat divergent from them due to a history of limited admixture with gray wolves (p. 8).
    f. Historic admixture between gray wolves and coyotes was followed by extensive back crossing to coyotes as the source population of gray wolves disappeared in the American South and Southeast (p. 8).

g. Von Holdt et al. (2016, p. 1) – intermediate body size of red and eastern wolves is consistent with an admixture scenario.

Commented [WE29]: Rutledge et al. (2012, pp. 187,) demonstrate that the data presented by von Holdt et al. 2011 are misconstrued due to flawed assumptions that bias interpretation and because authors fail to interpret their findings within the context of ecology, natural history, the fossil record, and other genetic markers.

Use by von Holdt et al. 2011 to utilize the C1 mtDNA haplotype as an eastern wolf species diagnostic is insufficient and inappropriate because hybridization between eastern wolves and coyotes resulted in a widespread geographic range of the C1 haplotype throughout coyotes across eastern NA (Rutledge et al. 2012, p. 188).

In assessing the evolutionary connection between eastern wolves and red wolves, the comparison should be between the population of Algonquin wolves and red, no Great Lakes wolves as done in von Hold et al. 2011 (Rutledge et al. 2012, p. 188).

Red wolves clearly distinct from other groups (p. 188). Explanation for pattern: a genetic bottleneck and subsequent drift occurred as a result of the captive breeding program that limited the gene pool to only 14 founding members (Hedrick and Fredrickson 2008) (p. 188).

Both mtDNA and Y-chromosome show distinct eastern wolf lineages that support the conclusion of an historic NA wolf that evolved independent of the gray wolf (Rutledge et al. 2010a,b; Fain et al. 2010, Wilson et al, in press)(p. 190)

a. Intermediate position of Great Lakes wolves and re wolves is consistent with a model of admixture between gray wolves and coyotes
b. All North American wolves and coyotes have significant amounts of coyote ancestry (p. 5).
c. Red wolf branched from coyote lineage (greater than 55-117,000 years ago) (pp. 7, 8).
d. Coyote ancestry is highest in individuals identified as red wolves (p. 8).
    i. South-North gradient of coyote ancestry is consistent with a known disappearance of wolf-like canids first from American south and east, concurrent with early European colonization (p.8).

h. Von Holdt et al. (2016, pp.7, 8) results suggest a surprisingly recent and admixed history of North American canids from the Great Lakes and southeastern regions of the U.S.
    a. Found little evidence of distinct genomic elements in red wolves that would support separate evolutionary legacies (p. 8).
    b. Uniformly low values of uniqueness among all admixed samples are not consistent with the presence of a distinct wolf-like canid in south (p. 8).

iv. COUNTER ARGUMENTS

i. Hohenlohe et al. (2016, p. 1) disagreed with von Holdt et al. (2016) conclusions, stating that the analysis does not actually test the hypothesis of a recent hybrid origin for red wolves, data does not support a conclusion of a lack of unique ancestry.
ii. Agree with von Holdt et al. (2016) that the genetic data support admixture as part of the evolutionary history of NA canids; however, they argue that the data is consistent with multiple evolutionary hypotheses, including ancient hybridization (p. 2), but do not support a recent origin by hybridization.
iii. Problematic samples – nonadmixed coyotes were taken from outside historic range of coyote – AL and Quebec, which is within ranges of red and eastern wolves.

Commented [WE30]: However, it is also consistent with the hypothesis that red and eastern wolves represent distinct conspecific populations (von Holdt et al. 2016, p. 3).

iv. Hybridization between eastward-expanding coyotes and native taxa has been well documented. Using these samples as representative coyotes confound estimates of admixture (p. 2).
v. The degree of differentiation calculated by von Holdt et al. (2016) is also consistent with an interpretation of red wolves as a distinct evolutionary lineage (p. 2).
vi. Differentiating gray wolves and coyotes along PC1, but GL wolves, red, eastern, and eastern coyotes along PC2 does not directly test evolutionary hypotheses, although it is consistent with multiple scenarios, including ancient hybridization or distinct origin (p.2).
vii. Tests for admixture indicate support for relatively large amounts of shared ancestry and admixture among NO canids. However, history of admixture doesn't imply that a taxon's origin traces back to a hybridization or that a taxon lacks unique ancestry (p. 2).
viii. Admixture analysis offered support for a relatively old origin of red wolves as a distinct evolutionary lineage (p. 2).
ix. Red wolves had an average of 4.4% unique alleles (p. 2); although von Holdt et al. (2016) expected proportion of new alleles to be higher than observed, the observed proportion of unique alleles reveal a higher degree of evolutionary distinctiveness in red and eastern wolves relative to other North American canids, a finding inconsistent with recent hybrid origin for the taxa (p. 2).
x. Recent hybrid origin requires interbreeding between gray wolves and coyotes. This has only occurred with limited success by artificial insemination in captivity. Evidence for interbreeding in the wild is limited (p. 2).
xi. Von Hold et al. (2016) suggest that GW and C would breed naturally when wolf population becomes very low; however, there is no evidence in the western GL where GW and C have existed since before European settlement, of ongoing or recent hybridization (p. 2). Other NA canids have undergone severe population bottlenecks without resulting in hybridization between gray wolves and coyotes. Such as the lack of hybridization between C and Mexican wolves (p. 2).

v. Distinct Origin

b. Assuming a distinct origin for the red wolf still requires substantial gene flow (admixture) from (with) gray wolves and coyotes and a relatively recent origin of the red and eastern wolves to account for its genomic composition (von Holdt et al. 2016, pp. 7, 8).
    i. This contradicts claims that red wolves have ancestry from native North American wolves that share common ancestry with coyotes more than 250,000 years ago (as in Wilson et al. 2000).
c. If red wolves were distinct species that hybridized with gray wolves and coyotes with proportions estimated, the expectation would be that they would have more novel alleles than actually observed. They fact that they do not provides additional support for our claim that these groups (red and eastern) are RECENT gray wolf-coyote hybrid populations (von Holdt et al. 20126, p. 7).
d. Von Holdt et al. (2017, p. 1) find no evidence for an independent ancestry for any of the New World wolves because this would have led to observation of more "novel" alleles that what was actually observed.
e. Mech (2012 In Rutledge et al. 2012, p. 190) report 3 main non-genetic reasons that support distinct eastern wolf lineage in eastern NA:
    i. Eastern are morphologically intermediate in size between gray and coyotes with no evidence of similarly intermediate sized wolves in western North America (p. 190)
    ii. No evidence of interbreeding between western gray wolf and western coyote.
    iii. Intolerant behavior between western gray and western coyotes makes natural breeding highly improbable and such mating has never been documented.

iv. Documentation of two wolf types in eastern NA in recorded historical accounts.
v. Fossil record demonstrates that C. lupus was not present in NA until Illinoian period appx. 300,000 ybp or perhaps late Rancholabrean (130,000 – 10,000 ybp).(p. 190) and little evidence that C. lupus occurred south of the glaciers prior to the late Rancholabrean (Nowak 2002).

vi.

b. Physiology?

Notes on Taxonomic Classification

Species on its own (C. rufus) – Nowak 1979, 1992, 1995; Nowak and Federoff 1996, 1998; Phillips and Henry 1992; Cronin 1993; Dowling et al. 1992a, 1992b

Two most recent comprehensive taxonomic reviews based on morphology both recognize 2 species C. lupus and C. rufus (Hall 1981 and Goldman 1944 in Chamber et al. 2012, p. 2).

According to Anderson (1943), Goldman (1937, 1944), and Jackson (1951), Hall and Kelson (1959 – there are 3 living species of wild Canis in North America (Nowak 1979, p. 1) (Paradiso and Nowak 1971, p. 1):

- Coyote – C. latrans
- Red wolf – C. rufus
- Gray wolf – C. lupus

- Genetic data supports a close relationship between eastern and red wolf, but do not support that they are the same species; more likely that they evolved independently from different lineages of a common ancestor with coyotes (Chambers et al. 2012, p. 1; Abstract).

Morphological studies have suggested that the red wolf is a distinct species with an intermediate phenotype. If so, unique mtDNA genotypes and nuclear alleles should exist in red wolves and should define them as a separate species clade (Wayne and Jenks 1991 and Wayne 1992 in Roy et al. 1994, p. 565).

An intermediate phenotype is also consistent with an origin due to hybridization between gray wolves and coyotes, a conclusion consistent with the absence of unique mtDNA genotypes in the red wolf (Wayne and Jenks 1991 and Wayne 1992 in Roy et al. 1994, p. 565).

Possible that unique genotype missed due to bottleneck, etc?

Red wolves possess wolf-derived nuclear DNA that produces a wolf-like rather that a hybrid-like organism; thus is seems red wolf is a valid taxon or at the very least a subspecies of gray wolf (Phillips and Henry 1992, p. 597).

Atkins and Dillon (1971) and Elder and Hayden (1977) confirmed the distinct speciation of red wolf (Parker 1989, p. 8).

Morizot (1981 in Parker 1989, p.8) found substantial genetic variation at three enzyme loci in red blood cell samples in comparison of dogs, coyotes, red wolves and an allele not seen in any other Canis.

Concluded that the red wolf was genetically more similar to coyote than gray wolf, but possess an allele unknown in coyotes.

Additional data derived from Skull measurements of red wolves and coyotes in early collections convinced him of the integrity of the red wolf as a separate form which should be recognized as a small wolf which evolved in North America (Parker 1989, p. 8).

- Red wolf has existed in southeastern North America, in much the same form as now, for at least 700,000 years (Nowak 1995, p. 2).

o Only 6 whole, fully developed male Canis skulls prior to 1918 – all are statistically separate from C. lupus and C. latrans (Nowak 2002, pp. 118-119). Taken from east of MS and south of Prairie Peninsula, Lakes Erie and Ontario, and the St. Lawrence River.

o This species, as defined by these eastern skulls, has diagnostic measurements statistically identical to two series of fragmentary specimens collected from the same region and dating from around 10,000 ybp and from 2,000-200 ybp.

o Supports view that C. rufus has continuously occupied the east since terminal Pleistocene and that it was the only species of wild Canis that was present in most of the region (Nowak 2002, p. 119).

o Seven additional complete skulls of males from northeastern LA, taken 1898-1905, and one prior to 1896 in south-central OK have about the same statistical distribution as the 6 above, when compared to C. lupus and C. latrans (Nowak 2002, p. 119).

o These argue for recognition as distinct species that is appropriately named C. rufus (Nowak 2002, p. 119).

Von Holdt et al. (2017, p. 1) “We know of no convinving genetic arguments for distinct species.

Species with C. lupus lycaon (C. lycaon) – Wilson et al. 2000 – See other explanation below

- C. l.lycaon and C. rufus have genetic sequences similarly divergent from those of C. latrans and distinct from those of other C. lupus (Nowak 2003, p. 253).
- One interpretation is that lycaon and rufus compose a separate species that is more closely related to C. latrans than to C. lupus (Wilson et al. 2000 IN Nowak 2003, p. 253).
- Nowak studies show lycaon statistically intermediate to C. rufus and C. lupus (Nowak 2003, p. 254).
- The molecular case for uniting rufus and Algonquin lycaon in a species separate from C. lupus, based on their readiness to hybridize with C. latrans, seems compelling (Nowak 2009, p. 241).
- Genetic data supports a close relationship between eastern and red wolf, but do not support that they are the same species (Chambers et al. 2012, p. 1; Abstract).

Results from Rutledge et al. (2010, p. 1278) suggest that the wolf that was historically present in the eastern temperate forests of SW Ontario was an eastern wolf (C. lycaon) that evolved in North America (New World).

- These results are consistent with the landscape and ecology of the area during the 16th century – dense forest and abundance of deer make it more suitable for eastern wolf than coyote or gray wolf (p. 1278). Could also be an eastern-gray wolf hybrid origin (1278).

Subspecies of gray wolf – Audubon and Bachman 1851; Lawrence and Bossert 1967, 1975

Audubon and Bachman 1851: noted the species Canis lupus rufus as the red wolf of TX.

- Account noted a description, color, size, and habits. Did not believe it inhabited the more northern prairies or Mississippi bottoms, but was likely present in northern Arkansas and Mexico (WMI 2016, p. 11).

- Wolves they described were varieties of one species (C. lupus), except coyotes (Nowak 1979, p. 24).
    - Canis lupus var. Ater (Black American Wolf – FL, SC, NC, KY, southern IN, southern MO, LA, and northern TX
    - Canis lupus var. Rufus (Red Texan Wolf – northern AR through TX, and Mexico)

Lawrence and Bossert (1967, p. 228) thought that separation of C. rufus as a distinct species rested too heavily on small red wolves of central TX, where hybridization with coyote may have been a factor. Separation of C. rufus from C. lupus would have been unlikely if study of wolves in south had been based on adequate series of specimens from FL (Nowak 1979, p. 25).

Commented [WE31]: Used linear discrimination

- Found C. lupus lycaon and C. rufus to overlap with C. lupus, but to be distinct from each other (p. 25).
- All 3 populations formed a cluster distinct from coyotes, with C. rufus being the farthest removed (pp. 25-26).

- Interpreted analysis that early pops east of coyotes was a local form of C. lupus, not a distinct wolf species (Lawrence and Bossert 1967, p. 229; Nowak 1979, p. 26).
- Did another 1975 study
- Nowak's 1979 work did not agree with Lawrence and Bossert.
- Paradiso (1968) argued that the small sample size used by Lawrence and Bossert (1967) did not adequately represent the variability shown by Canis, and thus the conspecificity of red and gray wolves had not been demonstrated (Nowak 1979, p. 26; Paradiso and Nowak 1971, p. 1)).
    - Also pointed out several cranial and dental characters in which rufus resembled latrans more (e.g., increased development in size of two upper molars compared with gray wolf, area of maximum width of braincase, length and structure of canines (Paradiso and Nowak 1971, pp. 6, 7)).

"It now appears that the early populations described as Canis niger [=C. rufus floridanus] and n. gregoryi [=C. rufus gregoryi] from southeastern wooded regions, east of the range of Canis latrans, are a local form of C. lupus (Lawrence and Bossert 1967, p. 229 in Paradiso and Nowak 1971, p. 1).

Red wolves possess wolf-derived nuclear DNA that produces a wolf-like rather that a hybrid-like organism; thus is seems red wolf is a valid taxon or at the very least a subspecies of gray wolf (Phillips and Henry 1992, p. 597).

Three valid subspecies (C. rufus rufus, gregoryi, floridanus) – Goldman 1937, 1944 – largely based on size (McCarley 1962, p. 227).

- Audubon and Bachman (1851) restricted rufus to Texas and some adjacent areas (Nowak 2002, p. 120).
- Goldman (1937, 1944) thought 2 more subspecies could be identified farther east: C. r. gregoryi in the lower MS Valley and C. r. floridanus from AL to Atlantic (id).
    - Goldman (1944) observed that the 2 eastern subspecies of C. rufus exhibited remarkable approach in size and general proportions to the eastern gray wolf, C. lupus lycaon, but there existed several specific cranial differences (Nowak 1979, p. 25)
        - C. l. lycaon clusters closely with other subspecies of gray wolf and no evidence that characters of C. rufus change toward those of lycaon from south to north; series from MO is consistent with a series from LA (Paradiso and Nowak 1971, p. 7).
        - The shift of lycaon toward rufus probably represents convergent evolution due to similarity of habitat and general lack of competition with other species of Canis (Paradiso and Nowak 1971, p. 7).
        - Nowak and Paradiso (1971, p. 7) indicate that C. rufus differs more from the western subspecies of C. lupus C. l. monstrabilis?) than it does from C. lupus lycaon.
- Red wolf becomes smaller to the west, especially in TX, but might be expected as it approaches a zone of sympatry with the larger gray wolf (id).

- Nowak's multivariate analyses reinforce Goldman's 3 subspecies designation. However, some rearrangement of subspecific lines is advisable, based on assessment of the oldest available material (Nowak 2002, pp 120-121):
    - C. r. floridanus – Atlantaic coast from Maine to FL and inland to Ohio and northern AL
    - C. r. gregoryi – throughout lower MS Valley, including some country along the Ohio and Red rivers in the Big Thicket area of eastern TX (LA, extreme eastern OK and TX – samples from here assigned to this ssp Paradiso and Nowak 1971, p. 3).
    - C. r. rufus – TX coast and probably central TX, maybe farther east along the Gulf coast (TX, OK, northwestern AR and southwestern MO– samples from here assigned to this ssp Paradiso and Nowak 1971, p. 3).
- Specimens assigned C. r. rufus by Goldman collected before 1930 from Texas, OK, and northwestern Arkansas were on the whole smaller and more narrowly proportioned, and hence more coyotelike than most specimens of gregoryi.
- McCarley (1962, p. 233) suggested C. r. rufus might be a hybrid of C. latrans and C. rufus. However, there is no evidence of intergradation between C. rufus and C. latrans (Paradiso and Nowak 1971, p. 3).
- West to east cline of increase in size is apparent between niger, gregoryi, and rufus (McCarley 1962, p. 227).

Canis lycaon a subspecies of gray, but one that developed from *natural hybridization with C. rufus*

MAP, Nowak 2009, p. 242

See also Kyle et al. 2006

- Oldest C. lupus lycaon from the northeast is statistically intermediate to C. rufus and western C. lupus (Nowak 2002, p. 119).
- Explains why the red and gray wolf differ so much along most of the line there their ranges meet, but resemble one another so closely in the northeast (id).
- Also keeps with mtDNA analyses indicating that C. rufus and lycaon contain genetic sequences similarly divergent from C. latrans and differing from those of C. lupus (id).
- Wilson et al. (2000) interpreted this to mean that rufus and lycaon for a single species. (id).
- However, another interpretation is that the modern range of lycaon originally was occupied by C. lupus, which moved in from west after retreat of glaciers at the end of the Pleistocene. C. rufus would also have moved northward to the southern edge of that area. The new available, possibly unstable, habitat may have been conducive to hybridization (Nowak 2002, p. 120).
- Lycaon is statistically near rufus, no overlap, but shows greater statistical similarity with lupus (id).

- Lycaon also does not substantively differ ecologically and behaviorally from other gray wolf subspecies (Forbes and Theberge 1995, Mech 1970, Pimlott et al. 1969 IN Nowak 2002, p. 120).
- Given DNA data, reasonable interpretation of the morphometric analysis is that C. rufus is a species distinct from lupus and latrans, but that hybridized with lupus, producing the population known as lycaon (Nowak 2003, p. 254).

As explained above, and in detail by Kyle et al. (2006) , there are three rival systematic positions on eastern wolves. The most divergent are the two based on molecular studies, one designating the red wolf part of an ancient and distinct species, the other holding that the red wolf originated as a modern hybrid. However, as indicated by the advocates of the former view (Kyle et al. 2006), the advocates of the latter view (Wayne and Vilà 2003) now have acknowledged that there might have been a distinct red wolf-like species that migrated into Canada after the last glaciation and interbred with the gray wolf, which is exactly what was proposed by the advocate of the third, morphologically based, view (Nowak 2002) . Wayne and Vilà (2003) used the name *C. lycaon* for that species, which would indeed have priority over *rufus* , if the animal named by Von Schreber in 1775 (see above) represented the red wolf, and/or if *rufus* and *lycaon* are accepted as conspecific (Nowak 2009, p. 244).

<u>Not a species, but a hybrid</u> – Reich et al. 1999; Roy et al. 1994a, 1994b, 1996; Wayne 1992; Wayne and Gittleman 1995; Wayne and Jenks 1991; Wayne et al. 1995, 1998

- Mech (1970) thought the differing views on status of C. rufus could be reconciled by recognition of red wolf as a hybrid of C. lupus x C. latrans (Nowak 1979, p. 27).
- Wayne and Jenks (1991, p. 566) - Red wolf genotype classified with those of either coyote or grey wolf. (Samples taken from 1905-1930 and 1974-1976). Situations that account for this result:
    - Red wolf *was* a distinct species, then hybridized with both coyote and grey wolves over much of its geographical range (no timeline given).
    - Red wolf phenotype could have been derived entirely from hybridization between coyotes and gray wolves
        - Could have been a southeastern subspecies of gray wolf that was morphologically but not genetically distinct from other gray wolves.
        - This subspecies then hybridized with coyotes that were numerically increasing throughout much of the red wolf's range. (Since early 1900s?)
- An intermediate phenotype is also consistent with an origin due to hybridization between gray wolves and coyotes, a conclusion consistent with the absence of unique mtDNA genotypes in the red wolf (Wayne and Jenks 1991 and Wayne 1992 in Roy et al. 1994, p. 565).
    - Possible that unique genotype missed due to bottleneck, etc?

- It is conceivable that red wolves may represent a phenotype resulting from a several-hundred year period of hybridization between coyotes and wolves in south-central U.S., which began with habitat changes associated with the arrival of settlers circa 1700 (Roy et al. 1994, p. 565).
    - After extermination of gray wolves in southern and northeastern U.S., the hybrids and their descendants, identified as red wolves, became rare and hybridized with coyotes (id).
    - More recent extensive hybridization with coyotes has caused red wolves to become more similar in allele frequency to coyotes (p. 566).
    - Documentation of gray wolves in southeastern U.S.?

Roy et al. (1996 in Federoff 1998, p. 723) acknowledge that their analysis cannot readily reduce the precise timing of hybridization or the true origin of red wolf.

Although no time frame is given (ancient or recent), Wayne and Jenks (1991, p. 566) propose that red wolves are hybrids of coyotes and gray wolves or were once a distinct taxon that hybridized with coyotes and gray wolves over much of its previous geographic range.

- All based on red wolf genotypes being classified/grouped with coyote and gray wolf genotypes (Wayne and Jenks 1991, p. 566).
- Hybrid zone as large as past geographical range of red wolf is possible (p. 567).

However, I also note that the authors did not seem to consider any additional information or consider what constitutes a distinct species. Furthermore, the authors say that red wolf-like individuals are NOT present in MN/Canada hybrid area (C and GW) and suggest that unique environmental and genetic conditions are required for red wolf phenotype. The authors also state that even if red wolf is entirely a hybrid, it filled a role as a top predator throughout its geographical range and was an integral part of the ecosystem (Wayne and Jenks 1991, pp. 567-568).

Hybrid – Coyote x C. r. gregoryi

V. Rufus rufus (C. niger rufus) is a hybrid between C. latrans and C. rufus gregoryi (C. niger gregoryi) (McCarley 1962, p. 233).

Additional support available from several sources

Seems plausible to hypothesize that sometime in the past, prior to 1900, interspecific hybridization occurred between coyotes and red wolves (probably C. n. gregoryi). This hybridization probably occurred first in central OK and Texas as Goldman suggested, producing a hybrid population described as C. niger rufus (McCarley 1962, pp. 233-234).

As coyotes expanded eastward, hybridization increased, gradually swamping out the red wolf populations as the previously effective isolation mechanisms broke down (p. 234).

Population sample of recent Canis with the largest skull dimensions came from eastern counties of OK, presumably the last portion to be extensively influenced by man (p. 234).

Skulls of eastern OK were, on the average, larger than typical coyotes, yet considerable smaller than C. n. gregoryi; This suggests that the population of Canis in OK may presently be of hybrid character (p. 234).

As far as known (at that time) no coyotes occurred in LA in contact with the apparent extant populations of red wolves (p. 234).

A population of natural hybrids (p. 234).

Red Wolf Meeting Discussion Outline

Does the red wolf meet the definition of a "species" under the ESA?

I. What is a "species"?
   a. ESA definition
      i. FWS Regulations
      ii. FWS Director's Memo
   b. Species in the Literature
      i. Species concepts
      ii. The species problem
      iii. Potential resolution
   c. "Species" in FWS findings/rules (examples)
      i. What has FWS done/used before
   d. Summary
   e. What criteria will we use to assess red wolf as a "species"?

II. Did the red wolf historically exist?
   a. Was there historically a wolf present in the southeast?
      i. Pre-1600s
      ii. 1600-Early 1900s
   b. Was the wolf inhabiting southeastern U.S. distinguishable from other canids?
      i. Pre-1600s
      ii. 1600-Early 1900s
   c. What was this wolf called?
      i. Pre-1600s
         1. Theories of Origin
      ii. 1600-Early 1900s
         1. Theories of origin

III. Is the current wolf representative of the historic wolf?
   a. Status of wolf post-European settlement
      i. Eradication
      ii. Habitat loss
      iii. Coyote expansion
      iv. Impacts
   b. Texas/Louisiana Roundup
      i. Standards used to distinguish entities
      ii. Selection of founders
      iii. Are founder/descendants the same as the historical entity?
   c. How relevant is representation of historical entity to the "species" question?

IV. Does the wolf we have today meet the definition of a "species" under the ESA?
   a. Morphology

Commented [WE1]: Move to make III?

Commented [WE2]: Important for structuring the discussion

Commented [WE3]: Reach consensus before moving along

Commented [WE4]: Is it a hybrid? What do we mean by a hybrid?
If not a hybrid, it's a "species."
If it was a hybrid origin, does it mean it's not a species today?
Conclusion is to eliminate one alternative (Not a "species"/hybrid) or the conversation ends because it is not a listable entity.

b. Phenotype
c. Ecology
    i. Diet
    ii. Habitat preference
    iii. Territory size
d. Behavior
    i. Reproduction
        1. Defense/exclusion
        2. Litter size
        3. Dispersal
    ii. Social behavior
        1. Pack/Family groups
        2. Howling
e. Genetics
f. Physiology?
g. Is it a listable entity?

V. If it is a listable entity, is it a species or subspecies?
a. Not a "species"/Hybrid
b. Species (*Canis rufus*)
c. 1 of 3 subspecies
    i. *C. rufus floridanus*
    ii. *C. r. gregoryi*
    iii. *C. r. rufus*
d. Conspecific with eastern wolf (*C. lycaon*)
e. Subspecies of gray wolf (*C. lupus rufus*)

Commented [WE5]: Origin will likely be discussed here too.

I. **Summary: What is a "species"?** *Note: "Species" refers to ESA definition; Species is the taxonomic entity*

a. ESA definition

- The term "species" includes any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature.
- Term is used in a legal sense to refer to any of those entities (NRC 1995, p. 46)
- As such, a "species under the Act may include any:
  - Taxonomically defined species of fish, wildlife, or plant;
  - Any taxonomically defined subspecies of fish, wildlife, or plant;
  - Or any DPS of any vertebrate species as determined by us per our Policy Regarding the Recognition of Distinct Vertebrate Population Segments (61 FR 4721; February 7, 1996). (coastal CA gnatcatcher; 81 FR 59957 (2016))

i. Service Regulation (50 CFR 424.11)

- The Secretary shall rely on standard taxonomic distinctions and the biological expertise of the Department and the scientific community concerning the relevant taxonomic group.

ii. Director's Memo Taxonomy and the Endangered Species Act (Nov. 25, 1992)

- Service is required to exercise a degree of scientific judgement regarding the acceptance of taxonomic interpretations, particularly when more than one possible interpretation is available
- When informed taxonomic opinion is not unanimous, we evaluate available published and unpublished information and come to our own adequately documented conclusion regarding the validity of taxa.

b. Species in the Literature

i. Species concepts

- At least 22 species concepts in the literature
- Historically, moderate to strong support for Biological Species Concept among mammologists (Mayr 1942 in Baker and Bradley 2006, p. 644).
- Before 1985, and the onset of DNA data sets, most descriptions of mammal museum species were based on morphological analyses (Baker and Bradley 2006, p. 644).
- Recent trend in Journal of Mammology toward use of PSC (Baker and Bradley 2006, p. 644).
- Most catalogues/checklists (e.g., Wilson and Reeder 1993, 2005) are not constructed under a single concept (Baker and Bradley 2006, p. 644).

ii. The species problem

- Biologists in different fields have different ideas about what a species is (Naomi 2011, p. 177; de Queiroz 2007, p. 56; Mayden 1997, p. 389; NRC 1995, p. 51)
- Concepts are incompatible, at least partially (de Queirzo 2007, pp. 879, 880)

- Concepts are incompatible, at least partially (de Queirzo 2007, pp. 879, 880)
    - So much is dependent on our ability to discover and study naturally occurring entitles
- All seem to have merits as they are all based on important biological properties (de Queirzo 2007, p. 880).
- The "species problem" is not a scientific problem at all, merely one about choosing and consistently applying a convention about how we use a word." (In Baker and Bradly (2006, p. 648) Brookfield 2007, cited in Coyne and Orr 2004).

iii. Potential resolution

- 2 integrated frameworks have been proposed
    - Hierarchy of species concepts (Mayden 1997)
    - Unified species concept (de Quierzo 1998, 1999, 2005, 2007)
- Same two major components:

  1) A concept for species category: evolutionary (or lineage) concept of species, and

  2) Multiple operational criteria for species delimitation or the contingent biological properties to serve to diagnose said lineages (Naomi 2011, p. 180).
- Same consequences:
    - All evolutionary lineages are species;
    - Issue of species delimitation is clearly separable from the issue of species conceptualization;
    - All of the biological contingent properties (secondary concepts) are relevant to the issue of species delimitation (Naomi 2011, p. 180).
- Revised Integrated Framework of Species Concepts (Naomi 2011)
    - Concept for species category: Wiley's version (1978) of ESC
    - The contingent biological properties of species are adopted as operational criteria in delimiting species.
    - E.g., morphological, phylogenetic, genetic, ecological, etc. differences
- Approach used by Chambers et al. 2012
    - Relied on for gray wolves 78 FR 35664 (2013)
    - Uses integrated approach with concordance principles of Avise and Ball 1990.
        - Identifies species as separate lineages supported by concordant data from various classes of genetic markers, morphometric analysis, behavior, and ecology (Chamber et al. 2012, p. 5).

c. "Species" in FWS findings/rules (examples)

i. 2011 Dusky/Red Tree Vole

- A subspecies must be discernable
- Used multiple sources of info/types of info
- Evaluated for consistent separation

ii. 2013 Preble's Meadow Jumping Mouse

- Conflicting studies on validity

- Best available scientific and commercial info
- Used multiple types of info

iii. 2016 Coastal CA Gnatcatcher
- Operational approach
- Evaluate and consider all available types of data
- Do not assign priority or weight to any particular type of data

iv. 2017 Hualapai Mexican Vole
- Methods for detecting different subspecies will be different for each due to uniqu evolutionary forces, selection, divergence time, etc.
- Used same approach as coastal CA gnatcatcher

d. What criteria will we use to assess red wolf as a "species"?

i. Discussion of what criteria will be used

ii. Reach consensus before moving along

III. Summary: Is the current wolf representative of the historic wolf?

a. Status of wolf post –European settlement

i. Eradication and Habitat Loss
- Prior to European settlement, the red wolf population possibly numbered in the hundreds of thousands (Parker 1984 In Brownlow 1996, p. 391).
- With settlement, wolves (red and gray) were subject to loss of forest habitat, construction of wolf-proof fences, extensive hunting by ranchers and farmers, the bounty system, and State and Federal predator control operations (Paradiso and Nowak 1971, p. 11; Nowak 1979, Cohn 1987, Peek et al. 1991 In Brownlow 1996, p. 391).
- These actions played a major role in the decline of red wolves (Paradiso and Nowak 1971, p. 11).
- Factors reached a peak in 1930s (Paradiso and Nowak 1971, p. 11).

ii. Coyote Expansion
- With decline/eradication of wolves, coyotes began appearing to the north, south and east of the prairies after the mid-19th century (De Vos 1964, Mech 1959, 1961, Young 1951 In Nowak 1979, p. 14).

iii. Impacts
- By mid-1930s, red wolves were gone from portions of its range (Paradiso and Nowak 1971, p.11).
- It was an extermination of a dominant carnivore followed by an influx of coyotes to fill its ecological niche; no gradual dilution of the gene pool (Paradiso and Nowak 1971, pp. 11-12, 16).
- Evidence of expanding hybridization between red wolf and coyotes began in 1930s (Paradiso and Nowak 1971, p. 2; Nowak 1979, p. 37; Nowak 1992, p. 594).
- By the 1960s, the red wolf had hybridized extensively with the coyote and a hybrid swarm was threatening the species with extinction (McCarley 1962, p. 232; Adams 2003, p. 2176).
    - Hybrid swarm first formed in central Texas around 1949, then spread east (Paradiso and Nowak 1971, pp. 14-15, 16).
    - As of 1969, pure red wolf populations existed in certain section of extreme southeastern Texas and southwestern Louisiana (Paradiso and Nowak 1971, pp. 15-18).

b. Texas-Louisiana Roundup

- By mid-1975, it became apparent that the only way the red wolf could be saved from extinction was to capture as many wild animals as possible and place them in a secured captive breeding program (USFWS 1989, p. 1).

i. Standards used to distinguish entities
- A number of indicators were used to determine whether an animal was a wolf, coyote, or hybrid. The following morphological measurements were used (specific standards for males and females listed in USFWS 1989, p. 11).
    - Skull length
    - Zygomatic breadth

        - Weight
        - Total length
        - Hind foot length
        - Ear length
        - Shoulder height
        - Brain/skull ratio
    ii. Selection of founders
        - Animals determined to be possible wolves were placed in the breeding/certification program (USFWS 1989, p. 11).
        - From fall of 1973-July 1980, over 400 wild canids were examined (USFWS 1989, p. 12).
            - Of those, only 43 wild canids were admitted to the breeding/certification program as probable red wolves.
            - Final proof of genetic integrity was determined through captive-breeding process itself.
            - 15 became founding stock.
            - 12 are represented in the wild/captive wolves today
    iii. Are founders/descendants representative of the historical entity?
        - Multiple studies indicate that the captive animals appear to be morphologically and genetically similar to historic red wolves (Nowak 1979, p. X; Wayne and Jenks 1991, pp. 567-568; Nowak 1992, pp. 594-595; Wayne 1995, p. 10; Nowak 2002, p. 121; Roy 1994 In Hailer and Leonard 2008, p. 8; Chambers et al. 2021, p. 12; Hinton et al. 2014, p. 856)

c. How relevant is representation of historical entity to the "species" question?

Summary: Does the wolf we have today meet the definition of a "species" under the ESA?

General

- Shaw (1975) evaluated data on behavior, ecology, vocalizations, allelic frequency, and morphology of *C. r. gregoryi* in southeast Texas and concluded the population represented a species distinct from both *C. lupus* and *C. latrans* (Nowak 1979, p. 26).
- Once man altered the environment and decimated the wolf population, ecological and behavioral isolation might have broken down, allowing large scale hybridization (Nowak 1979, p. 43).

Morphology

- Strongest evidence that red wolves are a separate species comes from Nowak (1979) (Wayne and Gittleman 1995, p. 3)
- Nowak's morphological studies (1979, 2002), as well as Paradiso and Nowak (1971, p. 8; 1972) and Atkins and Dillon (1971) consistently found *C. rufus* to be distinct from *C. latrans* and *C. lupus* (Paradiso and Nowak 1972, p. 2; Nowak 1979, p. 26).
    - Position of *C. rufus* intermediate to *C. latrans and C. lupus* (Nowak 1979, pp. 28, 31-32), but demonstrates clear separation (i.e., no overlap, lack of clinal variation, intergrading or blending) (Paradiso and Nowak 1971, pp. 7, 8; Paradiso and Nowak 1972 In Nowak 1979, p. X; Nowak 1995b, p. 389).
        - Gipson, Sealander, and Dunn (1974), Freeman (1976), and Elder and Hayden (1977) all found that red wolf fell statistically intermediate to *C. lupus* and *C. latrans* (Nowak 1979, p. 26).
    - Nowak also found that *C. rufus* and hybrids form distinct clusters (Nowak 1995, pp. 3-4)
    - *C. rufus* morphologically resembles *C. lupus lycaon* (also *C. lycaon*) more than other subspecies of gray wolf, but is more than subspecifically different than *C. lupus* (Nowak 1979, pp. 29-30).
    - Whether *C. rufus* is considered a full species or a subspecies, it is the most distinctive kind of wolf in the world. Except for a small overlap with *pallipes* red wolf is statistically separate from all series of *C. lupus* (Nowak 1995b, p. 397)
- Complete lack of morphological intergradation where two populations approach without physical barriers argues for specific distinction (Nowak 1995b, p. 394 referring to *C. rufus* and *C. latrans*). Significant morphometric differences most likely a result from true phylogenetic distinction (Nowak 2002, p. 99).
- Body-size measurements of red wolves and coyotes are distinct from one another. Findings are consistent with Nowak (1979, 2002) who demonstrated that little to no overlap in red wolf and coyote cranial and dental measurements (Hinton et al. 2014, pp. 857, 858, 859).
    - Using body-size measurement correctly classified 99% coyotes, 98% red wolves, and 13% hybrids (more likely to be misclassified as coyotes than as red wolves (Hinton et al 2014, p. 859).

- Nowak's multivariate analyses reinforce Goldman's 3 subspecies designation. However, some rearrangement of subspecific lines is advisable, based on assessment of the oldest available material (Nowak 2002, pp 120-121).
- *Canis rufus rufus* (*C. niger rufus*) is a hybrid between *C. latrans* and *C. rufus gregoryi* (*C. niger gregoryi*) (McCarley 1962, p. 233).
    - McCarley (1962, p. 229) found gradation in size/all measurements of skulls from presumed specimens of *C. niger* and *C. latrans,* with the largest assigned to *C. niger gregoryi* and the smallest to coyotes; intermediates were not easily assignable to either species .
        - Note that the majority of skulls were of unknown sex, therefore females (generally smaller) and males were treated together (McCarley 1962, p. 229).
    - Seems plausible to hypothesize that sometime in the past, prior to 1900, interspecific hybridization occurred between coyotes and red wolves (probably C. n. gregoryi). This hybridization probably occurred first in central OK and Texas as Goldman suggested, producing a hybrid population described as *C. niger rufus* (McCarley 1962, pp. 233-234).

Counters

- Fragmentary fossil remains makes the interpretation of the sparse fossil records difficult (Wayne 1995, p. 8).
- Efforts to use morphological criteria as a basis to classify red wolf as a distinct species are problematic. (Wayne 1995, p. 7).
    - Multivariate analysis of morphological measurements (like that in Nowak 1979), express an overall similarity in cranial and dental form of red wolves to other canids (p. 7).
    - Quantitative differences alone to define species status is controversial (Wayne 1995, p. 7 – other citations).
    - Phenotypic argument may be circular because hybrids between gray wolves and coyotes are expected to be intermediate in morphology; thus the phenotype of red wolf may reflect either:
        - Recent hybridization between gray wolf and coyotes in southeast, or
        - Ancient origin and long distinct evolutionary heritage (Wayne 1995, p. 7)
    - Nowak's cranial data are consistent with the possibility that the red wolf is a hybrid of the gray wolf and the coyote (Wayne and Gittleman 1995, p. 4).
        - Intermediate position is taken by researchers like Wayne and Gittleman (1995) to indicate hybridization; Nowak, however, suggests that a hybrid would show more grading/blending between the parental species rather than distinctive clusters.
    - Coyotes and gray wolves have been observed to mate in certain parts of Canada, resulting animals had skull dimensions resembling those Nowak found for red wolf (p. 4).

- Position of hybrid overlaps with position of red wolves (Wayne 1995, p. 7) – see figure here and Nowak 1979 (fig 10 and 15), and Wayne 1992).
- Because of hybrid possibility, discrete character state differences uniquely shared with red wolves is needed to define them as a separate taxon. Molecular data provide such data (Wayne 1995, p. 7). See genetics

Phenotype

- If Biological Species Concept difficult to apply, phenotype may be used as a surrogate. Two groups that have evolved separately are likely to display measurable differences in their traits (Wayne and Gittleman 1995, p. 3).
- Absence of red wolf-like individuals in hybrid zone in MN/Canada (where gray wolves and coyotes are hybridizing, suggest unique environmental and genetic conditions are required for the red wolf phenotype (Wayne and Jenks 1991, p. 568).
- Red wolves represent a unique phenotype in the southeastern U.S. (Hinton et al. 2014, p. X).
- Although difficulty in distinguishing between the red wolf and coyote and gray wolf has been noted (Audubon and Bachman 1851; Riley and McBride 1972, pp. 3, 12, 14); obvious external traits have been identified that are so pronounced that species can be readily distinguished in the field (Riley and McBride 1972, pp. 3, 4, 6, 8, 12, 14):
  - Disproportionately long legs
  - Large ears and the angle at which they are typically carried
  - Area of white around lips extends well up on sides of the muzzle; coyotes' area of white is thin and sharply demarcated
  - Facial appearance more massive than fox-like coyote
  - Weight: 40-60 lbs
  - Larger tracks than coyote (3.5 inches compared to 2.25-2.85 inches)

Ecology

- In terms of behavior, ecology, and morphology red wolves have never exhibited the variability one would expect if the species originated from interbreedings of gray wolves and coyotes (Phillips and Henry 1992, p. 597).

Diet

- Diets vary between red wolf packs (Dellinger et al. 2011, p. 738).
  - Five of six packs consumed only mammalian prey - deer and fawns combined accounted for 66% of total biomass of prey consumed (Dellinger et al. 2011, p. 736).
  - During pup-rearing season diets composed primarily of adult deer and fawns (Dellinger et al. 2011, p. 738).
- Differences noted in remnant population and reintroduced population: prior to extinction, principal prey included nutria, rabbits, and rodents (Riley and McBride 1972, p. X; Shaw 1972, p. X; Phillips and Henry 2013, p. 273).

- Diets of red wolves and coyotes in NC (reintroduced population) were similar (Hinton et al. 2017, p. X). White tailed deer was an important component to both, although red wolves and hybrids consumed more deer (Hinton et al. 2017, p. X; rabbits, white-tailed deer, and rodents were the prey most frequently eaten by both (Phillips and Henry 1992, p. 597; McVey et al. 2013, pp. 1144, 1146; Phillips and Henry 2013, p. 273).
    - Coyote use of deer appears to be seasonal (winter) (Phillips and Henry 1992, p. 597; Hinton et al. 2017, p. X).
    - Partitioning of food resources is likely via differences in proportions of similar prey consumed rather than in differences in types of prey exploited – coexistence, therefore may not be possible due to limited opportunities for niche partitioning to reduce competitive interactions (Hinton et al. 2017, p. X).
- Gray wolves make use of medium-sized mammals (Phillips and Henry 1992, p. 597).
- Red wolf not a serious predator on cattle like gray wolves (Riley and McBride 1972, p. 10).

Habitat preference

- Red wolf is essentially a warmth-adapted species in contrast to the more cold-adapted gray wolf (Paradiso and Nowak 1971, p. 8).
- Historically, coyote and red wolf were primarily allopatric species (Paradiso and Nowak 1971, p. 9).
    - Coyote range included drier regions and grasslands of the west, along the edge of the eastern forested zone (Paradiso and Nowak 1971, p. 9), as well as agriculture land, coastal bottomland forest, and pine forest (Hinton et al. 2015, pp. 7, 11).
    - Red wolf was found mainly in more humid regions of predominantly forest type (southeastern forests, swamps, and coastal marshes); considered a species of eastern forests (Nowak 1979).
- Agricultural areas represent an ideal habitat for coyotes (Ballard et al. 2003, p. XX, Thiel 2010, p. XX) offering an abundance of smaller prey (Phillips et al. 2003, p. 283) and cover when crops are in (Gosselink et al. 2003, p. XX; Karlin 2011, p. 68)

Range/Territory size

- Upper limit of coyote home-range size approximately 47 km2 - limit to area they can effectively exploit and defend as territories (13.4-47.3 in eastern NC) (Hinton et al. 2015, pp. 6, 9). Throughout North America, range from 2.5-70km2.
    - Transient ranges ranged from 64.5 km2-633.4km2 (greater during harvest season) (Hinton et al. 2015, p. 6).
- Riley and McBride (1972, p. 9) estimated home range for the red wolf to be 25-50 sq. mi; Shaw (1972) estimated average of 35 sq. mi.

<u>Behavior</u>

General

- Coyotes are also well-adapted to recover from harvest. Coyotes are highly adaptable and readily locate near humans. They eat a wide variety of foods, produce a higher than average number of offspring for a predator, and can readily breed with both wolves and dogs (Hinton et al. 2015, p. 1-2).
    - Will readily use resources associated with human presence (citations)
- Several studies have shown populations quickly replace lost individuals following substantial control efforts – this may be the result additional food availability allowing for larger litters and release of younger individuals to breed (Gese 2005, p. 281).
- Whatever the mechanism, it is generally agreed that control efforts can increase both birth and survival rates in coyote populations
- Coyotes have also shown to adapt to a more nocturnal lifestyle in specific areas (Iowa Study).

Isolating behavior

- Research indicates the importance of behavioral forces, especially social stability, in regulating hybridization and species boundaries (Bohling and Waits 2015, p. 115).
- Red wolves will displace both hybrids and coyotes, but coyotes and hybrids do not displace red wolves from a breeding pair (Gese and Terletzky 2015, p. 18).
    - In general, wolves will kill smaller canids like coyotes that invade the pack's territory, however, when other potential wolf mates are scarce wolves will interbreed with coyotes (Mech and Boitani 2003, p. 28).
    - Red wolves will choose the larger canid (wolf) over a coyote and will only resort to hybridization when numbers reach a critically low level and to avoid inbreeding (citation).
- Red wolves favor secondary roads and limited human presence to a greater extant than coyotes
- Most studies of territories held by packs indicate a degree of overlap among territories (Mech and Boitani 2003, p. 25) and once a territory is established, a wolf pair strongly resists losing it (Mech and Boitani 2003, p. 30).

Reproduction

- The red wolf is seasonally monestrous (experiencing one breeding season per year) and usually reaches sexual maturity by the second year (Phillips et al 2003, p. 273; Crawford et al. 2001, p. 244).

Litter size

- The average litter size has been reported variably as three to four (Phillips et al. 2003, p. 272; Riley and McBride 1972, p. 9) and five (USFWS, 1989, p. 48) pups per year.

Dispersal

Spatial use

Pack/family groups

- Red wolves normally live in extended family groups or packs, and are territorial and relatively intolerant of conspecifics, like gray wolves (Phillips and Henry 1992, p. 596).
- Typically, packs consist of a breeding pair, which are dominant, and their offspring from prior years (Crawford et al. 2001, p. 244; Phillips et al. 2003, p. 279).
    - Dispersal usually occurs around two years of age and is not sex-biased (Phillips et al. 2003, p. 279).
- Red wolves may hunt individually or in pairs, but not typically in packs like gray wolves. This is due to the smaller size of prey (Riley and McBride 1972, p. 9; Morse, pers. comm. 2017).
    - It is possible that hunting behavior may have been different historically when larger prey, such as eastern elk and woodland buffalo were present in southeastern U.S. (Morse, pers. comm. 2017).
- Conversely, coyotes are often more asocial; animals belong to breeding pairs or small family groups, home ranges of groups often show considerable overlap.
    - Pups often disperse before second summer
    - Intraspecific aggression is not thought to be an important source of mortality (Phillips and Henry 1992, pp 596-597).

Threat behavior

- Trapped red wolves are more aggressive than trapped coyotes or gray wolves (Riley and McBride 1972, p. 8).

Howling

- Howling pays a role in both territorial advertising and group cohesion. Thought to mediate much of canid social behavior like maintaining dominance relationships (Kershenbaum et al. 2016, p. 149).
- Early description in Riley and McBride (1972, p. 7) indicates it is similar to coyote; harmony more controlled and deliberate than coyotes, but not blended as well as vocalizations of gray wolves.
- Red wolf found to have a species-specific pattern of howl type usage and could be identified using howl type histograms (25% correct; coyote 50% correct) (Kershenbaum et al. 2016, pp. 152, 154).
    - Coyote and red wolf howl type usage differs significantly, but red wolf howling was similar to eastern timber wolves (Kershenbaum et al. 2016, p. 154).
- Red wolves and coyotes share their most common howl type (type 3), but red wolves will often use howl type 6, which coyotes and timber wolves almost never use (Kershenbaum et al. 2016, p. 154).
    - Intermediate nature of howl type 6 may provide potential evidence of hybridization (Kershenbaum et al. 2016, p. 155)

Genetics

Very few of the reviewed (genetic) studies were designed to address taxonomic questions (Chambers et al. 2012, p. 3).

Studies that support species status

- Ferrell et al. (1980, p. 47) found an allele only known in red wolves
- Genetic data supports a close relationship between eastern and red wolf, but do not support that they are the same species; more likely that they evolved independently from different lineages of a common ancestor with coyotes (Chambers et al. 2012, p. 1; Abstract).
- Red wolves possess wolf-derived nuclear DNA that produces a wolf-like rather that a hybrid-like organism; thus is seems red wolf is a valid taxon or at the very least a subspecies of gray wolf (Phillips and Henry 1992, p. 597).
- *C. l. lycaon* and *C. rufus* have genetic sequences similarly divergent from those of *C. latrans* and distinct from those of other *C. lupus* (Nowak 2003, p. 253).
    - One interpretation is that *lycaon* and *rufus* compose a separate species that is more closely related to *C. latrans* than to *C. lupus* (Wilson et al. 2000 IN Nowak 2003, p. 253).
- The molecular case for uniting *rufus* and Algonquin *lycaon* in a species separate from C. lupus, based on their readiness to hybridize with C. latrans, seems compelling (Nowak 2009, p. 241).

Studies that support subspecies status

- Red wolves possess wolf-derived nuclear DNA that produces a wolf-like rather that a hybrid-like organism; thus is seems red wolf is a valid taxon or at the very least a subspecies of gray wolf (Phillips and Henry 1992, p. 597).
- Lawrence and Bossert (1967, p. 228) thought that separation of C. rufus as a distinct species rested too heavily on small red wolves of central TX, where hybridization with coyote may have been a factor. Separation of C. rufus from C. lupus would have been unlikely if study of wolves in south had been based on adequate series of specimens from FL (Nowak 1979, p. 25).
    - Found *C. lupus lycaon* and *C. rufus* to overlap with *C. lupus*, but to be distinct from each other (p. 25).
    - "It now appears that the early populations described as Canis niger [=C. rufus floridanus] and n. gregoryi [=C. rufus gregoryi] from southeastern wooded regions, east of the range of Canis latrans, are a local form of C. lupus (Lawrence and Bossert 1967, p. 229 in Paradiso and Nowak 1971, p. 1).

Studies that support hybrid status

- Wayne and Jenks (1991, p. 566) proposed the red wolf is a coyote-gray wolf hybrid based on red wolf genotypes falling within both coyote and gray wolf genotypes.

    - Captive mtDNA genotypes are indistinguishable from that found in Louisiana coyotes (Wayne and Jenks 1991, p. 566).
    - Lack of discernable red wolf genotype may be due to:
        - Sample failed to include wolves with unique genotypes
        - 3 centuries of human settlement gave rise to gray wolf – coyote zone at least as large as red wolf range (Wayne and Jenks 1991, p. X; Wayne 1995, p. 9).
- Roy et al. (1994, p. 565) hypothesize that the red wolf phenotype may represent a phenotype resulting from several-hundred-year period of hybridization between coyote and gray wolf in south-central U.S., which began with arrival of settlers circa 1700. Results of their microsatellite analysis is consistent with this theory of origin (p. 565)
- Roy et al. (1996, p. 1414) used historic specimens (pre1940) (skins) and analyzed mtDNA and microsatellites – no unique mtDNA genotype or microsatellite alleles (pp. 1417, 1420; Wayne 1995, p. 10).
- Reich et al. (1999, p. 143), based on microsatellite allele length distributions estimate that hybridization originated less than 12,800 years ago, likely within 2,500 years ago – lends support to the hypothesis of a recent hybridization between coyotes and gray wolves associated with extensive agricultural cultivation by European settlers around 250 years ago.
- Von Holdt et al. (2011, p. 8) found that red wolves appear to have an admixed ancestry with 75-80% of their genomes attributed to coyotes and the remainder to gray wolves
    - Von Holdt et al. (2011, p. 8) estimate admixture initiated 144 generations (287-430 years ago), placing it approximately in a period when the Southeast U.S. was being converted and predators were intensely hunted.
- Von Holdt et al. (2016, pp.7, 8) results suggest a surprisingly recent and admixed history of North American canids from the Great Lakes and southeastern regions of the U.S.
    - Found little evidence of distinct genomic elements in red wolves that would support separate evolutionary legacies (p. 8).
    - Uniformly low values of uniqueness among all admixed samples are not consistent with the presence of a distinct wolf-like canid in south (p. 8).

Is it a listable entity under the ESA?

- Not a "species"/Hybrid
- Species (*Canis rufus*)
    - 1 of 3 subspecies
        - *C. rufus floridanus*
        - *C. r. gregoryi*
        - *C. r. rufus*
- Conspecific with eastern wolf (*C. lycaon*)
- Subspecies of gray wolf (*C. lupus rufus*)

Red Wolf Meeting Discussion Outline
Southeast Regional Office
30 August 2017

I. Introductions

II. Overview of the PrOACT cycle and roles & responsibilities in the process (Angela)
   a. Normative decision making
   b. Roles in the process

III. Problem Framing Exercise for DMs (Facilitated by Angela)
   a. ID decision-makers
   b. Problem statement
   c. Temporal extent
   d. ID stakeholders & implementers
   e. Decision type

IV. What is a "species"? (Emily)
   a. ESA definition
      i. FWS Regulations
      ii. FWS Director's Memo
   b. "Species" in the Literature
      i. Species concepts
      ii. The species problem
      iii. Potential resolution
   c. "Species" in FWS findings/rules (examples)
      i. What has FWS done/used before
   d. Summary
   e. Discussion

V. Risk Problems (Angela)
   a. Example species

VI. Types of evidence used to diagnose a species or subspecies entity (Emily & Mike)
   a. Morphology
   b. Phenotype
   c. Ecology
      i. Diet
      ii. Habitat preference
      iii. Territory size
   d. Behavior
      i. Reproduction
         1. Defense/exclusion
         2. Litter size
         3. Dispersal
      ii. Social behavior
         1. Pack/Family groups

2. Howling

e. Genetics
   i. Ancient hybrid theory (AKA: Pre-Columbian Hypothesis
   ii. Recent (=1970s to current) hybrid theory
   iii. Distinct Origin Theory

VII. Objective ID & Measurable Criteria (facilitated discussion)
   a. ID objectives
   b. Structure objectives
   c. Measurable criteria for objectives

VIII. Alternatives: Potential taxonomic classifications (facilitated discussion)
   a. Discussion of potential classifications
      i. Not a species
      ii. Species (*Canis rufus*)
      iii. 1 of 3 subspecies
         1. *C. rufus floridanus*
         2. *C. r. gregoryi*
         3. *C. r. rufus*
      iv. Conspecific with eastern wolf (*C. lycaon*)
      v. Subspecies of gray wolf (*C. lupus rufus*)

IX. Consequence Evaluation using SMART Tradeoff Method
   a. Normalize all attributes
   b. Assign weights to each attribute
   c. Calculate weighted sum of scores for each alternative
   d. Identify alternative with highest weighted score
   e. Evaluate the results for insights and sensitivity

X. Recommendation Discussion
   a. Consider risk: assess expected utility of decision

Red Wolf Taxonomy Meeting
Southeast Region Office
August 30, 2018
8:00 am – 5:30 pm EDT

Welcome and Introductions
Handouts and packet items include agenda, summaries for different sections, discussion topics, and figures/tables for reference.

Overview of agenda by Angela Romito; see Red Wolf Meeting Discussion Outline.

Participants: Bill Uilhein (ARD Science Apps); Pete Benjamin (ES NCFO); Michael Morris (Red Wolf Program Biologist); Joe Madison (Red Wolf Program Biologist); Aaron Valenta (Chief DRR ES); Dave Scott (FWS Science Executive Officer); Leo Miranda (ARD ES); Nathan Whelan (FWS Regional Geneticist); Angela Romito (ES DDS); Nicole Rankin (ES DCC); Erin Rivenbark (ES DDS); Michelle Everson (Area Supervisor ES); Emily Weller (Regional Red Wolf Recovery Lead); Roy Hewitt (Regional Web Developer); Jeff Fleming (ARD External Affairs); Kristen Peters (EA Congressional Affairs); Phil Kloer (EA Public Affairs); Daffny Pitchford (Area 3 Supervisor Refuges), Jack Arnold (DARD ES)

Overview of PrOACT cycle and roles & responsibilities in the process by Angela Romito

- See presentation
- Decision science can help with natural resource decisions. Prescriptive decision theory was formed. In natural resource world, this is called structured decision making. Process for dividing a complex problem into smaller parts to focus separately.
- Structured decision process can work to reduce and clarify important uncertainties to arrive at a recommendation.
- PrOACT – defining the problem; objectives; alternatives; consequences (models); trade-offs and optimization → then decide and take action
- Problem Definition – develop a decision statement to help determine which objectives are relevant and which alternatives to consider
    - Construct Your Decision By – see slide for equation
    - Classes of decision problems (need to be able to recognize these classes problems to help structure the problem and identify tools for resolving)
        1. Prediction Problems
        2. Multiple Objective Problems
        3. Portfolio Problems
        4. Risk Problems
        5. Information Problems
        6. Dynamic Problems
- Determining Objectives – objectives are not target
    - Target is a desired level of performance towards an objective
    - 2 Main Objectives: fundamental objective and means objective

    - Develop measurable attributes – content, preferred direction of the measured content (e.g. number of morphological characteristics relevant to red wolf), aspiration
    - Attributes can be used to predict how a given decision will lead to measurable objective outcomes
- Alternatives should be value-focused and within the scope of the problem
    - Complete and comparable, fully specified, internally coherent, distinct
    - These are not evaluated until Consequences step of PrOACT
- Consequences and Tradeoffs
    - Even though there is an optimal decision with numbers next to it, there is uncertainty around these decisions and the role of the decision maker is to make the decision not for the model to make the decision
    - Consequence analysis is a scientific endeavor; objective process but is embedded in a value-laden decision context
    - Models link actions to outcomes that are relevant to the objectives
    - We will be using a SMART Table to resolve the multiple objective problems and a decision tree to evaluate risk.
    - Multiple objectives problems can be complicated due to stakeholder values, competing objectives, evaluating trade-offs
    - Risk problems can be complicated because the decision must be made in the face of uncertainty
- **Questions**:
    - Aaron Valenta: Slide 30: outcomes and anticipated results of decision making: 1) is it a species as defined under ESA, 2) is it not a species as defined under ESA, 3) is it a subspecies?
    - Angela : Examples may include: we want to stick to the law and scientific evidence. Maximizing evidence for the species as a fundamental objective: Attributes would be genetic traits.
    - Bill Uihlein – there is no certainty in the 3 outcomes, correct? It is a species under the Act with a certain amount of certainty. Do we evaluate the risk of each outcome?
    - Angela Romito: We evaluate the consequences first and then we can evaluate risk about making the wrong decision. Ultimately what drives this is the risk tolerance of the decision maker.
    - Leo Miranda – main thing is: is it a species or not? In terms of evaluating the consequences, we are evaluating based on amount of uncertainty and risk.
    - Angela: Consequence evaluation is purely about science. Is it a subspecies? For example, number of morphological characteristics that are consistent with red wolf. Then we can add all these up to determine if this is a space's or subspecies. Then we can do (or do not) have to a risk evaluation. We will estimate the expected value of a one decision over another. Competing objectives might be the morphological and genetic objectives are competing
- Roles and Responsibilities: Angela is the decision coach; Technical experts are here to provide expert evidence and not sway decisions one way or another; Decision Makers are Bill, Leo, and Aaron and are held accountable for the decision.

Problem Framing Exercise facilitated by Angela Romito

Aaron Valenta - We are trying to define under the ESA whether the red wolf is a listable entity.
Leo Miranda - I would reframe to instead of a listable species, I would say is it a species or subspecies as defined under the ESA.
Angela – why do we want to determine red wolf is a species or subspecies under the ESA
Aaron – because we have congressional mandate to conserve threatened and endangered species under the ESA
Bill – to know whether or not to pursue legal requirements.
Angela – to achieve legal compliance
Emily – isn't also about whether or not to invest resources
Aaron – this would follow the legal component
Leo – Under the law, is this a species or subspecies (follow the law) and the second is based on law, we as an agency need to decide how much resources to put towards
Bill – will that happen today?
Leo – No that will come later. Using the science today, we will make a decision
Bill – Legal compliance doesn't quite fit. This triggers a legal process. Right now, we are deciding whether or not
Aaron/Leo – if is meets the definition the species or subspecies under the ESA
Jack – I'm wondering if the why is to determine whether continued listing of the red wolf is appropriate.
Aaron – that is where I started. But I went to whether or not it is a species or subspecies under ESA
Emily – the validity has been questioned multiple times
Leo – I can get my head around it because it is more operational.
Bill – Consequence of the decision by framing the problem exercise is very clear. Once the decision is made today, what is the next step? The decision is made?
Leo – this is a recommendation and not final decision
Bill – so this should be to "recommend"
Leo – yes this should be "recommend" not "determine"
Michelle – going back to species, subspecies, listable entity. Should we be thinking about DPS?
Leo – before we get to DPS, we need to decide is it a species or subspecies first. Then we go decide DPS.
Pete – if we decide it is a species or subspecies, the next thing is whether it is appropriate listed?
Leo – I don't think we will be able to tackle the DPS question today
Aaron – the term species under act captures DPSes.
Leo – if it is not a species or subspecies
Angela – what – is it a species or subspecies? Why – is it a listable entity?
Leo – decision today: if this changes to a different listable entity after recommendation today, then we would have to do a rule but that decision would come later.
Michelle – we are all here to inform the process so should the names be listed?
Leo – keep the decision makers name there.
Bill – can we change "to determine" to "to inform"
Leo – we are making a recommendation. That is the task at hand today. That decision on the recommendation will inform the Service if this is a listable entity or not.
Angela – are there any legal or policy constraints we will consider when making the decision?
Leo – The legal definition of a species. We do have policies on how we treat hybrids and species.
Bill – that is way to think about it. We do have some policies

Leo – scientific integrity
Angela – when thinking about its spatial extent, how are we thinking about the range?
Aaron – I don't think it is necessary.
Leo – it is a range-wide decision.
Michelle – this should be historic range.
Leo – it is the impact of the decision will be out the historical range.
Pete – may want to add best available scientific information
Angela – we will put best available information
Pete – if we recommend it is a subspecies. If the subspecies is extant from part of the historical range here, how do we deal with that in the context of this decision?
Leo – today, we can recommend species or subspecies. And then later, we can decide about the listable entity and range.
Bill – how are we making a decision?
Leo – try for consensus. If we cannot reach consensus, then the recommenders will vote.

Statement: We (Aaron, Bill, and Leo) will recommend whether or not red wolf is a species or subspecies as defined in the ESA to inform the Service if it's a listable entity considering the relevant policy, best available information, and given irreducible scientific uncertainty
Time: Today
Spatial Extent: Throughout the historical range of the red wolf

What is a "species" by Emily Weller

- See presentation
- ESA Definition for species is "XXX"
- Can include any taxonomically defined species, subspecies, or any DPSes of any vertebrate species as per our DPS Policy
- 50 CFR 424.11
- Director's Memo on taxonomy and the ESA (November 25, 1992)
- Question: Bill – we can think about removing subspecies from our problem statement because species under the ESA includes any taxonomically defined subspecies
- Species Problem:
    - Biologists in different fields have different ideas of what a species is.
    - There are 22 species concepts
    - Concepts are incompatible and lead to different/inaccurate conclusions on boundaries and numbers of species
    - Historically mammologists followed the biological species concept; before 1985 most used morphological analyses (before DNA data sets). Recent trend in mammology to use phylogenetic species concept
    - Biological species concepts versus phylogenetic species concept
    - Question: Aaron – can you define phylogenetic species concept?
    - Emily – Yes – see handout for definition.
- Resolution to species problem
    - 2 integrated frameworks have been proposed: hierarchy of species concepts (Mayden 1997) and unified species concept (de Quierzo 1998, 1999, 2005, 2007)
    - See presentation for similarities and differences of two frameworks
    - Namoi 2011 – Revised integrated framework

    - Chambers et al. 2012 was used by Service to make taxonomic call on gray wolves
        - Identifies species as separate lineage supported by data from various classes of genetic markers, morphometric analysis, behavior, and ecology
- Taxonomically defined species in FWS findings/rules
    - Multi-discipline approach has been used when defining something as a species or subspecies.
    - Most examples used are for subspecies
    - Dusky/Red Tree Vole (2011 76 FR 63726) – subspecies must be discernable (i.e. diagnosable), not merely exhibit mean differences. Determined it was not a ssp.
    - Preble's Meadow Jumping Mouse (2013) – conflicting studies on validity of PMJM as a valid ssp. Found to be a valid ssp. Based on DNA
    - Coastal CA gnatcatcher (2016) – followed a more operational approach, evaluate, and consider all available types of data that may inform taxonomy such as ecology, morphology, genetics and behavior. Confirmed the CCG is a valid ssp and recognized as a distinguishable entity.
    - Hualapai Mexican vole (2017) – mainly relied on genetics information and determined it was not a valid ssp.
    - None of these examples reference the integrated species concepts papers
    - All examples do state the importance of using multiple lines of evidence/types of data.
- Questions:
    - Bill – based on information read and presentation, are we looking at our problem statement (decision statement). Is it relevant to be more explicit about whether the red wolf is a species or if the captive populations are a separate species?
    - Aaron – from my review, there is a strong correlation of what we have today represents what was there 100 years ago
    - Bill – the uncertainty from what I read, is that there is not a lot of material to come to that conclusion in terms of the preservation of canids. It is the uncertainty of what
    - Pete – think this does matter. Was there ever a unique southeastern wolf different from gray wolves and coyotes? Is the thing that exists today the same historically or similar to that? We need to consider time in our definition. Issue of time is important: did it ever exist? Does it exist today? And it is forward looking – given intergression with coyotes, is there a point where the red wolf does not exist? Framing needs to be able to encompass all that information
    - Leo – in terms of lack of consensus of what we have now is how we define the red wolf. Some papers mention that we were too late in rescuing the 14 founders and there is debate.
    - Aaron – there is museum samples and papers that say these samples are similar to the modern individuals.
    - Erin – morphometrically, they are pretty solid. 90% of the heterozygosity in the entity left.
    - Emily – second summary handout has information about what was on the landscape. In general, the information states the entity is the same. It appears that what we have today is what we had then.
    - Aaron – the occurrence of high levels of variability of pre1914 red wolves – current founders is an accurate representation of the historical entity

- Emily – in the summaries. Our founders are representative of the historical entity and captive animals are morphologically and genetically similar to historical entity.
- Emily – as far as your time line (Pete), does this need to happen within a certain period?
- Pete – this is part of the historical controversy. The discussion should include was there ever a listable entity? And link to this is what we have today. There are values
- Bill – I don't' think we should be making a decision about whether there was ever a red wolf? Needs to be now and that includes the last 100 plus years.
- Angela – I'm going to add this to our temporal extent. Recommendation involves "current red wolves."
- Bill – what we have now is contemporary museum specimens, captive bred, experimental wild.
- Leo – what we know is what we have now is same as museum specimens. The current wolves that is good representatives of what was in the museum specimens. 12 founders still represent of what we know existed historically.
- Angela – Recommendation involves "current living red wolves" which represent what existed historically.
- Emily – what criteria are we using to define how red wolf fit under the ESA definition of a "species?
- Leo – genetics, morphology, etc.
- Question: Nathan – are we discussing what types of info we are going to use what information to use to inform whether it is a species under ESA? Or are we discussing which biological species concept are we going use?
- Angela and Emily – biological species concept
- Nathan – if we explicitly state we are going to use a certain BSC, then there are certain criteria to use to apply it operationally. We are going to use an evolutionary species concept, it will cover all the bases and allows us some flexibility.
- Emily – I agree and we just need to decide that

Further Discussion facilitated by Angela Romito

Angela – This is about decision framing. We need to know the definition of a species before we can dive into the rest of it. So we need to decide what definition of a species that we are going to use. Or do we not know and need to broaden our scope

Bill – what I heard. We are going to use definition of species under ESA and then define the criteria

Nathan – evolutionary species concept is not an operational species concept. It is a theoretically species concept. Any distinct lineage is a distinct species. Allows us to incorporate different lines of evidence. You can't use morphological data in a genetics species concept

Leo – Did all the examples that Emily presented use an evolutionary species concept?

Emily – they don't state that but they incorporate different lines of data

Leo – we have rules as recently published as June 2017 that operationally used all the lines of evidence and made the decision in a nice narrative. If that way – we are considering relevant policy and consistent with what has been done recently.

Bill- I don't think the evolutionary species concept is theoretically in itself. I don't want to approach this from a theoretical standpoint. It is the next up from a biological species concept.

Nathan – correct. It doesn't explicitly state as an evolutionary lineage. Evolutionary species concept is within the Maden publication.

Dave Scott - This is consistent with the scientific integrity policy.
Leo – this also helps with APA.
Angela – We chose to use an evolutionary species concept (ESP) to allow for the inclusion of all available scientific evidence to determine what defines a distinct lineage of red wolves. The ESP is consistent with recent policy (i.e. scientific integrity, recent listing decisions).
Michelle – concerned about flexibility of selection. We are supposed to inclusive
Dave – Correct inclusive of best available science.
Angela – fixed to have inclusion
Dave – Policy states consider all lines of evidence but some can discounted and this must be documented.
Aaron – we have morphometrics, behavior, phenotype, genetic, ecological
Angela – selecting ESP we are being consistent with recent policy and in terms of choosing criteria allow us to use all lines of evidence to help us determine red wolf species.
Michelle – distinct lineage of red wolves should be changed to determine if red wolf is a species under the ESA.
Angela – Changed to: We chose to use an evolutionary species concept (ESP) to allow for the consideration of all available scientific evidence to determine if red wolf is a species under the ESA. The ESP is consistent with recent policy (i.e. scientific integrity, recent listing decisions).
Leo – Think it will be best to include evolutionary species concept so we are transparent.
Angela – and this is not inconsistent with all lines of evidence
Bill – do we need any modifiers in front of evidence (e.g. all evidence, best available evidence)?
Leo – according to ESA… best available commercial and scientific. Perhaps add consideration of all "relevant" lines
Aaron – after further researching evolutionary species concept, I agree with including this.
Pete – phylogenetic species concepts are very similar and nested under ESP. Maybe a subspecies of ESP
Nathan – yes and you could say the BSC is a subset. ESP is recognized by the vast majority of people in the taxonomy field.
Dave – if evidence is relevant, then you consider and can dismiss based on a relevant argument. If you don't consider it, then you are at risk of violating policy.

Risk Problems by Angela Romito

- See presentation
- 50-50 is complete uncertainty
- Utilities will be scored by each decision maker. Risk attitude and approach to risk are reflected in the utility score.
- Summary: there is a challenge of irreducible uncertainty. Analytically we express uncertainty with probability by evaluating alternatives using expected value.
- Bill: how do the three types (linguistic, aleatory, epistemic) of uncertainty relate to this?
- Angela: Aleatory is irreducible. We have epistemic uncertainty.

Types of Evidence Used to Diagnose a Species or Subspecies Entity by Emily Weller and Mike Morris

- See presentation by Mike Morris
- Aaron - Are morphology and phenotype the same thing? Emily - I have morphology as skull size and phenotype as coloring

- 1972 survey from out of LA: stress that red wolf is strikingly different animal from the coyote. Massive chests, powerful shoulders, long bodies, long legs, long ears and more importantly the skulls. They have a big blocky head. Coyotes have finer skulls. In addition to unique external features, the morphology of brain skull differs from other canids.
- Diet
    - Red wolves eat deer year-round; raccoons; nutria; rabbits; pigs; rodents
    - Coyotes eat deer (winter/spring); rabbits; rodents; fruit; vegetables; rodents; seeds; fawn deer –
        - Leo – read a paper recently that mentioned they eat deer year-round
        - Mike – that is the exception
        - Erin – there are studies that show with one of the problems and hunter problems with coyotes and the coyotes are taking larger numbers of fawns and controlling reproductive
    - Grey wolves eat large ungulates (deer, moose, elk, musk ox, bison) and sometime extensive use of medium-sized mammals
    - Nathan – do you see a lot of fly larvae in red or gray wolves? Mike – no mainly in coyotes. Also not a lot of birds. They are opportunistic. Coyotes – 90% of the scats during certain times of the year had fly larvae.
    - Leo – is fly larvae because they ate it? Mike – it is because the coyotes eat carrion (dead fly larvae) and find it in the scat
    - Michelle – on NY state page and studies related to coyotes and deer, they radio-collared and then looked at what they are eating. Only 8% of adult deer were conclusively were killed by coyotes while 92% were only scavenged by coyotes.
    - Erin – overall impact of adult deer by coyotes is very low (recent paper from work conducted SRS).
- Pack Structure
    - Difference in packs and animals that pack up
    - Coyotes predominately live as single animals or pairs, but even in groups, the group size is small (3-4) and territory is small (10-15 km). They are known to pack up with wild dogs but they don't have a defined territory that they defend.
    - Pack is defined as animals and normally an extended family group that stake out a territory and defend it.
    - Red wolves have a pack size of 6-8/10 and territory of 40 to 200 km. They will have a larger territory when prey base is reduced Once you have a pair of wolves, then they will have a litter resulting in a pack size of 6-8. Like gray wolves, the pack size can be big but this to hunt larger prey. With red wolves, it is hard to observe pack hunting of large game. The habitat is so dense it is hard to observe. There is uncertainty if they hunt in packs.
    - Gray wolves have a pack size of 5-8 (9-13) and territory size of 116-300 km.
    - Mike: Wolves will stake out an area for territory and this doesn't change.
    - Leo – red wolf packs are family clusters. Based on gray wolves, these can be unrelated animals joining forces. Mike – yes. This is something that we have looked for. For a red wolf to accept a non-family member into the pack, and we haven't seen it. Once the young get sexually mature, the young have to leave the pack. Once we started using GPS collars on wolves, we learned that these young animals are leaving dozens of times before they disperse for good.

    - Bill – how is the pack-like structure for coyotes?
    - Erin/Mike – highly variable. Most of the pups leave before they are 10 months old and breeding that 1st year. Red wolves need to be 2-3 in order to breed. One study in the 80s that said up to 85% was transient.
    - Leo – read a paper that stated they are similar to red wolves and has familial packs. In urban areas though the coyotes are accepting non-familial members.
    - Erin –some of the hybrids are being accepted and highly adaptive
    - Mike – in urbanization, coyotes in large groups are necessarily hunting together but they are feeding together. They are very social animals.
    - Erin – newer Hinton paper from 2017. Red wolves consistently use deer throughout the year and rabbits seasonably. For more info – see the paper.
    - Leo – from the paper I read: when you have a 60-70 lb. coyote, they can take down a buck.
    - Mike – what we call a coyote genetically, there are mixed. Come are coy-dogs or coy-wolf-dogs. A western coyote is not a big animal. But as they move east, it has been documented the size is getting bigger (morphologically) and behaviorally different.
- Dispersal
    - Coyote pups disperse around 9-10 months of age
    - Red wolves disperse around 1.5 years. Males become reproductive around 2 years of age. Females typically become reproductive in captivity and wild around 3 years of age.
    - Gray wolves disperse as yearlings.
    - Erin – this drives recovery too when thinking about hunting. Coyotes disperse earlier in life and can recover from mortality faster. Mike – wolves cannot recover from the same kind of take that coyotes can.
    - Leo – putting dispersal together with pack behavior, since they tend to spend more time together since they are family members.
    - Mike - Gray wolf packs – not all members are equal. That is one of the things we were worried about when we starting putting captive pups into the wild packs. They are accepted and don't disperse earlier.
- Displacement
    - We know that gray wolves will kill coyotes. We know that red wolves will kill other red wolves.
    - Interference competition with gray wolves is an important factor influencing distribution and abundance of coyotes
    - Competition with gray wolves limits coyote's populations. Wolves responsible for 56% transient coyote deaths after introduction into YNP. Dispersal rates of transient coyotes 117% higher in wolf areas versus areas w/o wolves.
    - Red wolves displaced 37 or killing 14 coyotes in NC NEP between the time periods of 1999-2013. No coyote or hybrid ever displaced a red wolf. Only red wolves displaced other red wolves and killing other red wolves.
    - Bill does the 51 placeholders reference coyotes or wolves?
    - Mike – these are radio-collared and sterilized coyotes.
    - Leo – natural mortalities are generally rare and meaning wolf did not kill coyotes. This is Mori 2014. What is the study area (Mike)? Recovery area

- Pete – I believe it is talking about something different and it might be in a different. I think they stated that the wolves would exclude coyotes and displacement and unidirectional but wolves were able to extirpate coyotes from their area. The pressure of wolves on the coyotes doesn't put any additional pressure on the coyote population.
- Erin – all displacement was unidirectional based on Gese and Terletzky 2015. Number of coyotes harvested in 2010-2011 was 11,000. In 2016, it is 45,000 harvested annually. Hinten paper the function of transients in the wolf population to exclude coyotes from territory. One of the primary functions of having transients move between territories
- Pete – Maury 2015 – used actual peer reviewed data up until 2007. We wouldn't agree to reasonable terms of use for data from 2007-2013 and he tried to recreate the dataset from preliminary data and failed to note that in the paper. We see these trends up to 2007 but we don't see them beyond that and that is because the data is bad.
- Leo – this is published and peer-reviewed by one of our partners regardless of the validity.
- Pete – this is a good point about all published literature. Need to look at and understand the data that was used.

- Density
  - Coyote density fluctuates with prey density. 1/0.45 km in YNP and 1/0.65-1/5.2 km
  - Red wolves density is 1/21 km.
  - Gray wolves density is 1/18km to 1/26km.
  - Bill – are any of the coyote and wolf density studies performed in the same areas?
  - Mike/Erin –
  - 78% of observations of coyotes were lone animals. 17% in pairs and less than 6% were of more than 2 coyotes.
  - Coyote abundance is limited by competition with wolves and removing wolves contributes to high densities in coyotes.
  - Jay Bayers' studying pronghorn and the fawn mortality by coyotes was high.
  - Bill – all of these studies are based our non-essential experimental population of wolves?
    - All of them except for some of the diet work

Thinking about Measurable Criteria, Objectives, Characteristics facilitated by Angela Romito
Unique to red wolves
Gray wolf-like
Coyote-like

Level of likelihood of eastern population of canid. We know that gray wolf is a species and that coyote is a species. Whether or not red wolf is a species is whether it is separate from a gray wolf and coyote.

Angela: what level do you want to use? Leo – I was making notes based on coarser level for measurable objectives.

Angela: We are using a scale of 0 to 100. 100 means that it is most unique to each entity. 0 is least unique. The numbers don't have to equal to 1.00.
Leo – for example, coyotes like to eat small things are therefore very unique compared to gray wolves which eat larger things.
Bill – this makes a point at how the diet of coyote is unique and how the gray wolf is unique. It has to relevant to each other.
Leo – The number is percent of overlap.
Erin – coyotes did not occupy the east based on current assessment. If you are talking about habitat use, now the coyote is occupying unique habitats. But if you compare entities, are we referring to historic coyote or coyote that has moved in and occupy the area
Aaron – even if you discount the eastern entity, the coyote is getting bigger as it moves east and taking down different prey than it historically ever did take down.
Nathan – this is not how people do taxonomy. This seems very amorphous and trying to put arbitrary numbers on it. If I was a referrer on a systematics paper, I would have a lot of questions and I would have comments stating that this is not how we define a species in this context.
Angela – I came up with this uniqueness of traits: can you think of an alternate way that is constructed that we can use/score by the end of the day?
Nathan – the score would be the phylogeny using genetic, morphometrics, diet. There are these many traits supporting these species and added up characters shared among the traits and some only along the terminal lineage.
Leo – Notes I captured: diet very similar to coyote however red wolf tend to catch larger prey like deer. There is some differences and they overlap a certain amount. There is some features that are unique to it. Dispersal for red wolf is a little different than gray wolf and coyote and makes sense because of family packs, and I wasn't putting values but this is how my thought process is working.
Bill – scientific evidence has not revealed the distinction. We are not trying to get a quantitative approach. We are not trying to give that perception. We are trying to take the characteristics in front of us and make a transparent decision. Can we experiment with the experts? One where there is no overlap and another where there is overlap on an end of the spectrum. There are similarities of coyote/red wolf on one end of the spectrum and similarities of red wolf/gray wolf on the other end of the spectrum.
Erin – I think that Nathan is stating there is something else.
Nathan – based on genetics paper, if you are trying to say whether this is species or not, then a taxonomists would generate a phylogenetic tree.
Leo – this is not a scientific paper decision. This is a policy decision about whether the red wolf is defined as a species under the ESA.
Pete – if we are not doing what Nathan stated but we are making a policy determination, then we are doing something different from that. If the decision, that it is or it isn't. What are we doing that is different that is different from what taxonomists would do that would explain why we are using a different method?
Leo – Read the problem statement defined.
Erin – do you think what we are doing is consistent with evolutionary species concept?
Nathan – there is not an example of an evolutionary species concept using this type of scoring method.

Emily – this doesn't seem like a math problem. If I was writing a rule and figure out if it was a species, you have the information in front of you and then it may come down to theories of origin. And think it is a "yes or no" about is it morphology different, etc.
Leo – is it the numbers that you are having an issue with or the line of evidence?
Bill – we aren't going to use the evolutionary species concept. We are using a framework. Is there a way to arrive at my opinion based on this that uses a structured approach (not necessarily rigorous) that when looking at 20 or so characteristics, I can roll it up to help inform my decision.
Emily – I'm looking at what the Service did the gnatcatcher and the vole, they used that this had this characteristics and it had that characteristic to make their determination.
Bill – there are certain weights on the lines of evidence and you have a value to help make it more transparent
Leo – can we use an approach similar to listing recommendation meetings where each of the decision makers will follow a structured approach and write justifications for each of those and then have a confidence value associated with that?
Angela – this would be an alternate round to go and we wouldn't be considering the criteria individually. It would be Species/Not a Species and multiple rounds of scoring anonymously.
Emily – in writing this up, there needs to be a justification for this score.
Angela – yes they can write the justification for each score. I would definitely suggest that we do the risk exercise as well.
Michelle – what if instead of doing percentages? Does this characteristic tell us this is a unique entity. I'm worried about doing wolf-like, coyote-like characteristics.
Leo – I propose that we finish up the scientific information, and we then do similar to what we do for listing and answer the question does the red wolf meeting the definition of species under the ESA and have at least two rounds. I think that will get us to where we need to get. We need to make sure there is very detailed information in the justification.
Pete – will need to make sure that the beginning of the write up is consistent with recent rules.
Leo – using the director's memo to help write the FR justification.

Types of Evidence Used to Diagnose a Species or Subspecies Entity by Emily Weller
See presentation

- Litter Size
    - Litter size is 3-5 for captive stock and wild population for red wolves. Red wolf is under heavy mortality right now, the average litter size is 4.
    - Coyote litter size is 5-7. Where the populations are sparse, it can be 8-9 litter size. When harvest of coyotes results in lower population numbers, then litter size results in larger numbers.
    - Gray wolf litter size average litter size is 6.5 pups (Wildlife monograph).
- Howling
    - Red wolves have a species-specific pattern for howl type. Red wolves will often use howl type 6 which timber wolves and coyotes will never use.
    - Mike - 15 types of howls and they are all real similar. Type 6 howls is common with red wolves and not used by coyotes and eastern timber wolves. Intermediate nature of howl type 6 can suggest hybridization.
- Morphology

- Red wolf has been distinct/distinguishable from coyote and gray wolf (an intermediate position). Some folks will say that intermediate position is because it is a hybrid, but when studies have been done with red wolves, red wolf hybrids form distinct clusters from red wolves.
- Body size measurements of red wolves and coyotes are distinct – consistent
- Leo – can gray wolf and coyote hybridize? Mike – gray wolf and coyotes can hybridize and do not result in red wolves.
- Leo – we used morphology and eliminate real wolves that didn't meet the morphological definition of red wolves, but later we found that some of those wolves were actually red wolves?
- Complete lack of morphological intergradation where two populations approach without physical barriers argues for specific distinction.
- Leo – everyone agrees that in terms of morphology is intermediate between gray wolf and coyote, right? Just the interpretation of what that means differs among researchers. Emily/Mike - correct
- Nathan – if red wolves came to be where hybridization was the way, then we something of hybrid order something its own evolutionary trajectory which is what you would expect to see. Just because it might be of hybrid origin doesn't mean it isn't a unique entity.
- Those that has supported that red wolf is distinct due to intermediate decision, there are multiple studies that agree with Nowak findings.
- Another argument about intermediate position is that red wolf is essentially a gray wolf-coyote hybrid.
- Another argument is red wolf is a subspecies of gray wolf.
- Summary – results of intermediate position based on morphology is consistent but the interpretation of this is different.
- Nathan – I would think it would be almost impossible to distinguish the two based on morphology alone. It would be a lot easier with genetic data. You could have similarities or differences in skull shape could be driven by niche space on evolutionary time scale. Genetics could see hybridization. If morphology is the only thing used, then the risk tolerance goes up and it is not as reliable.
- Emily – red wolf would not be the first species where morphology was used to determine a species.
- Leo – and this happened before. In the 70s, morphology was used as the criteria to determine red wolf. We had 400 animals that we trapped and culled a bunch based on morphological criteria. There were hybrids within the 43 that met the morphological criteria and they didn't breed true and therefore were culled.
- Mike/Pete – there was a morphological standard and from standards that were available. Red wolves met this metrics and defined the standards and range of characteristics to make a red wolf. Given that.. we did not cull red wolves. They culled animals that did not meet that standard.
- Erin – found a 2014 paper found that you can still use morphometric standards to distinguish between coyote and red wolves
- Leo – 1990s we were looking at genetic markers –trying to get to an argument about how reliable morphology is a criterion. Mike Phillips that with good cost

we artificially selected the big dog when we culled the population. Therefore, what we have now is based on the cull and resulting wolves.
    - Michelle - yes
    - Pete – strength of morphology evidence (Brian and SE TX and LA) said these were distinguishable in the field by biologists and private land owners. And it is the same set of things.
    - Bill – need to be careful with any single source of evidence and weigh in on that. What about the museum specimens? Do we have anything
    - Leo – that was the source for the criteria
    - Mike – some of those standards from the 70s, and we want to try and figure out what it is. One of the main measurements we run is shoulder height, and the smallest standards were 68 cm. The wolves today (males adult) are 75-77 cm in the wild are considerable larger animals. When we went to TX and LA, we caught big animals. One of those measurements and might have ¾ of the measurements wouldn't meet the standard, than something wouldn't meet those standards. For the wolves today, all the wolves meet the minimum standards. They culled a lot of animals overtime and ~400 animals was over multiple years.
    - Leo – dead wolves in the SSP are perfectly genetic animal because they look foxy. They are using morphology instead of genetics within the captive population.
    - Mike – I don't think that decision should have been made so quickly, because genetically
    - Aaron – Nathan stated that morphology alone should be not used to determine if something is a species.
    - Nathan – Yes. Morphology should not be ignored. Given the new data and information, other methods should be used in addition to morphology. When you get the morphology form (skull) between gray wolf and coyote, you should not use that alone to determine hybridization.
- Phenotype
    - See presentation
    - Nathan - Generally phenotype is genetically controlled. In some spaces, phenotypes can be environmentally controlled.
- Genetics
    - Most of these studies don't answer a taxonomic question but try to answer an origin question
    - Distinct origin theory – see presentation
    - Leo – what does a unique allele mean?
    - Nathan – 4.4% unique alleles is an arbitrary cutoff. And these papers going back and forth were debating a 1% difference and there was not confidence interval on that. There was a lot of issues with using 4.4% and basing conclusion off of that. In a comparative context, 4.4% alleles is high compared to other species that no one is debating for. We are dealing with genetics – we are dealing with a lot of different kinds of markers. For example, the 1980 paper uses an outdated method. For mitochondrial genomes, you can signatures of hybridization to pop up stronger due to how mitochondrial genes are inherited and therefore could be a

biased story. Any studies after 2010 – are genome slide markers. The two 2016 papers are genome based studies.

- Leo – from 2010 and on, full genome is the way to look at genetics. Top notch technology today. Nathan – yes
- Nathan – they didn't present a confidence interval in the 2016.
- Leo – the counter paper and the counter-counter paper – the peer reviewers did not raise this issue
- Nathan – there is uncertainty in the observed that should have been discussed.
- Ancient hybrid theory – see presentation. I believe there are more studies like von Holdt that support more recent hybridization.
- Nathan – keep in mind that when recent and ancient are discussed, the time frames are different among researchers and we should state what the time period is. Von Holdt 2011 paper uses the whole genome. They have a figure that has principal components analysis of all wolf-like canids for the 48K NSP data set and you can see red wolf is coming out distinct. Figure 4 is somewhat misleading. K clustering – run analysis to figure out what the most likely k is. They should not have reported 2-7. When looking at 9 and 10, the red wolf is biologically distinct with some coyote grouping. There are caveats as is with any analysis, and I wouldn't just use a structure analysis. In this case, it is kind of clear. You can't say anything about migration patterns but you can see clustering of the genome.
- Leo – what can affect the amount of the orange in the figure?
- Nathan – this is genetically grouping these alleles and stating that these alleles are differently than everything else. The width is based on the individuals sequenced and gives you all the SNPs. Genetic structure is pretty distinct with some genetics coyote being mixed in.
- Pete – von Holdt recently stated to us in a meeting that distinctiveness of red wolf doesn't show up until K9.
- Nathan – some people have characterized K as the number of populations. Lower K values are meaningless compared to K7, K8, or K9.
- Michelle – for the sake of the question we get all the time, Chihuahua and great Dane are all showing up as red.
- Nathan – yes.
- Michelle- Because genotypically all breeds are dog are similar although phenotypically they are different.
- Nathan – there is a parameter called delta K and the graphs says the highest likelihood is at K8 and biologically likelihood to K10. Other problem that I have with this paper is that they don't include red wolves in the analysis such as the neighbor tree building analysis.
- Mike – is this paper using the latest way for genetic information?
- Nathan – yes. In figure 1 bottom left, one possible hypothesis is that red wolf is relatively recent split and going off on its own evolutionary trajectory and may still have some transgression which is what is expected in speciation.
- Leo – another one being when we thought we were going to lose the red wolf in the 1960s

- Nathan – Thinking of Alabama sturgeon - morphologically it is very distinct but mitochondrial DNA is identical to pallid sturgeon. It was geographically isolated from MS.
- Pete – One criticism of all the studies is that known of them have done real hypothesis testing to confirm or exclude other origin theory hypotheses.
- Nathan – none of these species have really built a phylogenetic tree. They have been using clustering.
- Recent Hybrid Theory – see presentation. Fossil records don't support that gray wolves occurred in the SE.
- Aaron – von Holdt 2011 found that red wolves appear to have a distinct admixed ancestry with 75-80% of coyotes and remainder to gray wolves. This seems pretty important. Please explain.
- Pete – Rutledge stated that this is only based on two species.
- Nathan – these are biasing their conclusion by saying that the genome is only 1. Gray wolf and 2. Coyote. And ignores everything else in the evolutionary history.
- Leo – are there any published science arguing that point?
- Nathan – There is the response that states this point.
- Aaron – so you are saying, they were only looking at gray wolves and coyotes and didn't look at anything else?
- Nathan – they stated that in the methods.
- Nathan – You have three entities that were sampled at current and then to say that part of the genome was gray wolf and red wolf. You also need to go back and look at ancestor for those things. When looking at a phylogenetic tree, alleles
- Aaron – So red wolf has no unique alleles because it comes form 75% coyote and 25% gray wolf?
- Nathan – right there will be genetic drift resulting in unique alleles. The way they reported the numbers as only coming from gray wolf and coyote is not correct. Need to take account into genetic evolution and any given gene is going to evolve on a different trajectory.
- Aaron – they were very specific that there was no uniqueness to red wolf but they did recognize that Mexican wolf does have unique alleles.
- Nathan – the von Holdt 2011 analyses does not support that.
- Pete – the make the point that Mexican wolves are distinct but the data seem to show that they are no more distinct than red wolves.
- Nathan – figure 3. Mexican wolf has overlap with some gray wolves. Red wolves does not have any overlap in this analysis. In the paper, they are saying the Mexican wolf is more distinct than the red wolf. Figure 2 is a hypothesis of hybridization of a phylogenetic tree.
- Leo – so figure 3 tell us that Red wolf is more closely clustered to coyote than gray wolf.
- Leo – with this methodology, what could affect overlapping or not? The boundary around is what.
- Nathan – red wolf has very little genetic diversity within the species.
- Nathan – When I look at the figures, red wolf seems distinct and if anything more distinct than Mexican wolf. Overall, there seems to be an attempt to get to an answer in the paper.

- Leo – I don't know if you can say there is a contradiction there.
- Aaron – in Figure 3, the data points is factual data within each bubble.
- Pete – in von Holdt 2011 and 2016, there was questions about some of the data that went into there. They assigned an animal from a group that may not necessarily be part of that group.
- Leo – Mexican wolf starts showing up in K5 versus red wolf showing up in K9. What does this mean?
- Michelle – it appears that you get higher resolution as you move up?
- Nathan – Yes but you could also go up until you split into individuals
- Bill – in the caption it speaks to the K7, so why K7?
- Nathan – they ran an analysis that only included Eurasian wolves and North American wolves and for that analysis they used a K7.
- Bill – what about the von Holdt 2016 paper? What are the conclusions and observations?
- Nathan – this is a discussion on the origin of red wolves other than the red wolf is distinct. It seems to state the red wolf is distinct and needs protection under the ESA. I thought were both papers were ok with red wolf being a distinct species.
- Leo – they didn't state distinct species. They stated distinct entity. And stated that FWS should modify the ESA.
- Leo – hybrids are not covered by the ESA.
- Nathan – how do you define a hybrid? Is that a F1 hybrid or a F2000 hybrid?
- Pete – von Holdt 2016 – timeline they produced of all the canids is much more recent than recently thought.
- Nathan – they did not use the best available method (fossil calibration) for dating divergence.
- Leo – The heart of the paper is timing of hybridization?
- Nathan – yes. That was the debate between the von Holt 2016 and XXX 2017 paper.
- Jack – do we have the answer to that?
- Nathan – I would love to do that.
- Nathan – I'm surprised that the recent paper hasn't discussed the bottleneck that has potentially occurred. And this would be the reason for loss of unique alleles.
- Emily – they stated in one of the papers. I believe that they stated the samples may have missed the unique alleles or the unique allele may have been lost.
- Bill – part of it is distinct origin theory or hybrid theory. There is still a lot of uncertainty and evidence suggesting hybridization has occurred at some point. The question becomes is it still a unique species? Do you see enough information on whether this hybrid is a unique species?
- Nathan – given the data I have in front of me- I think it is distinct origin theory. There are still some circles about how you can have hybrids and still have a unique species.
- Bill – what is the hybridization policy officially?
- Leo – Service tried to do a rule about this in the 90s. The only thing we have is the SOL opinion from 1983 which is the FWS policy and that hybrids were not protected under ESA and this will defeat purposes of ESA since hybrids will be entitled to protection of pure breed specimens. Service has taken hybridization in

the past as a threat to the species. So therefore, we cannot extend protections of ESA to hybrid species.
- Pete – I think this opinion is strictly limited to F1 hybrid
- Michelle – and not from species that may have hybrid origin
- Leo – gray wolf and red wolf hybrid that was in a circus, and therefore it was a hybrid
- Nathan – no therefore the courts stated the red wolf is a distinct species
- Erin – did we get an answer to the timing of hybridization (Jack's previous question)?
- Nathan – When gene flow is present, then a phylogenetic method is violated.
- Emily – question about the timing is a good and interesting. Does this really bear on what the species is now? Are these F1s?
- Nathan – based on 1970s journals, these suggest the hybridization is not recent
- Mike – Wayne and Jinks 1991 was the first one to state hybridization.
- Aaron – one theory is that red wolf is hybrid of gray and coyote and therefore doesn't warrant protection. But Wayne and Jinks stated they are breeding. See paper for further quotation.
- Leo – it comes down to a timing issues
- Nathan – the policy document from the 80s, then the timing issue may be important
- Aaron – if it is F1 or F2 hybrid, then it cannot be protected under ESA
- Nathan – neither von Holdt or Holenhall both stated potential hybrid origin but not within the last 10 generations
- Aaron – correct it was over 1000 years ago
- See Emily's presentation of hypotheses and alternatives.
    - 4 species hypothesis – red wolf is a species
    - 3 species hypothesis – red wolf is not a species; may be a subspecies; if not then a DPS
    - 2 species hypothesis – red wolf is not a species; might be a subspecies; likely a DPS
- Aaron/Leo – I don't think this helps.
- Leo – couple of highlights from von Holdt 2016 paper – results suggest that red wolf selected for captive breeding program had a higher fraction of gray wolf ancestry than is apparent in the current coyote population in US. See page 9 for further statements.
- Pete – anything in the east pre-Columbian was stated gray wolf.
- Joe – rebuttal paper stated the red wolf is distinct. See Hollenholl 2016.

Recommendation Discussion and Scoring

Aaron – Want to make sure all are on the same page for things to consider. Litter size, howling, hybridization, genetics, morphology, phenotype

Bill – what did we base our original decision on? And the 2013 decision used what.

Emily – an expert panel seems to rely heavily on the 2012 Chambers paper.

Bill – was this transparent about how they relied heavily on the Chambers paper?

Emily – yes, some peer reviewers didn't agree with

Leo – They decided to not use a lot of fossil evidence because they couldn't find evidence that the species was the actual species.
Aaron – no other factors that we need to consider?
Angela – the discussion doesn't stop here. As we go through the scoring, there will be more discussion. You will write your justification and then discuss.
Angela – look at Agenda and evidence to consider is listed under VI.

Three decision makers are: Leo Miranda, Aaron Valenta, and Bill Uihlein

Round 1 Scoring:
Two decision makers scored more likely to a species than not and one decision maker decision maker scored it is not a species.

Aaron – Scored the red wolf is a species. My initial conclusion was that this is not a species as defined by the ESA due to its likely origin from GW and coyote. The morphometric characteristics and prey base would indicate a hybrid intermediate between GW and Coyote. My opinion has changed as we further discussed the likely genetic origin of the RW and its uniqueness. Further consideration of Figure 3 graph in the vonHoldt 2011 paper showing the genetic uniqueness of the RW as opposed to the many other species of wolves was important to my assessment. This graph presents a different picture than was communicated in the written text in this and the other vonHoldt paper both seem to be reaching for an opposing conclusion. Much of my earlier belief that it is not an ESA species was based on the vonHoldt papers. I could see it not being a species when considering the genetic lineage being a hybrid of coyote and gray wolf, but the fact that it maps out as a unique entity with no overlap with other species is important. In addition, the uniqueness of this entity, to me, is far beyond the timespans that would be covered by the SOL determination that we do not provide ESA protection to "Hybrids". Concerning hybrids, I also do not believe the SOL opinion affects speciation that has occurred many generations ago but was focused on hybrids of F1 or F2 origin; similar to mules. The Wayne 1991 paper demonstrates that recent F1 hybrids from GW and Coyote do NOT result in individuals similar to the RW. To me, this indicates that while there may have been a hybridization event sometime in history, it has resulted in a unique species occurring on the landscape today. There was also ample evidence indicating that all canids in North America are admixtures containing varying amounts of coyote, grey wolf and domesticated dog. That being said, we clearly define coyote and grey wolf as species. I am fairly confident that RW is also unique. While other unique characteristics such as howling and litter size were of interest, genetics was the major factor in my assessment. Morphometric characteristics indicated an intermediate between gray wolf and coyote but the genetics are what my recommendation is based.

Bill – I am new and least read on all knowledge of the species. I'm bringing my expertise of the scientific method. I believe the RW meets the definition of a species under the ESA - with great deal of uncertainty. Based on the evidence I was presented today and was provided to me the week prior to our meeting, I believe the RW is a hybrid. Has hybridization over time been sufficient to result in a new species as define under the ESA? From 0 – 100 with 0 being I believe it is NOT a unique species verse I believe it IS a unique species by evidence. I put my weight and decision on behavior (highest), ecology and genetics (medium), and morphology

(lowest). I put morphology based on what I hear and we may have potentially biased based on artificial selection based on morphometric factors. Genetics put medium because genetics weren't genetics based hypotheses and more based on origin. Diet itself may be an artifact of size of the species. As it relates to behavior (I had this the highest) and it seems to be more of the hard-wired piece. Dispersal and pack piece are the closest things that moved the behavior score. Howling, litter size – did not help decide a species. The most compelling evidence that lead me to unique species was the K8 interpretation from the Von Holdt appear.

Leo – Genetics - Full genome is the current most reliable technology. Even when they cluster together, there is some genetic distinctiveness between coyote and red wolf. Everybody agrees that there has been some hybridization at some point. The big question is when did this happen? The recent papers like Von Holdt et al 2016 and subsequent rebuttals argue that this speciation happened relatively recent in evolutionary time but it was enhanced the effects of humans in the Southeastern landscape. The study showed that admixed ancestry is common and suggested that the red wolf is a hybrid that arose after Europeans arrived in NA, when gray wolves that managed to survive hunting and habitat loss mixed with expanding populations of coyotes (Morell 2016). The genetic closeness of coyotes and red wolves, together with the lack of reproductive barriers (i.e., the reproduce with coyotes and their subsequent progeny is viable) and very minimal phenotypic differences brings me to the conclusion that based on the best available information, the entity we currently have in captivity and in one wild population does not meet the definition of species under the ESA because of its hybrid origin. This is supported by recent comments from several experts (i.e., M. Phillips and D. Mech) agree that the most recent data published in Von Holdt 2016 and their conclusions will stand.

Thinking about the entity that we have right now from the 14 founders – all of these right now. I think we need to make a differentiation between "entity" and "species.' Right now the majority of the evidence presented and analyzed tend to show an entity that is very closely related to the coyote. In fact, the genetic clustering presented by VonHoldt 2011 shows coyotes and the current red wolf almost together, relatively far from all the other wolves. Morphology is important in terms of phenotype. Back in the 1970's the Service decided to capture all wild animals this is considered a type of artificial selection based on morphology which was the best technology at the time. The standards used at that time are still in use today. However, literature shows that we did and discarded many small red wolves and got some "big" coyotes and maybe even hybrids. This was demonstrated by some F1 and F2 litters that were found to be hybrids coming out of the selected wolves. At the end, we ended up with the 14 founders. In addition, morphology as its own mechanism is not very reliable as a method of defining a species. It is a phenotype. Finally, Morphology they form their own distinct cluster intermediate between Grays and coyote. Some say this is evidence of distinct species others say this is evidence of a hybrid.

In terms of Diet is very similar to coyote, however, red wolves tend to catch larger prey (like deer). Coyotes, although less than red wolves, can capture adult deer. Diet indicate a high degree of overlap between these two species.

In terms of Pack behavior, red wolves are mostly a family group, the same as coyotes. In fact, we have never seen a red wolf pack accepting a non-family member. They are "more coyote like" than "wolf like" in terms of their packing behavior. Although we assume that they do, we

have not observed red wolf hunting in packs. Dispersal of red wolves is a little different than Gray wolves. RW disperse on average 15-24 months. This makes sense because they pack as family. Grays disperse as yearlings, they could be accepted by other packs because, unlike the RW, they are not much family. Howling has a difference. Red Wolf type 6 (intermediate) howling is common with red wolf but that may provide potential evidence of hybridization. In terms of all the phenotype lines of evidence the red wolf we know today Closely resembles the coyote except the morphologic criteria developed in the 1970's.

Aaron – genetically – could that cluster develop in 200 years?

Nathan – yes – in a natural population it could but it is hard to say. You can show genetic variation but the causal reason for that is very hard to say.

Bill – could the artificial selection be a reason to see the genetic

Nathan – how long can they live? Erin – up to 13 years; Mike – we are at 6-7 generations in the wild right now. Nathan – that could impact it.

Leo – The culling may have created the clustering. They could have been more overlap between red wolves and coyote based on morphological criteria we used to cull. Artificial selection may have affected it
Nathan – it could have gone the other way.
Bill – it is possible but based on the criteria of how they were deciding, they were selecting based on red wolf morphological traits.
Leo – there an uncertainties on the genetics because of the morphology.

Bill – the way I distributed the weight on characteristics: behavior (high), genetics (medium), morphology (low). Did I do this the wrong way?
Mike – how they act in the wild? How they act around coyotes? How they act around themselves? This is very important. Some of the mechanics like litter size are similar.
Bill – the reason I didn't put much weight in the food. There are clear distinctions in the food is because of the artificial selection of the size of the wolf.
Mike – part of the issue is what everyone that described on the ground. Everyone said it was a wolf species and a separate wolf species (except for one person who said it was a subspecies). After an expert panel, It went back to a separate species. This carries some kind of weight because we weren't there and didn't see these animals. This is an important fact.
Leo – I started with the conclusion that this is hybrid. Based on most recent paper in my hand on genetics and look at what we have, and then I looked at our policy. The authority that we use is Mammals Species of the World and it doesn't classify the wolf as a species.

Aaron – what did you think of the Wayne publication from 1995?
Leo – I don't know the methods they used.

Erin – read the email from Dave Mech. This provides more clarification on hybridization caveats.

Dave – what he didn't say which we don't know. We don't know if his comments are specific to Von Holdt or to the entity in the East.

Angela discussed the expected utilities of the decisions. See utilities google drawings.

Leo – risk tolerance. I go strictly with what I see and more recent signs has more weight.
Nathan – they were discussing the timing of the origin of the animals. That has nothing to do with how this is a valid species or not.
Pete – there is no scientific finding that excludes the unique lineage hypothesis.

Emily – the Mammals Species of the World does not list Red Wolf as its own species but it lists it as a subspecies
Bill – another assumption that is influencing where I land is that I'm operating under the premise that we made a determination before and in 2013 we made another decision. What gives me information to how those are wrong?
Aaron – we are trying to much more precise and concise in how we interpret ESA and we have new data.
Bill – the 2013 finding officially recognized three species: one of which is red wolf.
Leo – that was the delisting the gray wolf. And the 2012 Chambers paper
Emily – there was an expert panel that went through and used the Chambers 2012.

Aaron – so from your read of the SOL memo, you think hybridization from 100s of years ago is how it should be interpreted.
Leo – it is hybridization. Timing of hybridization isn't defined.

Mike – what is the difference between admixture and hybridization?
Nathan - admixture is a result of hybridization. I don't think there is a timeframe associated with admixture.

Round 2:
Bill – the primary change was when we were talking and reminder about pack behavior. And how we don't completely understand the pack behavior since we don't see them as easily.
Aaron – behavior is smaller part of my decision. How they hunt and how they howl isn't how I would define a species.
Leo – Chambers 2012 paper – founder effects and genetic drift has likely effected genetic diversity. This is adding to hybrid theory.
Angela – I'm not sure how to interpret your answer (55).
Bill – I think it leans more towards a unique species than is not.
Aaron – I'm not certain but there is more evidence than not.
Angela – I'm confirming that Bill is stating is red wolf more likely a species than not.
Bill – the 2013 finding based on expert panel and somebody did work behind that.

Recommendation is a split decision: one person with it not a species, two decision makers it is a species. See the score sheet for scores.
Leo – everything I read is that it is hybrid. Based on policy and recent rules, they found unique genetic information only for that species and ended up deciding it was not listable entity.

Emily – So you believe it is an equivalent of a F1 or F2 hybrid?
Leo – yes
Aaron – if the policy had clearly defined what a hybrid is in the policy, then my decision may have changed.
Leo – our decision is based on our definition of species in the ESA.

Next Steps: We will be submitting a recommendation based on our meeting and present this recommendation to the RD.

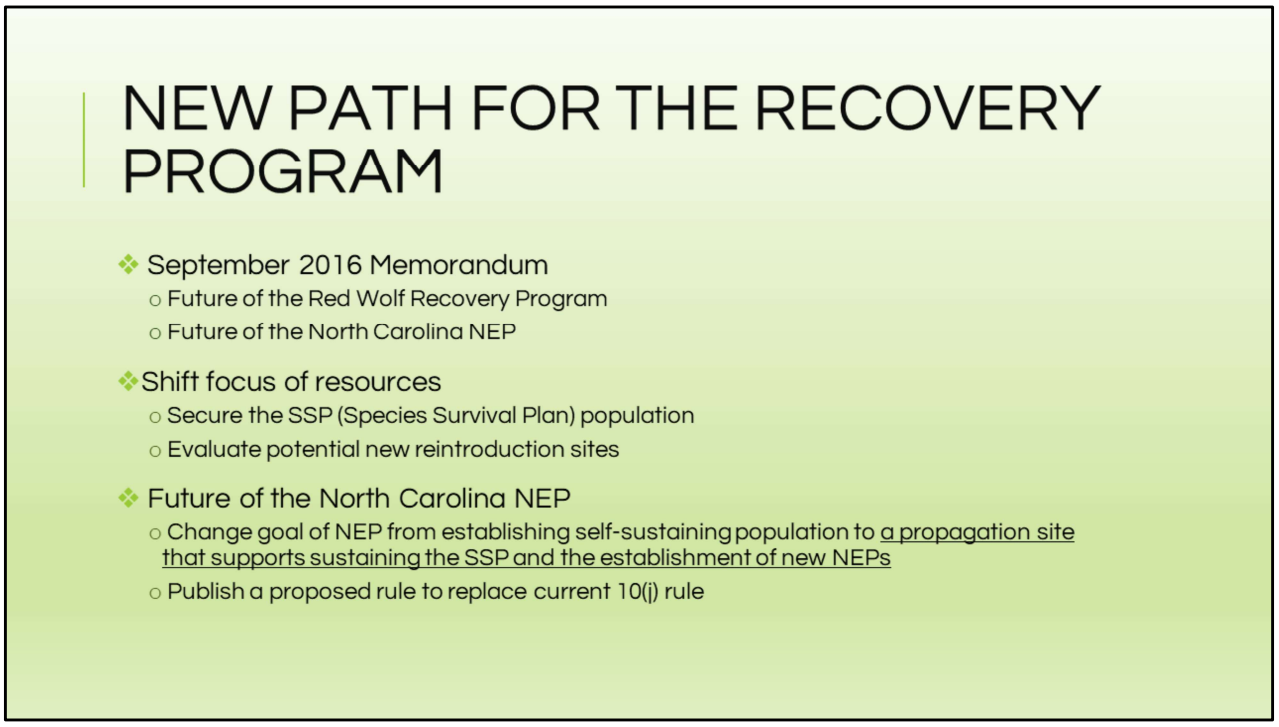


RED WOLF

Proposed Rule Under section 10(j) of the ESA

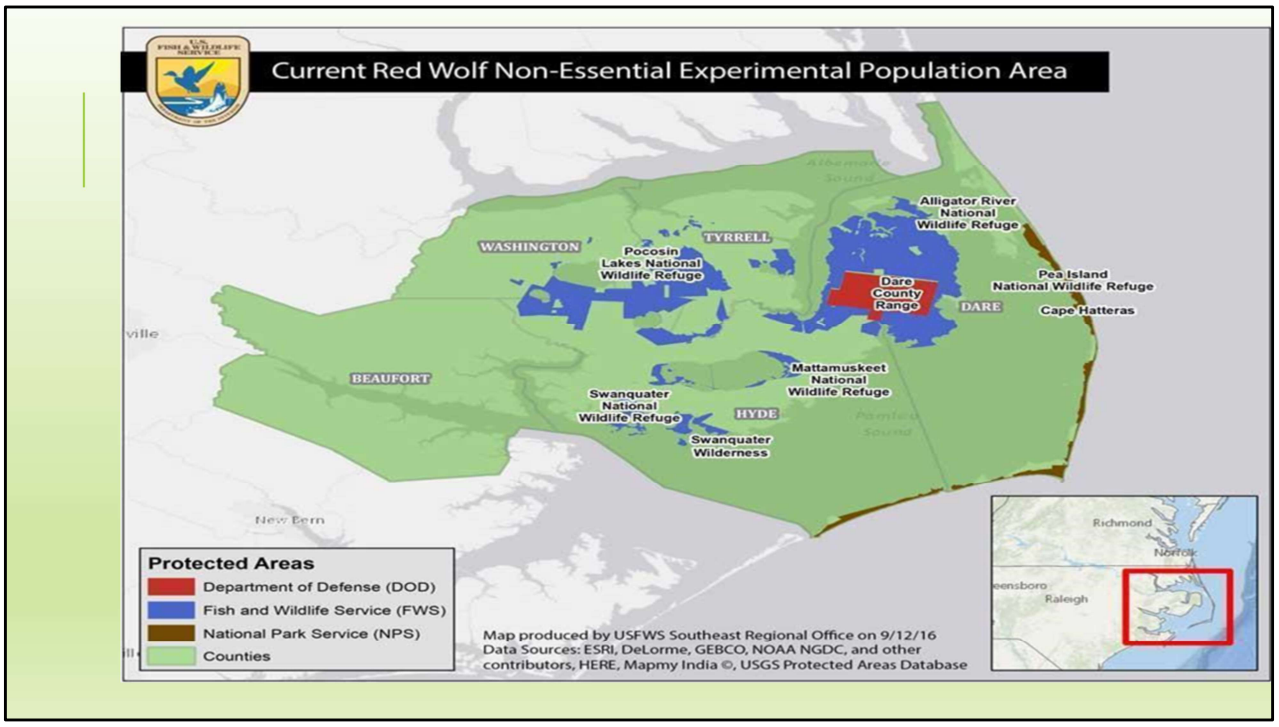
OVERVIEW

- New Path for the Red Wolf Recovery Program
- Current NEP area
- What is a 10(j) rule?
- Need for a new 10(j) rule
- Public and partner agency involvement
- Proposed rule
- Position of State Agency and public
- Questions

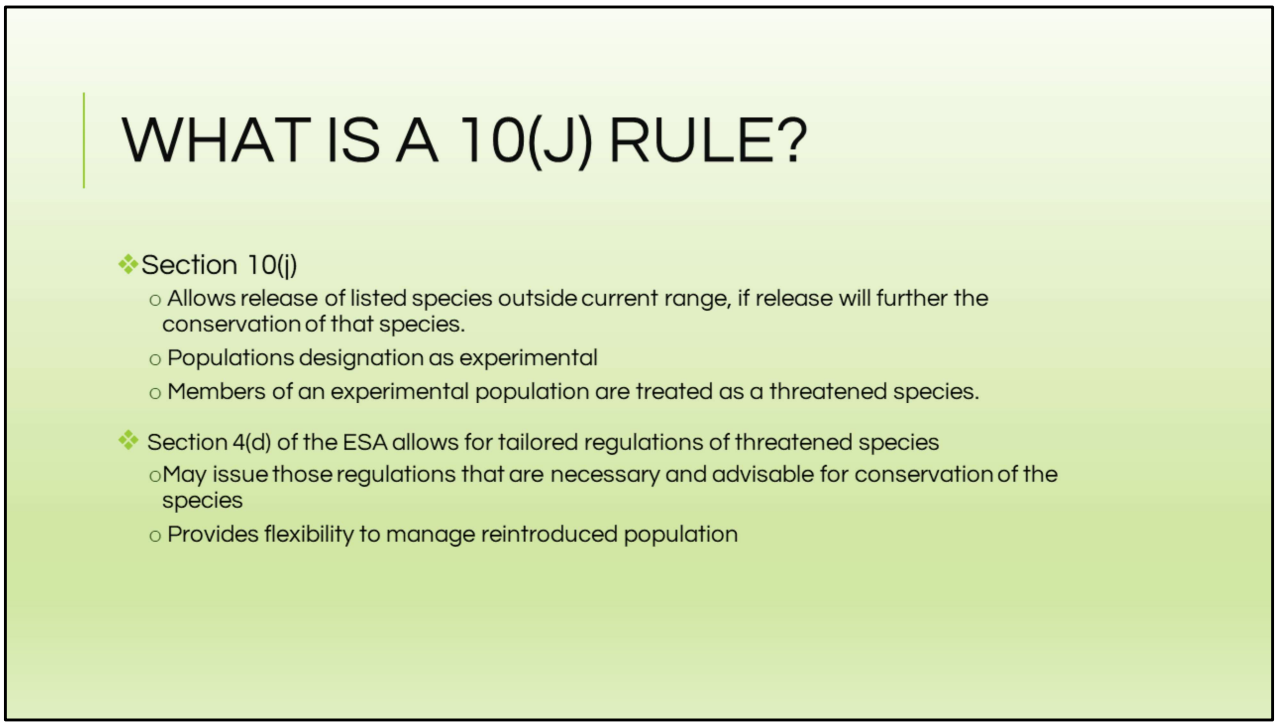


Based on program reviews, the Service proposed in 2016 (in the 2016 Memo) a new path forward for the RWRP. The Service made recommendation regarding the future of the program and the future of the NC NEP

Focus is on securing the SSP (increasing population #) and evaluating new NEP sites – EXPANDING, rather than putting most resources toward a single NEP site.



*** Fill in info on current regulations?



Section 10(j) of the ESA provides the Service authority to release listed species outside the species' current range when doing so furthers the conservation of the species. Individuals in the experimental population are treated as threatened regardless of its status as an endangered or threatened species under the ESA . The prohibitions and exceptions specified under sections 9 and 10, respectively, in the ESA only apply to endangered species. For threatened species, the Service, under section 4(d) of the ESA, may issue those regulations that are necessary and advisable to provide for the conservation of the species, giving great flexibility in crafting specific prohibitions and exceptions tailored to the particular needs of the species. Therefore, this non-essential experimental designation provides flexibility in managing the reintroduced population. In conjunction with the proposed 10(j) rule establishing the NEP, the Service is also proposing a rule under section 4(d) of the ESA to provide the regulations that are necessary and advisable for the conservation of the red wolf NEP.



Direction and management of NC NEP is unacceptable to all stakeholders (Recovery Team Final Report)
PVA indicates continuing current management will likely lead to its extirpation in as few as 8 years.
Currently, population is declining more rapidly than worse case PVA projections.
Continued high risks of hybridization, human-related mortality, continued loss of habitat due to sea level rise, and continued population decline
Future changes in habitat will favor coyotes

Many of these wild animals would benefit the SSP (IF capacity is increased).

Benefits of maintaining a smaller wild population fully integrated with SSP:

Animals removed from wild to support expansion and genetic health

Retain influences of natural selection
Source for new reintroduction efforts
Continued research on wild behavior

Purpose: Write a rule for the NENC NEP to further the conservation of the red wolf by optimizing use of available recovery resources.

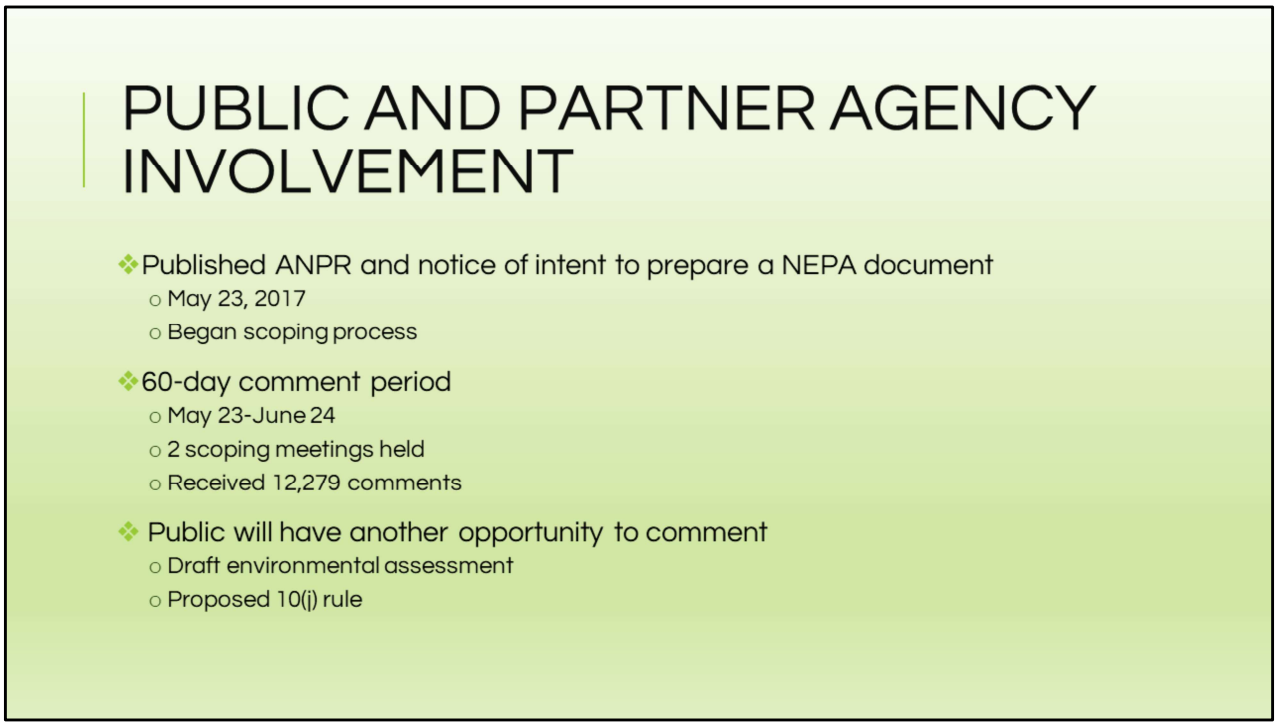
Need:
Assess and ensure effectiveness of the NENC NEP as it relates to the broader red wolf recovery program including population growth in captivity and the wild.

The replacement of the 1995 Final Rule is necessary, because the current regulations lack the needed flexibility to adapt to the arrival and proliferation of coyotes in the NENC NEP which adversely affected the NENC NEP in the following ways:
Decreased the probability of persistence of the wild population;
Created conflict with State efforts to manage coyote populations and precluded active participation by landowners, and State and local officials in canid management;
Increased costs, which had limited our ability to pursue broader recovery efforts.

Replacing the 1995 Final Rule is also necessary because current regulations fail to provide protections necessary to achieve our Congressional mandate to further the conservation of red wolves. The lack of protections provided by the 1995 Rule limited red wolf recovery in the following ways:
Allowed for the removal of upon landowner request which adversely affected the red wolf population without effectively fostering coexistence.
Impacted private landowners ability to manage coyote populations which led to excessive losses of red wolves to gunshot mortality which disrupted established packs of red wolves and breeding pairs, allowing for the further expansion of coyote populations and increasing red wolf/coyote hybridization.
Set a limit on the number of red wolves that could be release on the landscape. Movement of wolves between the captive and wild populations is needed to maintain the genetic integrity of the NEP and the overall population.
Limited flexibility to manage the NEP in close association with the state and private landowners.

Admin changes:

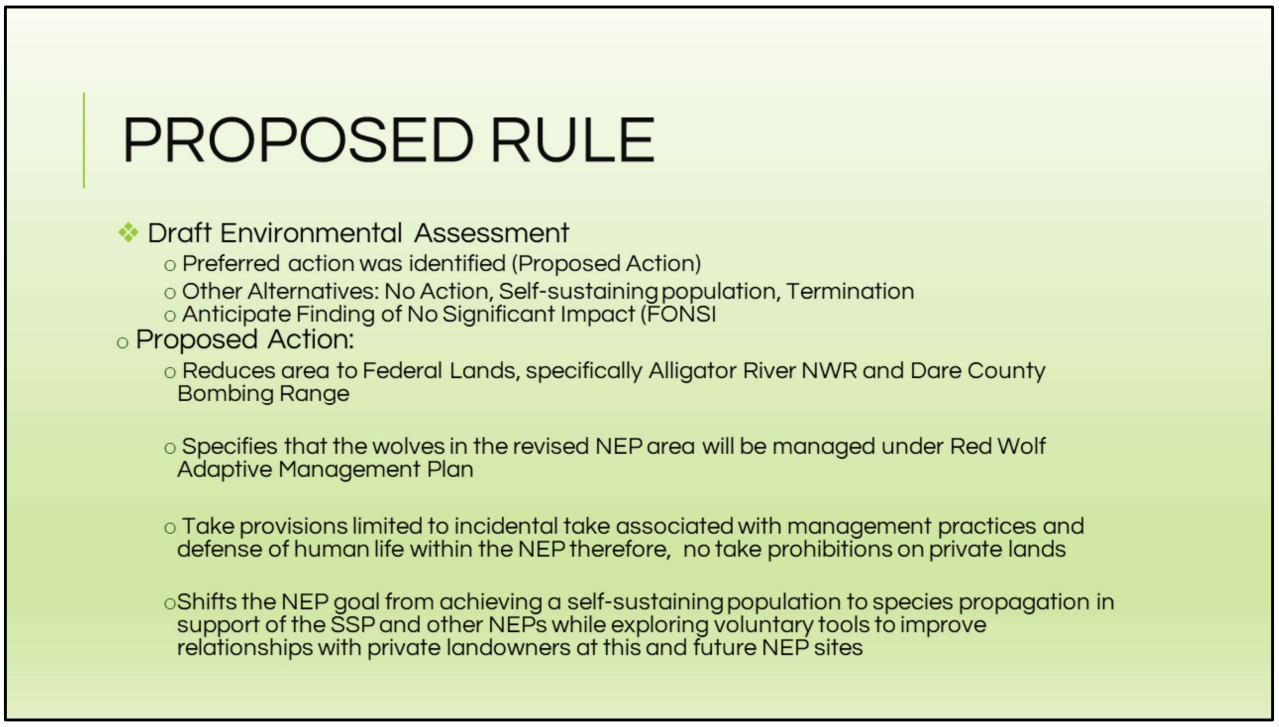
clarifying status of island propagation sites
remove GSMNP as part of the NEP area



Scoping process: Established an early and open process for determining the scope of the issues to be addressed in the NEPA document

The Service published an advanced notice of proposed rule-making and notice of intent to prepare a NEPA document on May 23, 2017. This established an early and open process for determining the scope of the issues to be addressed in the NEPA document through soliciting public comments. This process is commonly referred to as "scoping". The scoping public comment period opened with the publishing of the notice of intent and ended on July 24, 2017. During the 60-day comment period, The U.S. Fish and Wildlife Service received a total of 12,279 comments. This number includes verbal and written comments submitted in person at two public meetings and online through regulations.gov.
About 90 people attended the two public meetings held on June 6, 2017, at Mattamuskeet High School in Swan Quarter, NC and June 8, 2017, at the Coastal North Carolina National Wildlife Refuges Visitor Center in Manteo, NC. At these events, Service personnel provided an overview of the process for writing a new rule and the public visited with USFWS personnel and discussed different aspects of red wolf recovery. The public input received in response to the notice and scoping meetings has been reviewed, is incorporated throughout this EA, where appropriate,

and was specifically used to help craft the range of alternatives being analyzed.



Other Alternatives:

No Action – Where the NEP would be managed under the Service's existing regulations.

Self-sustaining recovery population – We would revise the current regulations to explicitly incorporate the Red Wolf Adaptive Management Plan (RWAMP) and modify the provisions for management of wolves on private lands within the current NEP five county area. The main goal would be to establish a self-sustaining population and allow for the legal implementation of tools identified in the RWAMP as needed. It would also authorize take of wolves limited to protection of oneself or others from potential harm, protection of livestock or pets in immediate danger and unintentional take. It would prohibit unauthorized lethal take. Based on our experience of over 40 years in red wolf management and the results of the Species Status Assessment, we don't believe a self-sustaining population could be achieved given the current and future conditions of the NEP reintroduction area. Therefore, we discarded the previous two alternatives as viable options.

Termination – We also considered a total termination of the current regulation and removing the animals from eastern North Carolina. This alternative was analyzed and discarded primarily because we would once again lose our ability to have a wild population component in our recovery program.

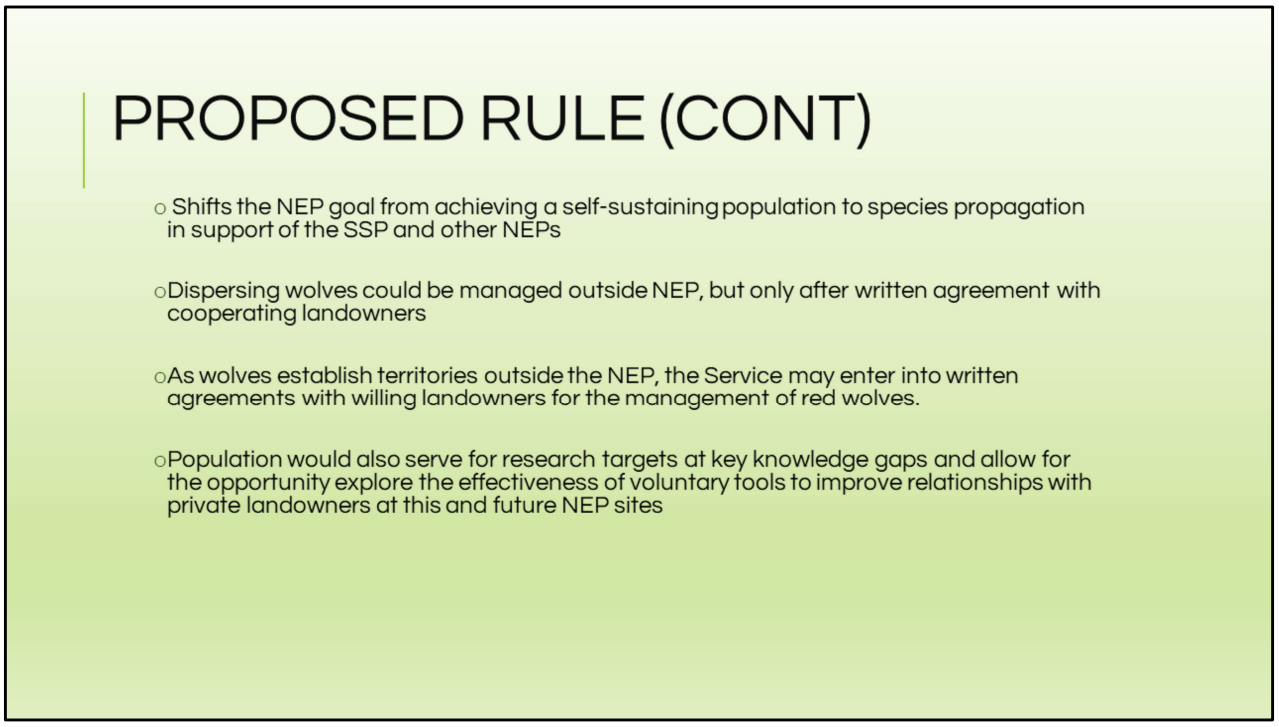
Propagation population – Finally, after full evaluation we selected our preferred alternative that would change the scope and management of the eastern NC red wolf NEP. The regulation would reduce the management area to just Alligator River NWR and Dare County Bombing Range. The scope of the new NEP would change from a recovery population to a propagation site by retaining red wolves in the wild and managed as one meta-population with the captive population. This alternative would fully implement the RWAMP within the propagation management area and authorize take outside of Federal lands.

The selection of this preferred alternative will be controversial. The State of North Carolina has officially requested the termination of this NEP. The North Carolina Farm Bureau and most private landowners with wolves using their property will likely be opposed to any alternative that keeps wolves in the wild. National and local environmental groups will likely oppose any alternative short of full protections under the ESA.

Under this Alternative, the Service would publish a new rule to change the scope and management of the NENC NEP. The NENC NEP area would include only Alligator River NWR and the Dare County Bombing Range. A small group (one or two packs likely consisting of less than 15 animals) would be maintained on Alligator River NWR and the Dare County Bombing Range. The red wolves in this smaller NENC NEP would be managed consistent with the recommendations in Alternative 2 with the exception of the take provisions, which would be limited to incidental take associated with management practices and in defense of human life. The primary role of this population relative to conservation of the species would be to provide a source of red wolves that are raised in and adapted to natural conditions for the purpose of facilitating future reintroductions.

It is anticipated that some red wolves would leave the Refuge and Bombing Range on a fairly regular basis. To address this, the regulations would specify no take prohibitions for red wolves on private lands. As such, there would be no need for provisions for removal of red wolves from private lands and no procedures for requesting authorization to take red wolves on private lands, because such take would be explicitly permissible under the regulations. The rules would require only

that the Service be notified within 24 hours regarding the take of any collared animals and that the collars be returned to the Service. However, red wolves could be managed outside this area subject to written agreements with cooperating landowners.



However, red wolves could be managed outside this area subject to written agreements with cooperating landowners.

The Service would work with the NCWRC to encourage landowners to avoid take of red wolves through a landowner incentive program (described above). The red wolf population could grow beyond the small number anticipated to be supported on Alligator River NWR and Bombing Range lands only to the extent that there was sufficient sustained support from willing landowners. As such, this alternative has a range of potential outcomes. If landowner support is low then the NENC NEP would be confined to Alligator River NWR and the Bombing Range, and would function essentially as a large propagation site. With sufficient landowner support this alternative could produce a more robust population.

Under this alternative, as red wolves move and establish territories outside the NEP geographic boundary by themselves, the Service intends to develop appropriate landowner agreements for the purpose of implementing the RWAMWP actions such as pup fostering and genetic management. Any specific management practices implemented by the Service on private lands will be explicitly described in a written agreement between the Service and the landowner.

Focusing management on Federal lands and developing effective tools for working with cooperating private landowners while removing the cumbersome provisions for authorizing take of red wolves should reduce overall program costs and facilitate the State and other partners to take a more active role in canid management and conservation on non-federal lands. Limiting the designated NENC NEP area to federal lands should also eliminate conflicts between State-authorized management of coyotes outside the NENC NEP area and management of red wolves within the NENC NEP area. Given the importance of private lands to red wolf conservation range-wide, development of effective means to foster State and landowner cooperation is imperative. Serenari et al. (2018) noted that the conflicting priorities and messaging between the NCWRC and Service undermines the credibility and public support for the actions of both agencies.

POSITION OF INTERESTED PARTIES

- Opposition from:
  - NCWRC have requested termination of NEP
  - NC Farm Bureau
  - Most private landowners with wolves using land
- Support
  - National and local red wolf supportive groups
  - Based on surveys conducted by NCWRC, a majority of local public is supportive, but, some public is quite opposed.
- Potential Issues
  - Continued opposition due to actual and/or perceived impacts to wild game, livestock, and pets
  - Continued mistrust of the government by local community
  - Additional questions of species legitimacy
  - Perceived reduction in interest by the Service to recover the red wolf



QUESTIONS?

Analyzing a Prospective Red Wolf (*Canis rufus*) Reintroduction Site for Suitable Habitat

by Jon Shaffer
April, 2007

Abstract

Since its declared extinction in the wild in 1980, the red wolf has been reintroduced into two areas of the South. The reintroduction in Northeastern North Carolina has been quite successful, while the reintroduction into the Great Smoky Mountains National Park was unsuccessful. The USFWS Red Wolf Recovery Plan calls for the additional establishment of two more wild populations of wolves. I analyzed the potential of one prospective release site to contain enough suitable habitat to support a reintroduction of red wolves. The Central Coastal North Carolina area was chosen for analysis as it met general criteria for the likely success of reintroduction, including a similar geography to the successful Northeastern North Carolina site, and a large amount of land in conservation. ArcGIS 9.2 was used to identify core patches of potential habitat within the study area and calculate the amount of their areas occurring on protected lands. The patches were examined for connectivity using least-cost path analysis, and optimal corridors containing the top 5th percentile best paths between patches were calculated. Three patches, that combined would provide suitable habitat for wolf reintroduction, were identified. Together these patches contained an area larger than the 68,800 hectares of habitat required for red wolf reintroductions. And over 75 % of this area occurred on conservation lands. It is therefore possible that the Central Coastal North Carolina area contains enough suitable habitat for the reintroduction of red wolves. The approach used in this analysis could by applied to other prospective red wolf release sites.

Introduction:

The red wolf (*Canis rufus*) was declared extinct in the wild in 1980. As a result of the Endangered Species Act of 1973, the U.S. Fish and Wildlife Service (USFWS) initiated the Red Wolf Recovery Program. It established a captive breeding program, and a reintroduction plan with a goal of establishing at least three wild populations of wolves totaling 220 animals; each population should occupy at least 178,000 acres (68,800 hectares) of contiguous habitat (USFWS 1990). Red wolves have been successfully reintroduced into Northeastern North Carolina; there is currently a population of approximately 100 centered among the Alligator River and Pocosin Lakes National Wildlife Refuges. However, a similar reintroduction effort was unsuccessful in the Great Smoky Mountains National Park (Kelly et al. 2004).

The USFWS is considering other prospective release sites for establishing additional red wolf populations. Thirty one prospective release sites have been identified throughout the former range of the red wolf (Van Manen et al. 2000). I will examine one of these potential sites, the Central Coastal North Carolina area. The goal of my analysis is to determine if this site contains enough physically suitable habitat to support a reintroduction of red wolves. The site will be analyzed for the amount of core habitat it contains, the connectivity of these areas, and the protection status of the core areas' land. An approach similar to that taken by Paquet et al. (1999) in their determination of habitat suitability for gray wolf reintroduction in the Adirondacks will be used, with some modifications to the methodology.

Methods:

Choice of site:

The Central Coastal North Carolina area consists of the land area, excluding barrier islands, of four counties: Carteret, Craven, Jones, and Onslow (Figure 1). This site was chosen for several reasons. First, it is geographically very similar to the northeastern North Carolina site where red wolves have been successfully reintroduced. Next, it contains several large protected areas of conservation lands including the Croatan National Forest and the Hofmann State Forest. Third, the site has a low coyote density compared to other areas of the state, and as much of the area is bounded by water, it may be possible to exclude coyotes from the site. Coyotes present one of the greatest challenges to the success of red wolf reintroductions as they readily hybridize with the wolves, and can quickly dilute the gene pool (Kelly et al. 2004, Phillips et al. 2003). Finally, the close proximity of the study site to the successful reintroduction site in Northeastern North Carolina will allow for easier exchange of resources, expertise, and personnel between reintroduction areas.

Data:

The National Elevation Dataset (1 arc second) and National Land Cover Dataset 2001 from the USGS were used to determine elevation and land cover at the site. Highway, county boundary, state boundary, and waterbody vector data were obtained from the USGS National Atlas of the United States. Vector data on municipal town boundaries and roads were obtained from the North Carolina Flood Mapping Program. Vector data on

protected conservation lands were obtained from the North Carolina Corporate Geographic Database's "Lands Managed for Conservation and Open Space" data layer (NCCGDB 2003). Deer density data were obtained from the North Carolina Wildlife Resources Commission. The ranges of red wolf populations reintroduced into the Great Smoky Mountains and Northeastern North Carolina were obtained in the form of vector data from NatureServe (Patterson et al. 2003). All data were projected to NAD 1983 UTM Zone 18N and most layers were clipped to the four county research site. All raster data throughout the analysis were set to a 30 by 30 meter resolution.

Analysis:

Analysis was conducted in ArcMap 9.2 (See Appendix for models and Python Scripts).

Patches of core habitat for red wolves were identified in the study area based on the following criteria:

1. Road density of less than 0.25 km/km^2.
2. 1 km from highways.
3. 2 km from incorporated towns.
4. Land cover of one of the following classes: deciduous, evergreen, or mixed forest, shrub/scrub, grassland/herbaceous, woody wetlands, or emergent herbaceous wetlands.
5. Deer density of at least 5 deer/km^2.
6. Slopes no greater than 20^o.
7. Patch area of at least 45.6 km^2.

Low human density and distance from roads are among the most important predictors of potential red wolf habitat in North Carolina (Kelly et al. 2004). Following the model of Patterson et al. (2003), road density was used as an approximation of human density. Road density was calculated by converting the roads data into a raster and calculating focal statistics on a moving 1km by 1km window. The highway and town data were buffered and combined into a raster of unsuitable habitat. The land cover data were reclassified to reflect the habitat preferences of red wolves depicted above. Deer are the most important prey item for red wolves, accounting for 43% of the biomass digested by wolves in Northeastern North Carolina (Phillips et al. 2003). As such, a raster was created from the deer data identifying areas with a deer density of at least 5 deer/km^2. As slopes greater than 20^o may be avoided by wolves (Callaghan 1999), a slope raster was created from the elevation data.

The above raster layers were combined to create a raster of potential habitat patches. Then habitat patches with an area of at least 45.6 km^2 were extracted from this raster to create the core habitat patches raster. The area of 45.6 km^2 represents the minimum home range size for a pack of red wolves (Phillips et al. 2003). The area of core habitat patches existing on protected conservation land was then extracted and tabulated.

Least-cost path analysis was used to examine functional connectivity between core habitat areas. A raster cost surface reflecting the variable resistance to wolf movement was created. Each value of the raster represented how much relative cost a wolf would

face when traveling through each 30 by 30 meter pixel. The cost surface was generated from a composite of three different cost rasters: land cover cost, road density cost, and highways cost. Table 1 displays the features associated with these rasters and their respective costs. Estimates of the relative costs of different features were adapted from Paquet et al. (1999) when possible and estimated from knowledge gleaned from the literature on wolves. The minimal cost distance from core habitat patches was then calculated through the cost surface. Allocation boundaries were drawn at the locations where the maximum least-cost distance occurred between any two core patches. The cells along each allocation boundary with the minimum 5% of cost distance values were then used (as described by Theobald 2006) to create multiple pathways and a corresponding corridor containing the top 5^{th} percentile best paths between patches.

Results:

Nine core patches of habitat were identified in the study area (Fig. 2). These ranged in size from 48 to 432 km^2 (Table 2). Three of the core patches (4, 5, and 7) were better connected to each other than the other patches; these other patches tended to lay along the periphery of the study area. The lower cost distances between these three patches can be seen in Figure 3. Much of the land in patches 4, 5, and 7 had the added benefit of existing under conservation protection (Croatan National Forest and Hofmann State Forest), while almost none of the land in the other core patches was protected (Table 2). Most of the

likely corridors between core patches did not lie on protected land. The exception to this was the corridor between patches 5 and 7, which occurred almost completely on conservation lands (Fig. 4).

Discussion:

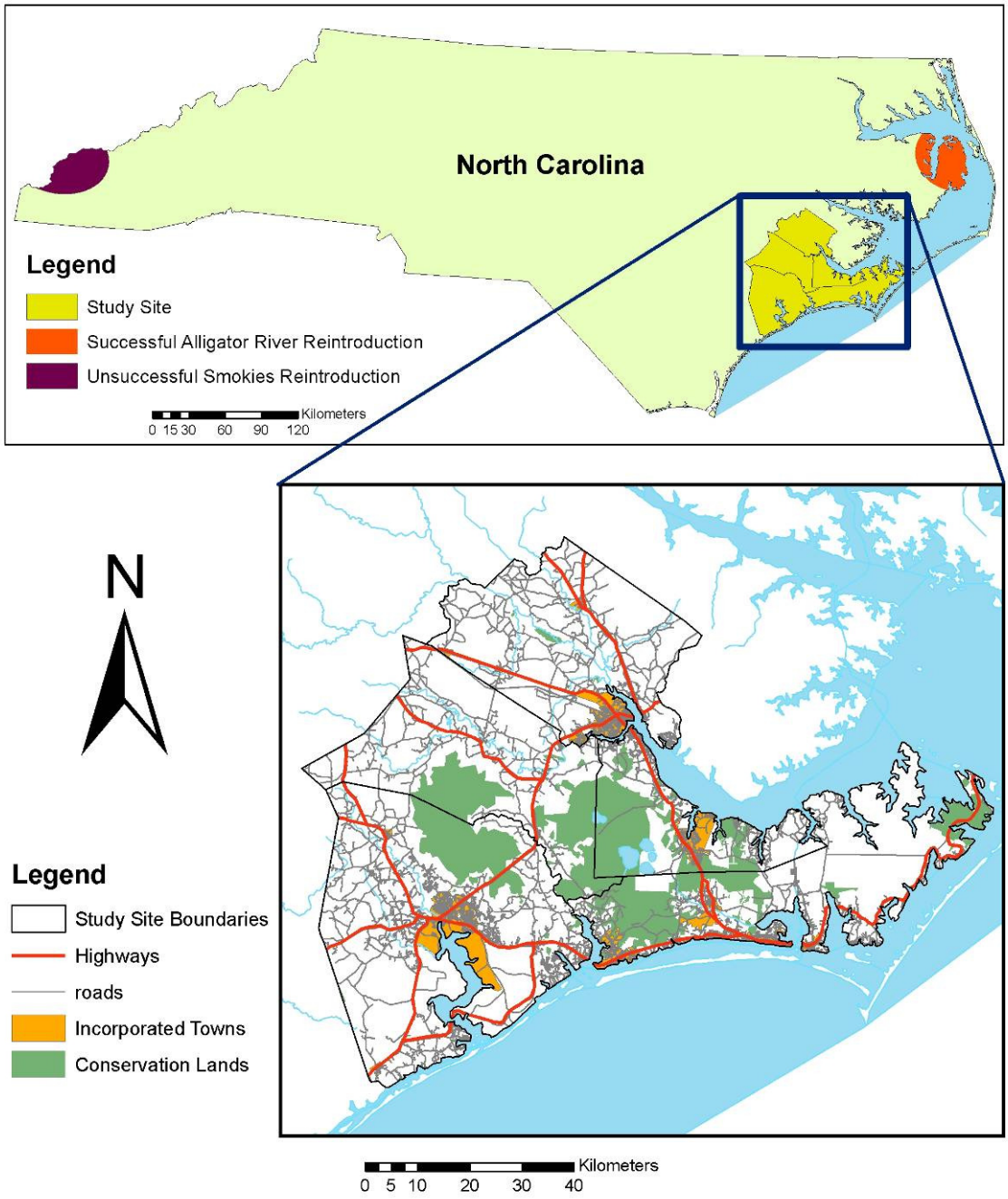
In light of the large cost distances between many of the potential core habitat patches, their relatively small size, and their peripheral location where they may be less protected from coyote immigration, it is recommended that only the three central, connected patches be considered as suitable habitat (patches 4, 5, and 7). This selection includes the two largest habitat patches and has the added benefit of being mostly contained within conservation lands. Taken together these patches have an area of 84.0 km^2 (Table 3). This meets the reintroduction requirement of 170,000 acres (68.8 km^2) of wolf habitat. Especially encouraging is that over 75% of this suitable habitat occurs on protected conservation lands, and the most likely corridors between two of the patches are protected.

There were several limitations to this analysis. First, it did not take coyote density into account. Hybridization with coyotes is the one of the greatest challenges to successful red wolf reintroduction, and it was one of the main factors preventing the success of the Great Smoky Mountain reintroduction effort (Kelly et al. 2004, Phillips et al. 2003). Anecdotally, coyote density is low in the study area, but actual numbers need to be

accurately surveyed. Another limitation to the study was the use of land cover data that is several years old. Although this is the most recent data available, the study site is located in a fast growing area of North Carolina and faces continuing development pressure. A third limitation is the subjectivity involved in the estimation of cost for the cost surfaces. Actual costs of movement for wolves over certain surfaces may be much different than those estimated. Also, it is tough to determine the magnitude of cost distance at which travel between two core patches of habitat becomes unlikely or impossible. But, as more information is gleaned from telemetry and behavioral studies we can update the relative costs of movement in the model.

Though there are limitations, this geospatial approach provides a useful framework for determining if the prospective reintroduction site will provide suitable wolf habitat. It is flexible in that costs can be adjusted and more variables added as more data are obtained regarding the habitat needs of the red wolf. On the basis of this study, it appears quite possible that the Central Coastal North Carolina area contains enough suitable habitat for the reintroduction of red wolves. I recommend that this site be analyzed further for consideration for red wolf reintroduction. The models used in this approach may be useful when analyzing other prospective reintroduction sites for the red wolf.

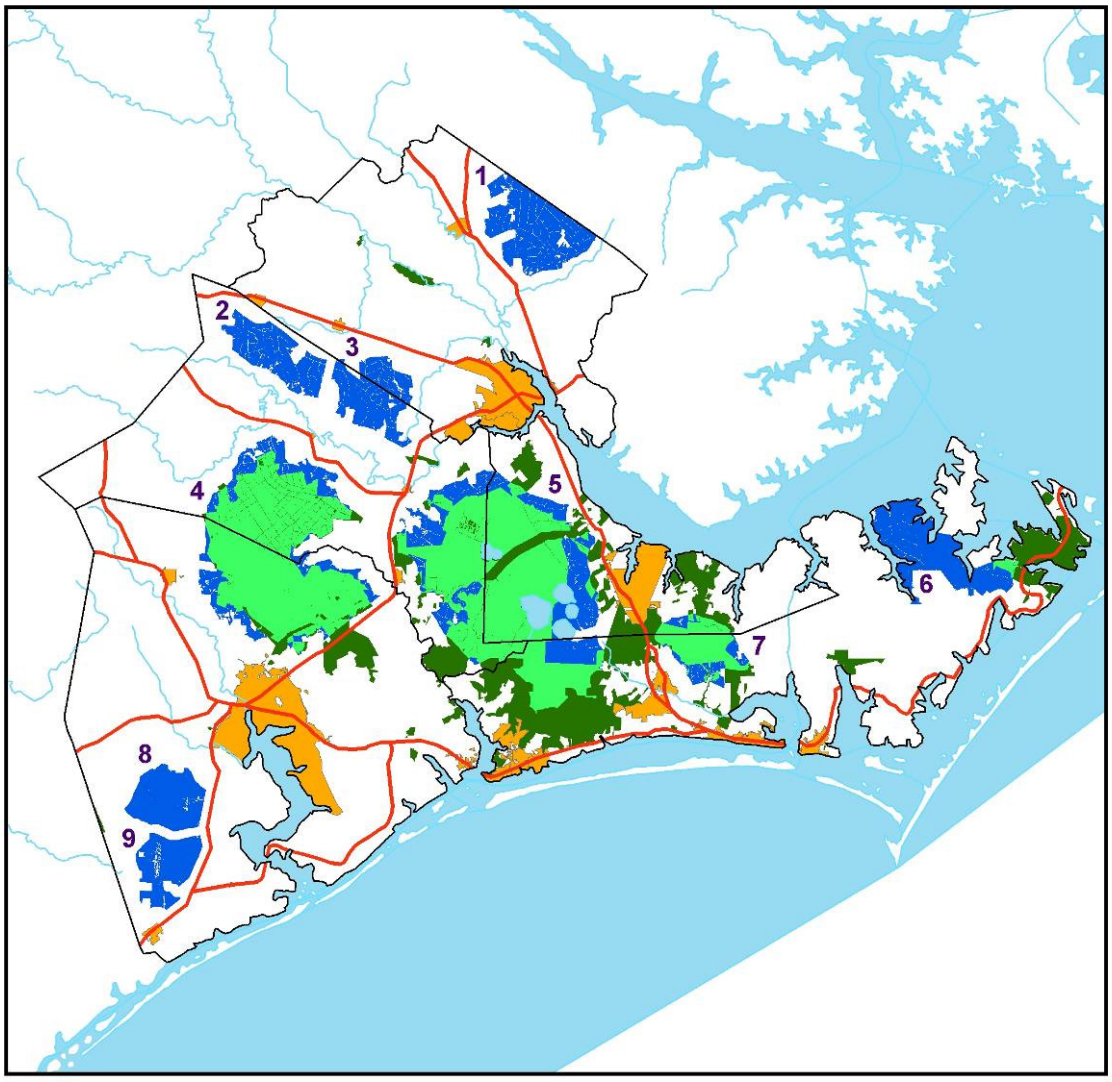
Figure 1. Study Site Location and Overview



Projection: NAD 1983 UTM Zone 18N.

Map Produced by Jon Shaffer, April 2007.

Figure 2. Identified Core Red Wolf Habitat Patches



Legend

- Core habitat patches
- Core habitat protected in Conservation Lands
- Non core habitat Conservation Lands
- Study Site Boundaries
- Highways
- Incorporated Towns

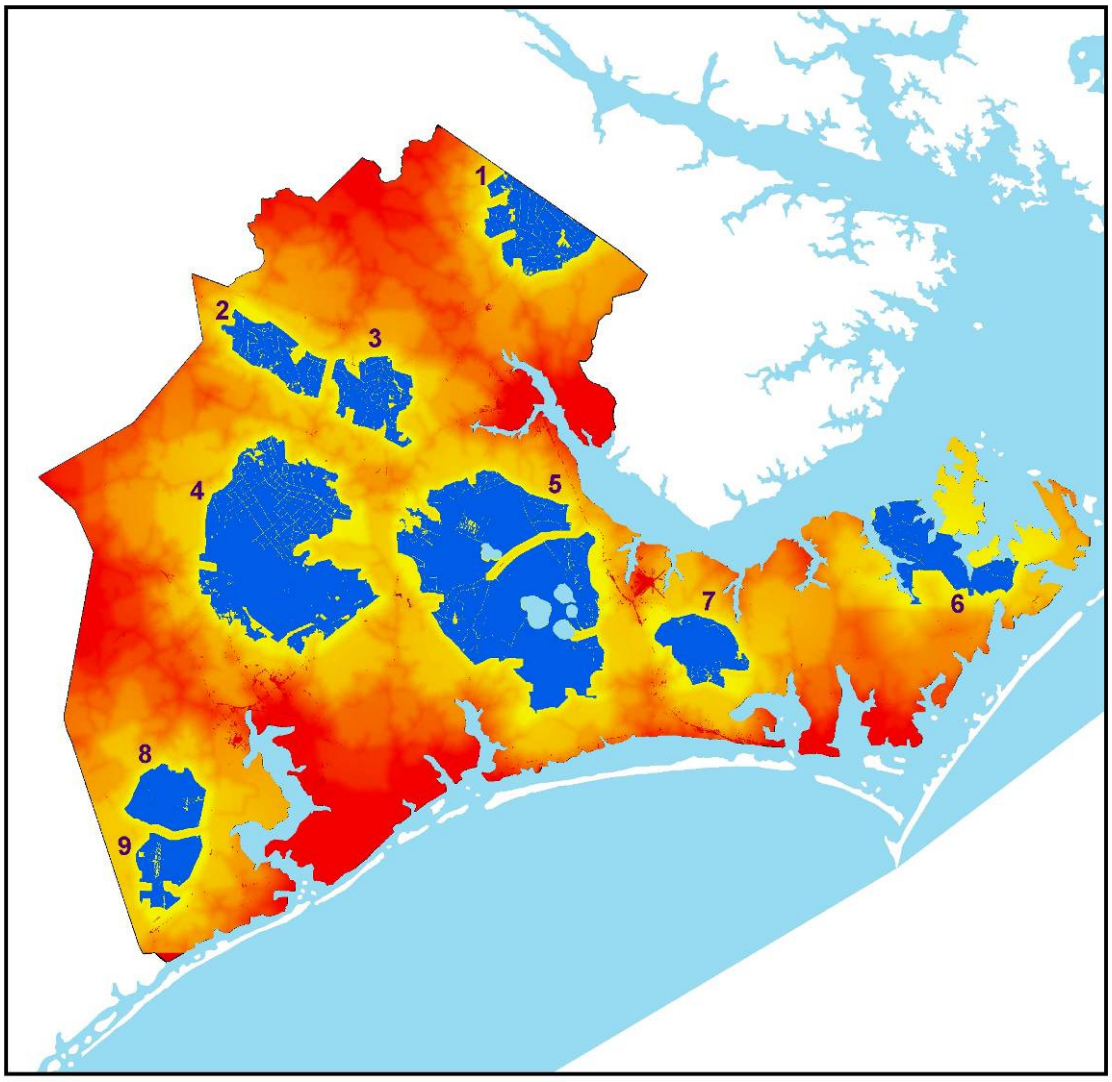
0 5 10 20 30 40 Kilometers

Projection: NAD 1983 UTM Zone 18N.

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Map Produced by Jon Shaffer, April 2007.

Figure 3. Travel Cost from Core Habitat Patches



Legend

Core habitat patches

Travel Cost

High

Low

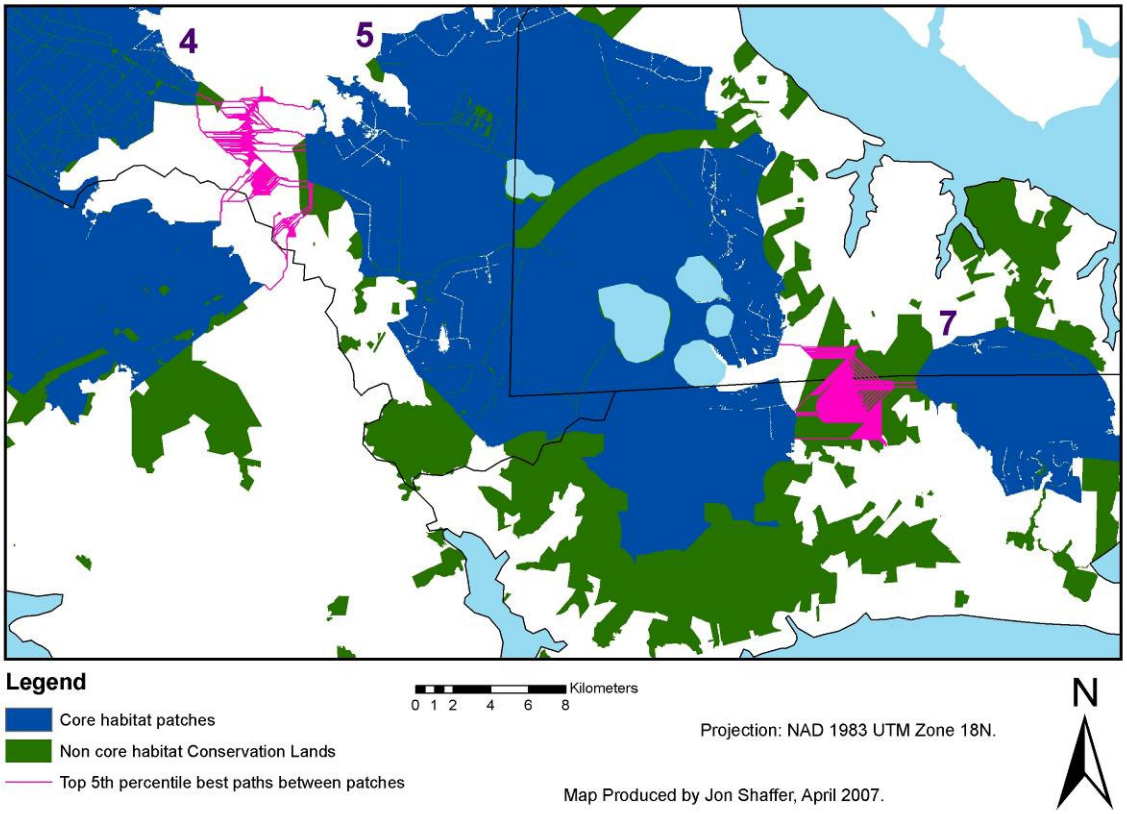
0 5 10 20 30 40 Kilometers

N

Projection: NAD 1983 UTM Zone 18N.

Map Produced by Jon Shaffer, April 2007.

Figure 4. Optimal Corridors between Habitat Patches 4, 5, and 7.



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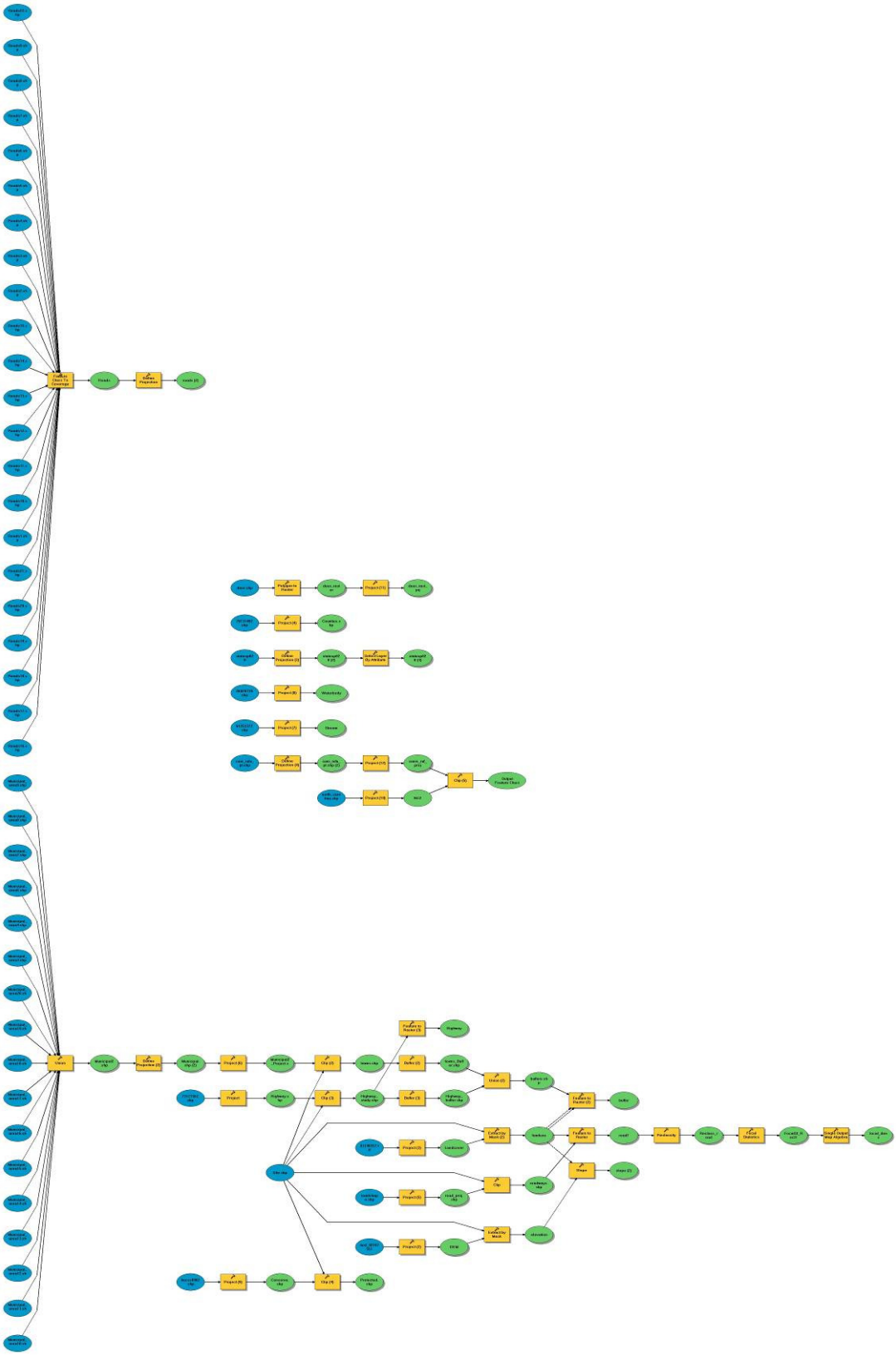
I would like to thank the North Carolina Wildlife Resources Commission for providing me with deer density data. I would also like to thank Dr. Jennifer Swenson for allowing me to turn this report in late.

Table 1. Cost Surface Assignment for Study Site	
Landcover Surface	***Cost***
Open Water	10
Developed, Open Space	8
Developed, Low Intensity	10
Developed, Medium Intensity	No Data
Developed, High Intensity	No Data
Barren Land	8
Deciduous Forest	1
Evergreen Forest	1
Mixed Forest	1
Shrub/Scrub	1
Grassland/Herbaceous	3
Pasture/Hay	6
Cultivated Crops	7
Woody Wetlands	1
Herbaceous Wetlands	1
Road Density Surface (km/km^2)	***Cost***
0 - 0.25	0
0.25 - 0.5	5
> 0.5	10
Highway Surface	***Cost***
Highway Presence	5
Highway Absence	0

Table 2. Summary Statistics of Core Habitat Patches			
Core Patch #	*Area (ha)*	*Area (ha) in Conservation*	*% Protected*
1	9,063.18	-	0.0%
2	5,996.70	-	0.0%
3	6,593.04	-	0.0%
4	34,496.28	27,775.26	80.5%
5	43,184.25	31,142.79	72.1%
6	9,181.17	368.64	4.0%
7	6,334.92	4,547.43	71.8%
8	5,918.67	-	0.0%
9	4,796.73	-	0.0%
Total	125,564.94	63,834.12	50.8%

Table 3. Summary Statistics of Suitable Habitat Patches			
Core Patch #	*Area (ha)*	*Area (ha) in Conservation*	*% Protected*
4	34,496.28	27,775.26	80.5%
5	43,184.25	31,142.79	72.1%
7	6,334.92	4,547.43	71.8%
Total	84,015.45	63,465.48	75.5%

Appendix A: Data Preparation Model and Scripts



```
# Import system modules
import sys, string, os, arcgisscripting

# Create the Geoprocessor object
gp = arcgisscripting.create()

# Set the necessary product code
gp.SetProduct("ArcInfo")

# Check out any necessary licenses
gp.CheckOutExtension("spatial")

# Load required toolboxes...
gp.AddToolbox("C:/Program Files/ArcGIS/ArcToolbox/Toolboxes/Spatial
Analyst Tools.tbx")
gp.AddToolbox("C:/Program Files/ArcGIS/ArcToolbox/Toolboxes/Conversion
Tools.tbx")
gp.AddToolbox("C:/Program Files/ArcGIS/ArcToolbox/Toolboxes/Data
Management Tools.tbx")
gp.AddToolbox("C:/Program Files/ArcGIS/ArcToolbox/Toolboxes/Analysis
Tools.tbx")

# Set the Geoprocessing environment...
gp.cellSize = "z:\\classes\\ENV261\\Project\\Data\\landuse"
gp.mask = "z:\\classes\\ENV261\\Project\\Data\\landuse"


# Local variables...
Roads = "z:\\classes\\ENV261\\Project\\scratch\\roads"
roads__2_ = "z:\\classes\\ENV261\\Project\\scratch\\roads"
Municipal2_shp =
"z:\\classes\\ENV261\\Project\\scratch\\Municipal2.shp"
Municipal_shp__2_ =
"z:\\classes\\ENV261\\Project\\scratch\\Municipal2.shp"
ned_92187551 = "ned_92187551"
v61246557_tif = "61246557.tif"
Highway_shp = "z:\\classes\\ENV261\\Project\\Highway.shp"
DEM = "z:\\classes\\ENV261\\Project\\dem"
Landcover = "z:\\classes\\ENV261\\Project\\Landcover"
Counties_shp = "z:\\classes\\ENV261\\Project\\Counties.shp"
Roads16_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads16.shp"
Roads17_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads17.shp"
Roads18_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads18.shp"
Roads19_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads19.shp"
Roads20_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads20.shp"
Roads21_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads21.shp"
Roads1_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads1.shp"
Roads10_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads10.shp"
Roads11_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads11.shp"
Roads12_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads12.shp"
Roads13_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads13.shp"
Roads14_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads14.shp"
Roads15_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads15.shp"
Roads2_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads2.shp"
Roads3_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads3.shp"
Roads4_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads4.shp"
Roads5_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads5.shp"
```

```
Roads6_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads6.shp"
Roads7_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads7.shp"
Roads8_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads8.shp"
Roads9_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads9.shp"
road_proj_shp = "z:\\classes\\ENV261\\Project\\road_proj.shp"
roadways_shp = "z:\\classes\\ENV261\\Project\\Data\\roadways.shp"
Site_shp = "z:\\classes\\ENV261\\Project\\Data\\Site.shp"
elevation = "z:\\classes\\ENV261\\Project\\Data\\elevation"
landuse = "z:\\classes\\ENV261\\Project\\Data\\landuse"
Municipal_area10_shp =
"z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area10.shp"
Municipal_area11_shp =
"z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area11.shp"
Municipal_area12_shp =
"z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area12.shp"
Municipal_area13_shp =
"z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area13.shp"
Municipal_area14_shp =
"z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area14.shp"
Municipal_area15_shp =
"z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area15.shp"
Municipal_area16_shp =
"z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area16.shp"
Municipal_area17_shp =
"z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area17.shp"
Municipal_area18_shp =
"z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area18.shp"
Municipal_area19_shp =
"z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area19.shp"
Municipal_area20_shp =
"z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area20.shp"
Municipal_area3_shp =
"z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area3.shp"
Municipal_area4_shp =
"z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area4.shp"
Municipal_area6_shp =
"z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area6.shp"
Municipal_area7_shp =
"z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area7.shp"
Municipal_area8_shp =
"z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area8.shp"
Municipal_area9_shp =
"z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area9.shp"
Municipal2_Project_shp =
"z:\\classes\\ENV261\\Project\\scratch\\Municipal2_Project.shp"
towns_shp = "z:\\classes\\ENV261\\Project\\Data\\towns.shp"
v61253372_shp =
"z:\\classes\\ENV261\\Project\\shapefiles\\streams\\61253372.shp"
Stream = "z:\\classes\\ENV261\\Project\\Data\\Stream"
Highway_study_shp =
"z:\\classes\\ENV261\\Project\\Data\\Highway_study.shp"
v26828739_shp =
"z:\\classes\\ENV261\\Project\\shapefiles\\waterbodies\\26828739.shp"
Waterbody = "z:\\classes\\ENV261\\Project\\Data\\Waterbody"
Roads22_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads22.shp"
roadshape_shp = "z:\\classes\\ENV261\\Project\\scratch\\roadshape.shp"
road1 = "z:\\classes\\ENV261\\Project\\scratch\\road1"
```

```
Reclass_road = "z:\\classes\\ENV261\\Project\\scratch\\Reclass_road"
FocalSt_Recl1 = "z:\\classes\\ENV261\\Project\\scratch\\focalst_recl1"
local_dens = "z:\\classes\\ENV261\\Project\\scratch\\local_dens"
towns_Buffer_shp =
"z:\\classes\\ENV261\\Project\\scratch\\towns_Buffer.shp"
slope__2_ = "z:\\classes\\ENV261\\Project\\Data\\slope"
Highway_buffer_shp =
"z:\\classes\\ENV261\\Project\\scratch\\Highway_buffer.shp"
buffers_shp = "z:\\classes\\ENV261\\Project\\scratch\\buffers.shp"
buffer = "z:\\classes\\ENV261\\Project\\scratch\\buffer"
lmcos0902_shp =
"z:\\classes\\ENV261\\Project\\Conservation\\Cons\\lmcos0902.shp"
Protected_shp = "z:\\classes\\ENV261\\Project\\Data\\Protected.shp"
Conserve_shp = "z:\\classes\\ENV261\\Project\\Data\\Conserve.shp"
Highway = "z:\\classes\\ENV261\\Project\\scratch\\highway"
statesp020 = "statesp020"
statesp020__2_ = "statesp020"
statesp020__3_ = "statesp020"
NC2 = "z:\\classes\\ENV261\\Project\\scratch\\NC2"
v79131492_shp =
"z:\\classes\\ENV261\\Project\\shapefiles\\counties_east\\79131492.shp"
v73121562_shp =
"z:\\classes\\ENV261\\Project\\shapefiles\\roads_east\\73121562.shp"
deer_shp = "z:\\classes\\ENV261\\Project\\scratch\\deer.shp"
deer_raster = "z:\\classes\\ENV261\\Project\\scratch\\deer_raster"
deer_rast_prj = "z:\\classes\\ENV261\\Project\\scratch\\deer_rast_prj"
cani_rufu_pl_shp = "z:\\classes\\ENV261\\Project\\shapefiles\\red
wolf\\cani_rufu_pl.shp"
canis_ruf_proj =
"z:\\classes\\ENV261\\Project\\scratch\\canis_ruf_proj"
cani_rufu_pl_shp__2_ = "z:\\classes\\ENV261\\Project\\shapefiles\\red
wolf\\cani_rufu_pl.shp"
Output_Feature_Class =
"z:\\classes\\ENV261\\Project\\scratch\\canis_ruf_proj_Clip1.shp"
north_carolina_shp__2_ =
"z:\\classes\\ENV261\\Project\\scratch\\north_carolina.shp"

# Process: Feature Class To Coverage...
gp.FeatureclassToCoverage_conversion("z:\\classes\\ENV261\\Project\\NC_
flood\\Roads17.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads16.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads18.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads19.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads20.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads21.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads1.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads10.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads11.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads12.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads13.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads14.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads15.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads2.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads3.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads4.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads5.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads6.shp
```

```
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads7.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads8.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads9.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads22.shp ROUTE",
Roads, "", "DOUBLE")

# Process: Define Projection...
gp.DefineProjection_management(Roads,
"PROJCS['NAD_1983_StatePlane_North_Carolina_FIPS_3200_Feet',GEOGCS['GCS
_North_American_1983',DATUM['D_North_American_1983',SPHEROID['GRS_1980'
,6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['Degree',0.0174
532925199433]],PROJECTION['Lambert_Conformal_Conic'],PARAMETER['False_E
asting',2000000.002616666],PARAMETER['False_Northing',0.0],PARAMETER['C
entral_Meridian',-
79.0],PARAMETER['Standard_Parallel_1',34.33333333333334],PARAMETER['Sta
ndard_Parallel_2',36.16666666666666],PARAMETER['Latitude_Of_Origin',33.
75],UNIT['Foot_US',0.3048006096012192]]")

# Process: Project (4)...
gp.Project_management(v79131492_shp, Counties_shp,
"PROJCS['NAD_1983_UTM_Zone_18N',GEOGCS['GCS_North_American_1983',DATUM[
'D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['T
ransverse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER['Fal
se_Northing',0.0],PARAMETER['Central_Meridian',-
75.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0
.0],UNIT['Meter',1.0]]", "",
"GEOGCS['GCS_North_American_1983',DATUM['D_North_American_1983',SPHEROI
D['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['De
gree',0.0174532925199433]]")

# Process: Project (7)...
gp.Project_management(v61253372_shp, Stream,
"PROJCS['NAD_1983_UTM_Zone_18N',GEOGCS['GCS_North_American_1983',DATUM[
'D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['T
ransverse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER['Fal
se_Northing',0.0],PARAMETER['Central_Meridian',-
75.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0
.0],UNIT['Meter',1.0]]", "",
"GEOGCS['GCS_North_American_1983',DATUM['D_North_American_1983',SPHEROI
D['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['De
gree',0.0174532925199433]]")

# Process: Project (8)...
gp.Project_management(v26828739_shp, Waterbody,
"PROJCS['NAD_1983_UTM_Zone_18N',GEOGCS['GCS_North_American_1983',DATUM[
'D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['T
ransverse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER['Fal
se_Northing',0.0],PARAMETER['Central_Meridian',-
75.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0
.0],UNIT['Meter',1.0]]", "",
"GEOGCS['GCS_North_American_1983',DATUM['D_North_American_1983',SPHEROI
D['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['De
gree',0.0174532925199433]]")
```

```
# Process: Project (5)...
gp.Project_management(roadshape_shp, road_proj_shp,
"PROJCS['NAD_1983_UTM_Zone_18N',GEOGCS['GCS_North_American_1983',DATUM[
'D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['T
ransverse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER['Fal
se_Northing',0.0],PARAMETER['Central_Meridian',-
75.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0
.0],UNIT['Meter',1.0]]", "",
"PROJCS['NAD_1983_StatePlane_North_Carolina_FIPS_3200_Feet',GEOGCS['GCS
_North_American_1983',DATUM['D_North_American_1983',SPHEROID['GRS_1980'
,6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['Degree',0.0174
532925199433]],PROJECTION['Lambert_Conformal_Conic'],PARAMETER['False_E
asting',2000000.002616666],PARAMETER['False_Northing',0.0],PARAMETER['C
entral_Meridian',-
79.0],PARAMETER['Standard_Parallel_1',34.33333333333334],PARAMETER['Sta
ndard_Parallel_2',36.16666666666666],PARAMETER['Latitude_Of_Origin',33.
75],UNIT['Foot_US',0.3048006096012192]]")

# Process: Clip...
gp.Clip_analysis(road_proj_shp, Site_shp, roadways_shp, "")

# Process: Project (3)...
gp.ProjectRaster_management(v61246557_tif, Landcover,
"PROJCS['NAD_1983_UTM_Zone_18N',GEOGCS['GCS_North_American_1983',DATUM[
'D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['T
ransverse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER['Fal
se_Northing',0.0],PARAMETER['Central_Meridian',-
75.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0
.0],UNIT['Meter',1.0]];-5120900 -9998100
450445547.391054;#;#;0.001;#;#;IsHighPrecision", "NEAREST", "30", "",
"",
"PROJCS['USA_Contiguous_Albers_Equal_Area_Conic_USGS_version',GEOGCS['G
CS_North_American_1983',DATUM['D_North_American_1983',SPHEROID['GRS_198
0',6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['Degree',0.01
74532925199433]],PROJECTION['Albers'],PARAMETER['False_Easting',0.0],PA
RAMETER['False_Northing',0.0],PARAMETER['Central_Meridian',-
96.0],PARAMETER['Standard_Parallel_1',29.5],PARAMETER['Standard_Paralle
l_2',45.5],PARAMETER['Latitude_Of_Origin',23.0],UNIT['Meter',1.0]];-
16901100 -6972200 266467840.990852;#;#;0.001;#;#;IsHighPrecision")

# Process: Extract by Mask (2)...
gp.ExtractByMask_sa(Landcover, Site_shp, landuse)

# Process: Feature to Raster...
gp.FeatureToRaster_conversion(roadways_shp, "LPOLY_", road1, landuse)

# Process: Reclassify...
gp.Reclassify_sa(road1, "VALUE", "0 1;NODATA 0", Reclass_road, "DATA")

# Process: Focal Statistics...
gp.FocalStatistics_sa(Reclass_road, FocalSt_Recl1, "Rectangle 1000 1000
MAP", "SUM", "DATA")

# Process: Single Output Map Algebra...
```

```
gp.SingleOutputMapAlgebra_sa("z:\\classes\\ENV261\\Project\\scratch\\fo
calst_recl1*0.03", local_dens,
"z:\\classes\\ENV261\\Project\\scratch\\focalst_recl1")

# Process: Project (2)...
gp.ProjectRaster_management(ned_92187551, DEM,
"PROJCS['NAD_1983_UTM_Zone_18N',GEOGCS['GCS_North_American_1983',DATUM[
'D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['T
ransverse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER['Fal
se_Northing',0.0],PARAMETER['Central_Meridian',-
75.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0
.0],UNIT['Meter',1.0]];-5120900 -9998100
450445547.391054;#;#;0.001;#;#;IsHighPrecision", "NEAREST", "<Null>",
"", "",
"GEOGCS['GCS_North_American_1983',DATUM['D_North_American_1983',SPHEROI
D['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['De
gree',0.0174532925199433]],VERTCS['Unknown VCS from ArcInfo
Workstation',VDATUM['Unknown'],PARAMETER['Vertical_Shift',0.0],PARAMETE
R['Direction',1.0],UNIT['Meter',1.0]];-400 -400
11258999068426.2;#;#;8.98315284119521E-09;#;#;IsHighPrecision")

# Process: Extract by Mask...
gp.ExtractByMask_sa(DEM, Site_shp, elevation)

# Process: Slope...
tempEnvironment0 = gp.cellSize
gp.cellSize = "z:\\classes\\ENV261\\Project\\Data\\landuse"
gp.Slope_sa(elevation, slope__2_, "DEGREE", "1")
gp.cellSize = tempEnvironment0

# Process: Union...
gp.Union_analysis("z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_ar
ea10.shp #;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area11.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area12.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area13.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area14.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area15.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area16.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area17.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area18.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area19.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area20.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area3.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area4.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area6.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area7.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area8.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area9.shp #",
Municipal2_shp, "ALL", "", "GAPS")

# Process: Define Projection (2)...
gp.DefineProjection_management(Municipal2_shp,
"PROJCS['NAD_1983_StatePlane_North_Carolina_FIPS_3200_Feet',GEOGCS['GCS
_North_American_1983',DATUM['D_North_American_1983',SPHEROID['GRS_1980'
,6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['Degree',0.0174
532925199433]],PROJECTION['Lambert_Conformal_Conic'],PARAMETER['False_E
```

```
asting',2000000.002616666],PARAMETER['False_Northing',0.0],PARAMETER['C
entral_Meridian',-
79.0],PARAMETER['Standard_Parallel_1',34.33333333333334],PARAMETER['Sta
ndard_Parallel_2',36.16666666666666],PARAMETER['Latitude_Of_Origin',33.
75],UNIT['Foot_US',0.3048006096012192]]")

# Process: Project (6)...
gp.Project_management(Municipal_shp__2_, Municipal2_Project_shp,
"PROJCS['NAD_1983_UTM_Zone_18N',GEOGCS['GCS_North_American_1983',DATUM[
'D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['T
ransverse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER['Fal
se_Northing',0.0],PARAMETER['Central_Meridian',-
75.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0
.0],UNIT['Meter',1.0]]", "",
"PROJCS['NAD_1983_StatePlane_North_Carolina_FIPS_3200_Feet',GEOGCS['GCS
_North_American_1983',DATUM['D_North_American_1983',SPHEROID['GRS_1980'
,6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['Degree',0.0174
532925199433]],PROJECTION['Lambert_Conformal_Conic'],PARAMETER['False_E
asting',2000000.002616666],PARAMETER['False_Northing',0.0],PARAMETER['C
entral_Meridian',-
79.0],PARAMETER['Standard_Parallel_1',34.33333333333334],PARAMETER['Sta
ndard_Parallel_2',36.16666666666666],PARAMETER['Latitude_Of_Origin',33.
75],UNIT['Foot_US',0.3048006096012192]]")

# Process: Clip (2)...
gp.Clip_analysis(Municipal2_Project_shp, Site_shp, towns_shp, "")

# Process: Buffer (2)...
tempEnvironment0 = gp.newPrecision
gp.newPrecision = "SINGLE"
tempEnvironment1 = gp.XYResolution
gp.XYResolution = ""
tempEnvironment2 = gp.scratchWorkspace
gp.scratchWorkspace = "z:\\classes\\ENV261\\Project\\scratch"
tempEnvironment3 = gp.MTolerance
gp.MTolerance = ""
tempEnvironment4 = gp.randomGenerator
gp.randomGenerator = "0 ACM599"
tempEnvironment5 = gp.outputCoordinateSystem
gp.outputCoordinateSystem = ""
tempEnvironment6 = gp.projectCompare
gp.projectCompare = "NONE"
tempEnvironment7 = gp.outputZFlag
gp.outputZFlag = "Same As Input"
tempEnvironment8 = gp.qualifiedFieldNames
gp.qualifiedFieldNames = "true"
tempEnvironment9 = gp.extent
gp.extent = "DEFAULT"
tempEnvironment10 = gp.XYTolerance
gp.XYTolerance = ""
tempEnvironment11 = gp.outputZValue
gp.outputZValue = ""
tempEnvironment12 = gp.outputMFlag
gp.outputMFlag = "Same As Input"
tempEnvironment13 = gp.geographicTransformations
gp.geographicTransformations = ""
```

```
tempEnvironment14 = gp.ZResolution
gp.ZResolution = ""
tempEnvironment15 = gp.workspace
gp.workspace = "z:\\classes\\ENV261\\Project\\Data"
tempEnvironment16 = gp.MResolution
gp.MResolution = ""
tempEnvironment17 = gp.derivedPrecision
gp.derivedPrecision = "HIGHEST"
tempEnvironment18 = gp.ZTolerance
gp.ZTolerance = ""
gp.Buffer_analysis(towns_shp, towns_Buffer_shp, "2 Kilometers", "FULL",
"ROUND", "ALL", "")
gp.newPrecision = tempEnvironment0
gp.XYResolution = tempEnvironment1
gp.scratchWorkspace = tempEnvironment2
gp.MTolerance = tempEnvironment3
gp.randomGenerator = tempEnvironment4
gp.outputCoordinateSystem = tempEnvironment5
gp.projectCompare = tempEnvironment6
gp.outputZFlag = tempEnvironment7
gp.qualifiedFieldNames = tempEnvironment8
gp.extent = tempEnvironment9
gp.XYTolerance = tempEnvironment10
gp.outputZValue = tempEnvironment11
gp.outputMFlag = tempEnvironment12
gp.geographicTransformations = tempEnvironment13
gp.ZResolution = tempEnvironment14
gp.workspace = tempEnvironment15
gp.MResolution = tempEnvironment16
gp.derivedPrecision = tempEnvironment17
gp.ZTolerance = tempEnvironment18

# Process: Project...
gp.Project_management(v73121562_shp, Highway_shp,
"PROJCS['NAD_1983_UTM_Zone_18N',GEOGCS['GCS_North_American_1983',DATUM[
'D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['T
ransverse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER['Fal
se_Northing',0.0],PARAMETER['Central_Meridian',-
75.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0
.0],UNIT['Meter',1.0]]", "",
"GEOGCS['GCS_North_American_1983',DATUM['D_North_American_1983',SPHEROI
D['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['De
gree',0.0174532925199433]]")

# Process: Clip (3)...
gp.Clip_analysis(Highway_shp, Site_shp, Highway_study_shp, "")

# Process: Buffer (3)...
gp.Buffer_analysis(Highway_study_shp, Highway_buffer_shp, "1
Kilometers", "FULL", "ROUND", "NONE", "")

# Process: Union (2)...
gp.Union_analysis("z:\\classes\\ENV261\\Project\\scratch\\towns_Buffer.
shp #;z:\\classes\\ENV261\\Project\\scratch\\Highway_buffer.shp #",
buffers_shp, "ALL", "", "GAPS")
```

```
# Process: Feature to Raster (2)...
tempEnvironment0 = gp.cellSize
gp.cellSize = "z:\\classes\\ENV261\\Project\\Data\\landuse"
tempEnvironment1 = gp.mask
gp.mask = "z:\\classes\\ENV261\\Project\\Data\\landuse"
gp.FeatureToRaster_conversion(buffers_shp, "Id", buffer, "30")
gp.cellSize = tempEnvironment0
gp.mask = tempEnvironment1

# Process: Project (9)...
gp.Project_management(lmcos0902_shp, Conserve_shp,
"PROJCS['NAD_1983_UTM_Zone_18N',GEOGCS['GCS_North_American_1983',DATUM[
'D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['T
ransverse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER['Fal
se_Northing',0.0],PARAMETER['Central_Meridian',-
75.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0
.0],UNIT['Meter',1.0]]", "",
"PROJCS['NAD_1983_StatePlane_North_Carolina_FIPS_3200',GEOGCS['GCS_Nort
h_American_1983',DATUM['D_North_American_1983',SPHEROID['GRS_1980',6378
137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['Degree',0.017453292
5199433]],PROJECTION['Lambert_Conformal_Conic'],PARAMETER['False_Eastin
g',609601.22],PARAMETER['False_Northing',0.0],PARAMETER['Central_Meridi
an',-
79.0],PARAMETER['Standard_Parallel_1',34.33333333333334],PARAMETER['Sta
ndard_Parallel_2',36.16666666666666],PARAMETER['Latitude_Of_Origin',33.
75],UNIT['Meter',1.0]]")

# Process: Clip (4)...
gp.Clip_analysis(Conserve_shp, Site_shp, Protected_shp, "")

# Process: Feature to Raster (3)...
gp.FeatureToRaster_conversion(Highway_study_shp, "NAME", Highway, "30")

# Process: Define Projection (3)...
gp.DefineProjection_management(statesp020,
"GEOGCS['GCS_North_American_1983',DATUM['D_North_American_1983',SPHEROI
D['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['De
gree',0.0174532925199433]]")

# Process: Select Layer By Attribute...
gp.SelectLayerByAttribute_management(statesp020__2_, "NEW_SELECTION",
"\"STATE\" = 'North Carolina'")

# Process: Polygon to Raster...
gp.PolygonToRaster_conversion(deer_shp, "Dens_km", deer_raster,
"CELL_CENTER", "NONE", "30")

# Process: Project (11)...
gp.ProjectRaster_management(deer_raster, deer_rast_prj,
"PROJCS['NAD_1983_UTM_Zone_18N',GEOGCS['GCS_North_American_1983',DATUM[
'D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['T
ransverse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER['Fal
se_Northing',0.0],PARAMETER['Central_Meridian',-
75.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0
.0],UNIT['Meter',1.0]];-5120900 -9998100
```

```
450445547.391054;#;#;0.001;#;#;IsHighPrecision", "NEAREST", "30", "",
"",
"PROJCS['NAD_1983_UTM_Zone_17N',GEOGCS['GCS_North_American_1983',DATUM[
'D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['T
ransverse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER['Fal
se_Northing',0.0],PARAMETER['Central_Meridian',-
81.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0
.0],UNIT['Meter',1.0]];-5120900 -9998100
450445547.391054;#;#;0.001;#;#;IsHighPrecision")

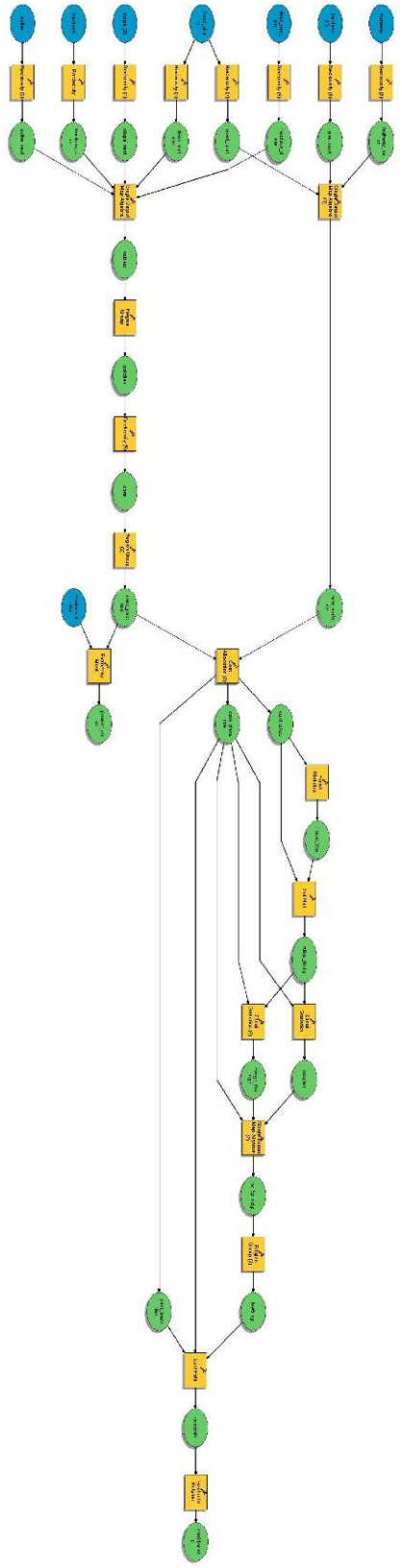
# Process: Define Projection (4)...
gp.DefineProjection_management(cani_rufu_pl_shp,
"GEOGCS['GCS_North_American_1983',DATUM['D_North_American_1983',SPHEROI
D['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['De
gree',0.0174532925199433]]")

# Process: Project (12)...
gp.Project_management(cani_rufu_pl_shp__2_, canis_ruf_proj,
"PROJCS['NAD_1983_UTM_Zone_18N',GEOGCS['GCS_North_American_1983',DATUM[
'D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['T
ransverse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER['Fal
se_Northing',0.0],PARAMETER['Central_Meridian',-
75.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0
.0],UNIT['Meter',1.0]]", "",
"GEOGCS['GCS_North_American_1983',DATUM['D_North_American_1983',SPHEROI
D['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['De
gree',0.0174532925199433]]")

# Process: Project (10)...
gp.Project_management(north_carolina_shp__2_, NC2,
"PROJCS['NAD_1983_UTM_Zone_18N',GEOGCS['GCS_North_American_1983',DATUM[
'D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['T
ransverse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER['Fal
se_Northing',0.0],PARAMETER['Central_Meridian',-
75.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0
.0],UNIT['Meter',1.0]]", "",
"GEOGCS['GCS_North_American_1983',DATUM['D_North_American_1983',SPHEROI
D['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['De
gree',0.0174532925199433]]")

# Process: Clip (5)...
gp.Clip_analysis(canis_ruf_proj, NC2, Output_Feature_Class, "")
```

Appendix B: Analysis Model and Scripts



```
# Import system modules
import sys, string, os, arcgisscripting

# Create the Geoprocessor object
gp = arcgisscripting.create()

# Check out any necessary licenses
gp.CheckOutExtension("spatial")

# Load required toolboxes...
gp.AddToolbox("C:/Program Files/ArcGIS/ArcToolbox/Toolboxes/Spatial
Analyst Tools.tbx")
gp.AddToolbox("C:/Program Files/ArcGIS/ArcToolbox/Toolboxes/Conversion
Tools.tbx")

# Set the Geoprocessing environment...
gp.XYResolution = ""
gp.scratchWorkspace = "z:\\classes\\ENV261\\Project\\scratch"
gp.MTolerance = ""
gp.randomGenerator = "0 ACM599"
gp.outputCoordinateSystem = ""
gp.outputZFlag = "Same As Input"
gp.qualifiedFieldNames = "true"
gp.extent = "798393.534402281 3818666.10197191 931413.534402281
3926216.10197191"
gp.XYTolerance = ""
gp.cellSize = "30"
gp.outputZValue = ""
gp.outputMFlag = "Same As Input"
gp.geographicTransformations = ""
gp.ZResolution = ""
gp.mask = "landuse"
gp.workspace = "z:\\classes\\ENV261\\Project\\Data"
gp.MResolution = ""
gp.ZTolerance = ""


# Local variables...
buffer = "z:\\classes\\ENV261\\Project\\scratch\\buffer"
landuse = "z:\\classes\\ENV261\\Project\\Data\\landuse"
local_dens = "z:\\classes\\ENV261\\Project\\scratch\\local_dens"
landcov_cor = "z:\\classes\\ENV261\\Project\\scratch\\landcov_cor"
buffer_recl = "z:\\classes\\ENV261\\Project\\scratch\\buffer_recl"
dens_reclass = "z:\\classes\\ENV261\\Project\\scratch\\dens_reclass"
slope_recl = "z:\\classes\\ENV261\\Project\\scratch\\slope_recl"
habitat = "z:\\classes\\ENV261\\Project\\Data\\habitat"
patches = "z:\\classes\\ENV261\\Project\\scratch\\patches"
core = "z:\\classes\\ENV261\\Project\\Data\\core"
core_patches = "z:\\classes\\ENV261\\Project\\Data\\core_patches"
landuse__2_ = "z:\\classes\\ENV261\\Project\\Data\\landuse"
land_cost = "z:\\classes\\ENV261\\Project\\scratch\\land_cost"
cost_alloc = "z:\\classes\\ENV261\\Project\\scratch\\cost_alloc"
cost_distance = "z:\\classes\\ENV261\\Project\\Data\\cost_distance"
cost_backlink = "z:\\classes\\ENV261\\Project\\Data\\cost_backlink"
Focal_Var = "z:\\classes\\ENV261\\Project\\scratch\\Focal_Var"
Alloc_Ridg = "z:\\classes\\ENV261\\Project\\Data\\Alloc_Ridg"
ridgmin = "z:\\classes\\ENV261\\Project\\scratch\\ridgmin"
```

```
Ridge_Range = "z:\\classes\\ENV261\\Project\\scratch\\Ridge_Range"
lw_5p_ridg = "z:\\classes\\ENV261\\Project\\scratch\\lw_5p_ridg"
low5_rg = "z:\\classes\\ENV261\\Project\\scratch\\low5_rg"
costpath = "z:\\classes\\ENV261\\Project\\Data\\costpath"
road_cost = "z:\\classes\\ENV261\\Project\\scratch\\road_cost"
highway = "z:\\classes\\ENV261\\Project\\scratch\\highway"
highway_cost = "z:\\classes\\ENV261\\Project\\scratch\\highway_cost"
cost_surface = "z:\\classes\\ENV261\\Project\\scratch\\cost_surface"
slope__2_ = "z:\\classes\\ENV261\\Project\\Data\\slope"
protect_core = "z:\\classes\\ENV261\\Project\\scratch\\protect_core"
Protected_shp = "z:\\classes\\ENV261\\Project\\Data\\Protected.shp"
deer_rast_prj = "Z:\\classes\\ENV261\\Project\\scratch\\deer_rast_prj"
Reclass_deer = "z:\\classes\\ENV261\\Project\\scratch\\Reclass_deer"
corridor_shp = "z:\\classes\\ENV261\\Project\\Data\\corridor.shp"

# Process: Reclassify (2)...
gp.Reclassify_sa(buffer, "VALUE", "0 NODATA;NODATA 0", buffer_recl,
"DATA")

# Process: Reclassify (4)...
gp.Reclassify_sa(slope__2_, "Value", "0 20 0;20 30 NODATA", slope_recl,
"DATA")

# Process: Reclassify...
gp.Reclassify_sa(landuse, "VALUE", "11 NODATA;21 NODATA;21 24 NODATA;24
31 NODATA;41 43 0;43 52 0;52 71 0;81 82 NODATA;90 95 0", landcov_cor,
"DATA")

# Process: Reclassify (3)...
gp.Reclassify_sa(local_dens, "Value", "0 0.25 0;0.25 17.600000000000001
NODATA", dens_reclass, "DATA")

# Process: Reclassify (9)...
gp.Reclassify_sa(deer_rast_prj, "Value", "0 NODATA;0 5 NODATA;5
17.374500274658203 0", Reclass_deer, "DATA")

# Process: Single Output Map Algebra...
gp.SingleOutputMapAlgebra_sa("z:\\classes\\ENV261\\Project\\scratch\\bu
ffer_recl+z:\\classes\\ENV261\\Project\\scratch\\dens_reclass+z:\\class
es\\ENV261\\Project\\scratch\\slope_recl+z:\\classes\\ENV261\\Project\\
scratch\\landcov_cor +
z:\\classes\\ENV261\\Project\\scratch\\reclass_deer", habitat,
"z:\\classes\\ENV261\\Project\\scratch\\buffer_recl;z:\\classes\\ENV261
\\Project\\scratch\\slope_recl;z:\\classes\\ENV261\\Project\\scratch\\l
andcov_cor;z:\\classes\\ENV261\\Project\\scratch\\dens_reclass;z:\\clas
ses\\ENV261\\Project\\scratch\\Reclass_deer")

# Process: Region Group...
gp.RegionGroup_sa(habitat, patches, "FOUR", "WITHIN", "ADD_LINK", "")

# Process: Reclassify (5)...
gp.Reclassify_sa(patches, "COUNT", "1 50666 NODATA;50667 500000 0",
core, "DATA")

# Process: Region Group (2)...
gp.RegionGroup_sa(core, core_patches, "FOUR", "WITHIN", "ADD_LINK", "")
```

```
# Process: Extract by Mask...
gp.ExtractByMask_sa(core_patches, Protected_shp, protect_core)

# Process: Reclassify (7)...
gp.Reclassify_sa(local_dens, "Value", "0 0.25 0;0.25 0.5 5;0.5
17.600000000000001 10", road_cost, "DATA")

# Process: Reclassify (8)...
gp.Reclassify_sa(highway, "VALUE", "1 14 5;NODATA 0", highway_cost,
"DATA")

# Process: Reclassify (6)...
gp.Reclassify_sa(landuse__2_, "VALUE", "11 10;21 8;22 10;23 NODATA;24
NODATA;31 8;41 52 1;71 3;81 6;82 7;90 95 1", land_cost, "DATA")

# Process: Single Output Map Algebra (3)...
gp.SingleOutputMapAlgebra_sa("z:\\classes\\ENV261\\Project\\scratch\\hi
ghway_cost + z:\\classes\\ENV261\\Project\\scratch\\land_cost +
z:\\classes\\ENV261\\Project\\scratch\\road_cost", cost_surface,
"z:\\classes\\ENV261\\Project\\scratch\\road_cost;z:\\classes\\ENV261\\
Project\\scratch\\highway_cost;z:\\classes\\ENV261\\Project\\scratch\\l
and_cost")

# Process: Cost Allocation (2)...
gp.CostAllocation_sa(core_patches, cost_surface, cost_alloc, "", "",
"VALUE", cost_distance, cost_backlink)

# Process: Focal Statistics...
gp.FocalStatistics_sa(cost_alloc, Focal_Var, "Rectangle 3 3 CELL",
"VARIETY", "DATA")

# Process: Set Null...
gp.SetNull_sa(Focal_Var, cost_alloc, Alloc_Ridg, "\"VALUE\" = 1")

# Process: Zonal Statistics...
gp.ZonalStatistics_sa(Alloc_Ridg, "VALUE", cost_distance, ridgmin,
"MINIMUM", "DATA")

# Process: Zonal Statistics (2)...
gp.ZonalStatistics_sa(Alloc_Ridg, "VALUE", cost_distance, Ridge_Range,
"RANGE", "DATA")

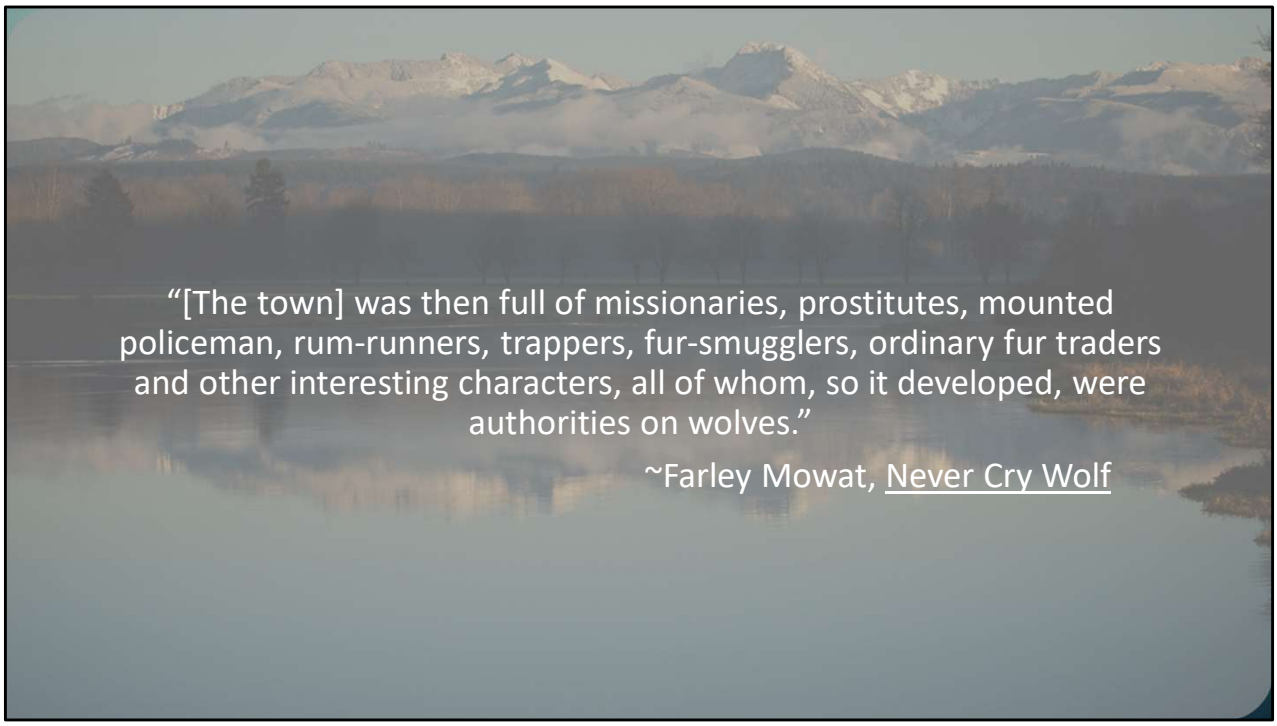
# Process: Single Output Map Algebra (2)...
gp.SingleOutputMapAlgebra_sa("Con(cost_distance <= (ridgmin +
(Ridge_Range / 20)) , 1)
", lw_5p_ridg,
"z:\\classes\\ENV261\\Project\\scratch\\ridgmin;z:\\classes\\ENV261\\Pr
oject\\scratch\\Ridge_Range;z:\\classes\\ENV261\\Project\\Data\\cost_di
stance")

# Process: Region Group (3)...
gp.RegionGroup_sa(lw_5p_ridg, low5_rg, "EIGHT", "WITHIN", "ADD_LINK",
"")

# Process: Cost Path...
gp.CostPath_sa(low5_rg, cost_distance, cost_backlink, costpath,
"EACH_CELL", "VALUE")
```

```
# Process: Raster to Polyline...
gp.RasterToPolyline_conversion(costpath, corridor_shp, "ZERO", "0",

"SIMPLIFY", "VALUE").
```


"[The town] was then full of missionaries, prostitutes, mounted policeman, rum-runners, trappers, fur-smugglers, ordinary fur traders and other interesting characters, all of whom, so it developed, were authorities on wolves."
~Farley Mowat, Never Cry Wolf

"We stress that the red wolf is a strikingly different animal from the coyote."

~Glynn Riley & Roy McBride (1972)



"We feel the difficulties described in the literature in distinguishing this animal from coyotes or hybrids are exaggerated from the true situation in the field."

~Glynn Riley and Roy McBride (1972)



DISPERSAL

- Coyotes: As pups (>9-10 months of age) [Bekoff (1986); Gese (1989); Harrison (1992).
- Red Wolves: As yearlings [27 months (males), 24 months (females)] [Phillips and Henry (2013). Study period (1987 – 1994).
- RW Average age (15.5 months); [Karlin and Chadwick (2011). Study Period (1990 – 2007).
  - High dispersal rates for red wolves are similar to grey wolves (Fritts and Mech, (1981), Petterson and Woolington (1984) and Boyd et al. (1995).
- Gray Wolves: As yearlings (Fuller, (1989)
  - Similar ages have been reported for gray wolves in Minnesota [Mech (1987); Alaska [Ballard et al. (1987); and Montana [Boyde et al, (1995).

Displacement

- Interference competition with gray wolves is an important factor influencing distribution and abundance of coyotes. [Thurber (1992); Peterson (1995)].
- Competition with gray wolves limits coyote populations. Wolves responsible for 56% of transient coyote deaths after introduction into YNP. 39% lower density of coyotes (<90% in wolf core areas). Dispersal rates of transient coyotes 117% higher in wolf areas vs. areas w/out wolves [Smith and Peterson (2003); Berger and Gese (2007)].
- Red wolves displaced (37) or killed (14) 51 placeholders in the NC NEP between the years of 1999 – 2013. No coyote or hybrid ever displaced a red wolf. Only red wolves displaced other red wolves. [Gese and Terletzky (2015)].

Diet

BEHAVIOR

BioOne RESEARCH EVOLVED

Effectiveness of GPS-Based Telemetry to Determine Temporal Changes in Habitat use and Home-Range Sizes of Red Wolves

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Effectiveness of GPS-based Telemetry to Determine Temporal Changes in Habitat Use and Home-range Sizes of Red Wolves

John Chadwick[1,*], Bud Fazio[2], and Melissa Karlin[1]

Abstract - Four adult male *Canis lupus rufus* (Red Wolf) were monitored with GPS collars in 2006–2008 on the Albemarle peninsula of North Carolina in the first high temporal resolution (4 locations/day) study of this endangered species in the wild. The Wolves occupied home ranges during 11–18 month observation periods, and the GPS data were divided into 30-day subsets to evaluate changes in the spatial characteristics of the home ranges over time. The subset location data were then combined with land-cover maps derived from Landsat satellite imagery. Proportions of different land-cover types occupied by the Wolves were seasonally cyclic, with increased use of agricultural areas when tall row crops were available from summer to autumn and increased use of adjacent grass, brush, and forest areas from winter to late spring when tall crops were absent. The spatial extents of home ranges (95% fixed-kernel probability areas) were also seasonally variable, reaching maximum sizes (73–121 km^2) in early autumn to winter and contracting by 40% to 63% during whelping and pup-rearing in the spring. Our study shows the potential for GPS collars to provide useful information about space and habitat use by Red Wolves, and that at least a full year of observation may be required to fully determine the variability of home-range characteristics.

Introduction

Canis lupus rufus Audubon and Bachman (Red Wolf) historically ranged over an extensive portion of the southeastern US, and possibly throughout the eastern woodlands to Maine (Nowak 1979, 2002; Paradiso and Nowak 1971; Riley and McBride 1972). Extermination and habitat loss dramatically reduced the population during the 19th and 20th centuries, and by the 1960s they only survived in isolated, marginal habitats in Texas and Louisiana (Carley 1975, Shaw 1975). On the verge of extinction, they were federally listed as endangered in 1967, and the remaining wild Wolves were brought into captivity between 1973 and 1980 to begin a captive-breeding program (McCarley and Carley 1979, USFWS 1990, van Manen et al. 2000). The Red Wolf was thought to be extinct in the wild by 1980 (McCarley and Carley 1979).

Based on morphological criteria, 14 founders were selected for the Red Wolf captive-breeding program. That program was successful, and 4 pairs of Wolves were reintroduced in the wild in 1987 on the Albemarle Peninsula in eastern North Carolina (Parker 1987, Phillips 1994). The reintroduction and ongoing management program have been successful, with annual counts

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between 114 and 131 individuals during 1999–2007, 10 to 22 wild breeding social groups, and 33 to 55 pups born per year. The reintroduced population is intensively managed by the USFWS. Although the Wolves are federally listed as an endangered species (USFWS 2007), this population is considered a non-essential experimental population (Parker and Phillips 1991).

The US Fish and Wildlife Service (USFWS) Red Wolf recovery and management area encompassed about 6900 km^2 in portions of 5 counties on the Albemarle Peninsula (Fig. 1). That area included Alligator River and Pocosin Lakes National Wildlife Refuges and private lands largely consisting of agriculture (corn, soybeans, and cotton in summer and fall, winter wheat in winter and spring) and managed pine plantations. Approximately half of the recovery area consisted of managed and native forests, but these were fragmented by farms, open areas due to recent timber management, and stands in various stages of regeneration. Cypress trees and pocosin wetlands dominated the coastal areas of the peninsula.

An animal's home range is the spatial expression of its survival and reproductive behaviors (Burt 1943), and can be influenced by seasonal environmental variation (Wingfield 2005). Previous studies of Red Wolf home-range characteristics were limited to durations of a few months using conventional radiotelemetry collars and abdominal transmitters (Beck 2005, Hinton 2006, Mauney 2005). These studies revealed that Red Wolves

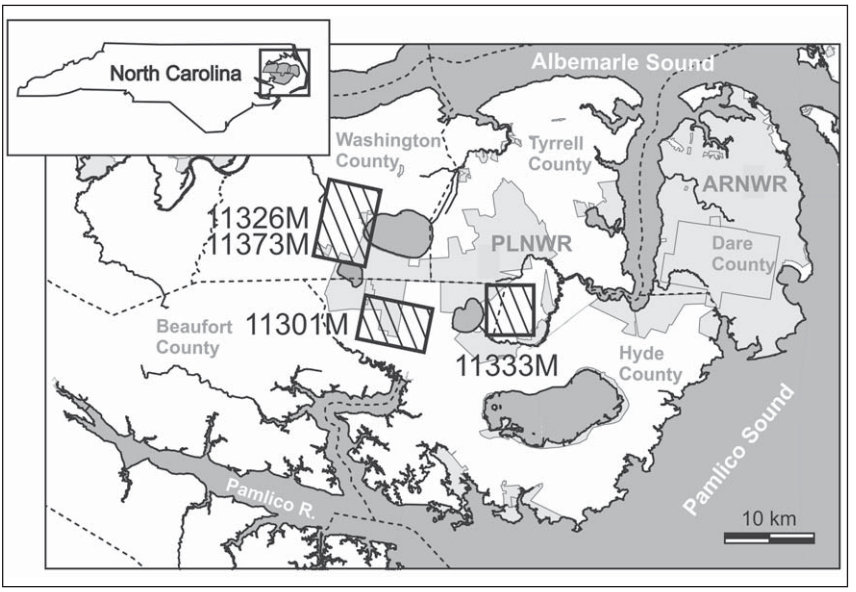


Figure 1. The Red Wolf recovery area located on the Albemarle Peninsula in northeastern North Carolina, encompassing approximately 6900 km^2 in 5 rural counties. Hachured boxes show the 3 general locations of home ranges of the 4 Wolves in the study (Wolves 11326M and 11373M shared a similar area). Federal lands, including Pocosin Lakes and Alligator River National Wildlife Refuges (PLNWR and ARNWR) are shown in gray.

are habitat generalists, with highly variable home ranges (7.8–272.8 km^2). In-depth knowledge of Red Wolf home-range characteristics and how they vary over time can improve current management practices, aid with determining the carrying capacity of the Albemarle management area for this species, and enhance the success of future reintroduction projects (USFWS 1990) elsewhere within the historic range of the Red Wolf.

Animal-tracking collars with global positioning system (GPS) capability can acquire frequent, accurate positions over long periods of time and have become an important tool for monitoring and managing free-ranging canids and other species over a broad range of temporal and spatial conditions (e.g., Demma et al. 2007). Our primary goal was to test the utility of GPS data to determine the temporal variability in patterns of land-cover use and the sizes of home ranges of Red Wolves on the Albemarle Peninsula.

Methods

GPS data acquisition and processing

We collected GPS locations from 4 adult male Wolves and mapped land-cover types in their home ranges using multispectral Landsat Thematic Mapper satellite imagery. All 4 Wolves were wild-born in the recovery area in 2004, and all but Wolf 11333 had been previously captured by USFWS personnel prior to our study (C. Lucash, USFWS, Columbia, NC, pers. comm.). Two of the Wolves were collared and released in 2006 and 2 in 2007 (Table 1). The Wolves were captured as part of routine management activities in which a portion of the population is captured to radiocollar new individuals, replace aging or failed collars, manage breeding- and health-related issues, and to respond to complaints by local residents. Following capture, the animals were transported in kennels to a central processing facility where biologists conducted a physical examination, administered vaccines, and collected a blood sample. After the GPS collars were fitted on the Wolves, the animals were released by USFWS personnel near their capture location.

We used Lotek model 4400S GPS collars (Newmarket, ON, Canada). With no differential correction, the manufacturer reported a horizontal error of <35 m for 95% of acquired locations. After deployment, the collars collected locations 4 times per day, during evening through morning hours, at 4-hour intervals (2000, 0000, 0400, and 0800 hours; local Standard Time;

Table 1. Observation periods and GPS data summary for 4 Red Wolves, Albemarle Peninsula, NC, 2006–2008.

Animal no.	Release date	Observation period	Duration (months)	No. locations	GPS success rate[A]
11301M	18-Jan-06	Apr 06–Sep 07	18	1823	83%
11333M	18-Jan-06	Mar 06–Jan 07	11	1271	95%
11326M	31-Mar-07	May 07–Aug 08	16	1774	91%
11373M	31-Mar-07	May 07–Apr 08	12	1340	92%

[A]Proportion of all scheduled GPS locations that were successfully acquired by each collar.

1 hour later during Daylight Savings Time) when the Wolves were thought to be most active.

Each collar was programmed to emit a VHF locator beacon each day for 4 hours, enabling USFWS field personnel to locate the Wolves every 4–6 weeks and download the stored data. To acquire the data, Wolves typically were first tracked from an airplane to identify the general location, allowing ground teams to download the data from a location approximately 100–300 m away, the distance depending on vegetation density or the presence of other physical barriers.

At the end of the monitoring period, we divided the final data sets for each Wolf into 30-day increments (i.e., 120 GPS location attempts). Two locations (of the 4/day) between each 30-day subset were not used, resulting in a total of 12 subsets of equal duration spanning a calendar year (equaling 365.5 days; the first 2 locations from 1 January were used in both the first and last subsets of a calendar year). These 30-day periods closely approximate calendar months for ease of interpretation (e.g., the first 30-day period approximates the month of January [January 1–30], the second 30-day period approximates February [January 31–March 2], and so on) and have durations that are short enough to reveal short-term and seasonal variations in patterns of land use and home-range sizes.

Satellite image data processing

Preliminary field observations suggested that the Wolves occupied large (>75 km^2), contiguous blocks of agricultural fields at least part of the time. To investigate variability in the proportions of different land-cover types occupied by the Wolves over time, we mapped land cover in the study area using Landsat 5 Thematic Mapper (TM) satellite images (US Geological Survey, Sioux Falls, SD; 30-m spatial resolution; Path 14, Row 35). The cloud-free images were acquired on 1 August 2006, 20 August 2007, and 6 August 2008, when crops were near their peak and prior to any agricultural harvesting or leaf senescence of trees.

To produce land-use maps for each year, we used ENVI image-processing software (ITT Visual Information Solutions, White Plains, NY) and a conventional maximum likelihood supervised classifier (e.g., Foody et al. 1992, Swain and Davis 1978), which categorizes each image pixel into a spectral class based on its brightness values in the 6 visible, near-, and mid-infrared spectral bands. Ground-truthing was conducted to identify the 8 dominant summer land-cover types in the study area (corn, soybeans, cotton, managed conifer forest, native mixed deciduous-conifer forest, bare soil [recent timber harvest areas], tall wild grasses or brush in previously harvested forest stands or fallow agriculture fields, and water), to locate training and validation areas for each class, and to evaluate the accuracy of the land-cover mapping. We obtained GPS coordinates for 10 locations within each land-cover type. We used 5 locations for each land-cover type as training observations for image classification and the remaining 5 to assess the accuracy of the land-cover classification. We used minimum-mapping-

unit (Saura 2002) and pixel-clumping techniques to consolidate and remove small regions of minor classes. Overall classification accuracy was 90–93% for the 3 images, and classification accuracy exceeded 75% for all classes. Commission errors were highest for the 2 forest classes (9–19% commission of conifer pixels in the mixed trees class) and 2 agriculture classes (23–26% commission of soybean pixels in the cotton class). Other than annual rotation of crops, little land-cover change took place (<10 km^2 total area) for the time period corresponding to the 3 images, and most changes were a result of forest management. In winter months, the areas mapped as corn, soybeans, and cotton had bare soils or were used to grow winter wheat.

We grouped the classified land-cover types into 3 land-use categories (excluding water) based on vegetation height and seasonal permanence: row-crop agriculture, mixed grasses-brush, and forest (managed and native). We delineated the 3 land-use categories based on the 2006, 2007, and 2008 classified images with vector polygons via heads-up digitizing in ENVI, and combined the vector maps in a geographic information system (ArcGIS 9.2, ESRI, Inc., Redlands, CA) with the 30-day subsets of GPS data from the corresponding years to calculate the proportions of the 3 land-use types associated with Wolf locations during each 30-day interval.

Home-range area

We calculated home-range areas using all GPS data for each Wolf (11–18 months) and for each of the 30-day subsets. We calculated home-range sizes with a fixed-kernel method, which uses location data to estimate the probability that an animal will be in a particular location, and delineated home-range boundaries based on the area encompassing the 95% utilization distribution (Seaman and Powell 1996, Seaman et al. 1999, Worton 1989). Kernel methods provide the most accurate measures of space use (Kernohan et al. 2001, Worton 1995) and exclude large areas not used by an animal (White and Garrott 1990). We calculated the smoothing parameter (h statistic) with Animal Space Use 1.2 (Horne and Garton 2007) using likelihood cross-validation (CVh), which conforms better to the distribution of location data than least squares cross-validation (Horne and Garton 2006). The value of the smoothing parameter influences the calculated area of a home range, so we generated a smoothing parameter for each 30-day subset for each Wolf and used the average values in the 30-day home-range calculations, which allowed us to make direct comparisons of the areas over time. This average smoothing parameter was also used to calculate the long-term home-range areas using the full GPS datasets.

Results

The overall success rate for scheduled GPS acquisitions by the collars varied from 83% to 95% (Table 1). For most of the 30-day subsets, the proportion of successful location acquisitions was relatively high and consistent (88–100%), except for those from periods 7 and 8

(corresponding with the months of July and August), which were lower for all 4 Wolves (73–84%).

After release, the Wolves either temporarily occupied a confined area close to the release site or moved out of the area they would ultimately occupy as a home range, perhaps because of temporary disorientation, acute caution, or stress resulting from capture, confinement, and release. For 3 of the Wolves (11333M, 11326M, and 11373M), we excluded data from our analyses prior to the second full month after each release to remove the possible effects of the capture process on their movements, a method similar to that used in previous GPS studies of canids (e.g., Demma et al. 2007). Animal 11301M ranged over a wide area beyond its ultimate home-range boundaries for several weeks, so we did not use data from that Wolf prior to the third full month.

Wolves 11326M and 11373M were collared and released in late March of 2007, and began to share the same home range soon after their release. After May of 2007, 47% of the GPS locations of the 2 males were within 100 m of each other and 64% were within 1000 m. Field records suggest that 11373M was the sibling of the mate of 11326M, and both animals were part of an extended family group that included the breeding female and 3 pups born in April, 2008. Thus, our study involved 4 Wolves in 3 separate areas (Fig. 1).

The 30-day location subsets for each Wolf showed areas with high concentrations of locations corresponding with the spring denning areas of the 4 Wolves (2007: 11301M and 11333M; 2008: 11326M and 11373M; Fig. 2; C. Lucash, pers. comm.).

Land-cover use

A substantial percentage of all locations for each Wolf were in areas classified as agriculture (40.0% for 11301M, 66.7% for 11333M, 68.3% for 11326M, and 63.5% for 11373M). The remaining locations primarily were in the mixed wild grass-brush areas adjacent (<1 km) to these agricultural tracts (56.4% for 11301M, 30.6% for 11333M, 29.9% for 11326M, and 33.6% for 11373M). The fewest locations were in the forest land-use category (3.6% for 11301M, 2.7% for 11333M, 1.8% for 11326M, and 2.9% for 11373M).

The 30-day subsets combined with the land-cover maps showed variability in the proportions of different land-cover types used by the Wolves over time. This variability had a seasonal pattern, and the timing was similar among the 4 Wolves (Table 2, Fig. 3A). In summer and early autumn (periods 7–10; July–October), all Wolves increased their use of agricultural fields, with the greatest use occurring in July, August, and September. In winter to spring (periods 11–12 and 1–5; November–May), the proportion of locations in agricultural areas were substantially lower, and the use of grass-brush and forest areas adjacent to agricultural fields increased. Use of agricultural areas generally was lowest in winter and spring (Table 2, Fig. 3A).

Home-range size

Home-range areas for all collected GPS data (11–18 months) for each Wolf were 118.3 km^2 for 11301M, 81.6 km^2 for 11333M, 149.5 km^2 for 11326M, and 148.1 km^2 for 11373M. The 30-day home ranges were highly variable, but showed similar temporal patterns among the 4 Wolves (Table 2, Fig. 3B). The 5 largest areas calculated for each Wolf occurred almost exclusively in late summer to winter (periods 9–12 and 1–3; September–March; Table 2). The single exception was the large area we observed for 11301M (80.4 km^2) in June 2006. Home ranges for period 1 (January of 2007 and 2008) were at or near their maximum annual size (94–100%; Fig. 3B). Home-range areas were smallest during spring and summer (periods 4–8; April to August; Table 2). These home-range areas were 40 to 63% smaller than the largest seasonal home ranges.

Discussion

The Wolves in our study showed considerable temporal variation with regard to land-cover use and home-range size but the temporal patterns were similar for the 4 animals over the study period (Fig. 3). Although Wolves

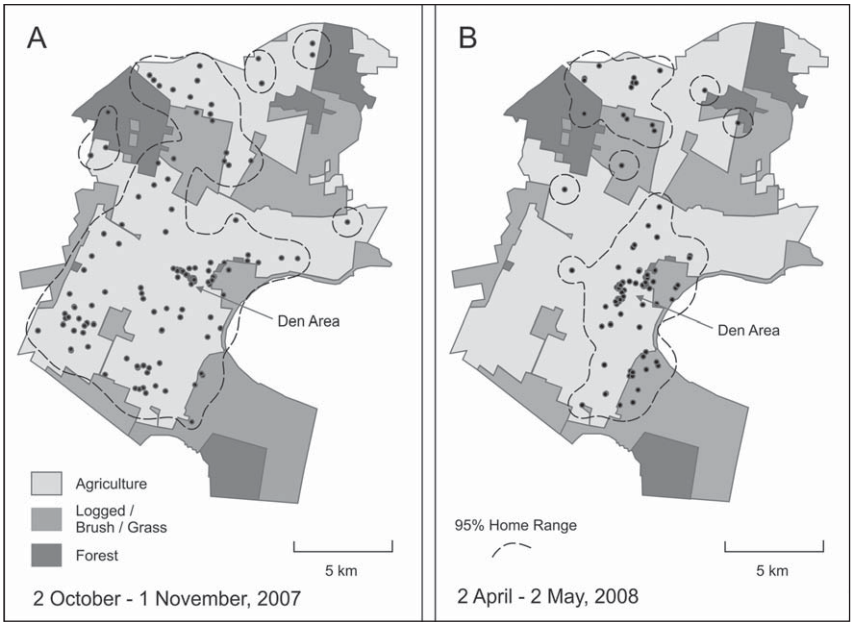


Figure 2. Fixed-kernel home-range boundaries (95%) for Wolf 11326M, Albemarle Peninsula, NC. The 30-day home range reached maximum size (A) in October 2007 (120.5 km^2) when agriculture land use was near a maximum (89.3% of locations). By April 2008 (B), the home range had decreased to 64.1 km^2, and agriculture land use was near a minimum (65.5% of locations). Pups were born to the mate of this Wolf in late April, and a large proportion of locations during the study period were in the den area.

Table 2. Proportions of home ranges classified as agricultural land use and home-range areas (km^2) of 4 Red Wolves, Albemarle Peninsula, NC, 2006–2008.

30-day Period:	1 (Jan)	2 (Feb)	3 (Mar)	4 (Apr)	5 (May)	6 (June)	7 (July)	8 (Aug)	9 (Sep)	10 (Oct)	11 (Nov)	12 (Dec)
Wolf 11301M												
2006 % agriculture	-	-	-	6.1	21.2	37.1	78.3	65.9	70.0	63.8	31.3	29.1
2007 % agriculture	35.1	28.4	33.3	4.2	7.9	46.9	64.1	70.9	81.3	-	-	-
2006 home-range area	-	-	-	51.7	61.8	80.4	58.0	58.1	74.1	81.6	73.0	78.0
2007 home-range area	96.4	83.4	84.4	48.0	35.3	68.1	58.6	54.0	59.4	-	-	-
Wolf 11333M												
2006 % agriculture	-	-	61.9	70.8	58.3	79.6	86.2	83.8	85.8	73.6	59.5	50.0
2007 % agriculture	61.2	-	-	-	-	-	-	-	-	-	-	-
2006 home-range area	-	-	63.5	52.4	44.0	50.6	44.5	51.1	70.2	68.0	70.7	73.0
2007 home-range area	69.3	-	-	-	-	-	-	-	-	-	-	-
Wolf 11326M												
2007 % agriculture	-	-	-	-	56.4	79.6	85.3	94.1	88.8	89.3	69.5	62.5
2008 % agriculture	58.1	55.0	56.9	65.5	63.6	83.5	91.5	94.3	-	-	-	-
2007 home-range area	-	-	-	-	98.6	94.5	90.6	109.4	114.9	120.5	113.4	113.9
2008 home-range area	116.1	99.3	74.1	64.1	54.3	65.8	72.0	62.6	-	-	-	-
Wolf 11373M												
2007 % agriculture	-	-	-	-	37.6	75.2	85.6	94.8	85.2	88.3	67.5	66.4
2008 % agriculture	58.5	9.6	30.8	31.3	-	-	-	-	-	-	-	-
2007 home-range area	-	-	-	-	76.1	61.0	75.3	95.5	107.3	112.5	111.9	120.9
2008 home-range area	113.5	105.3	86.8	50.7	-	-	-	-	-	-	-	-

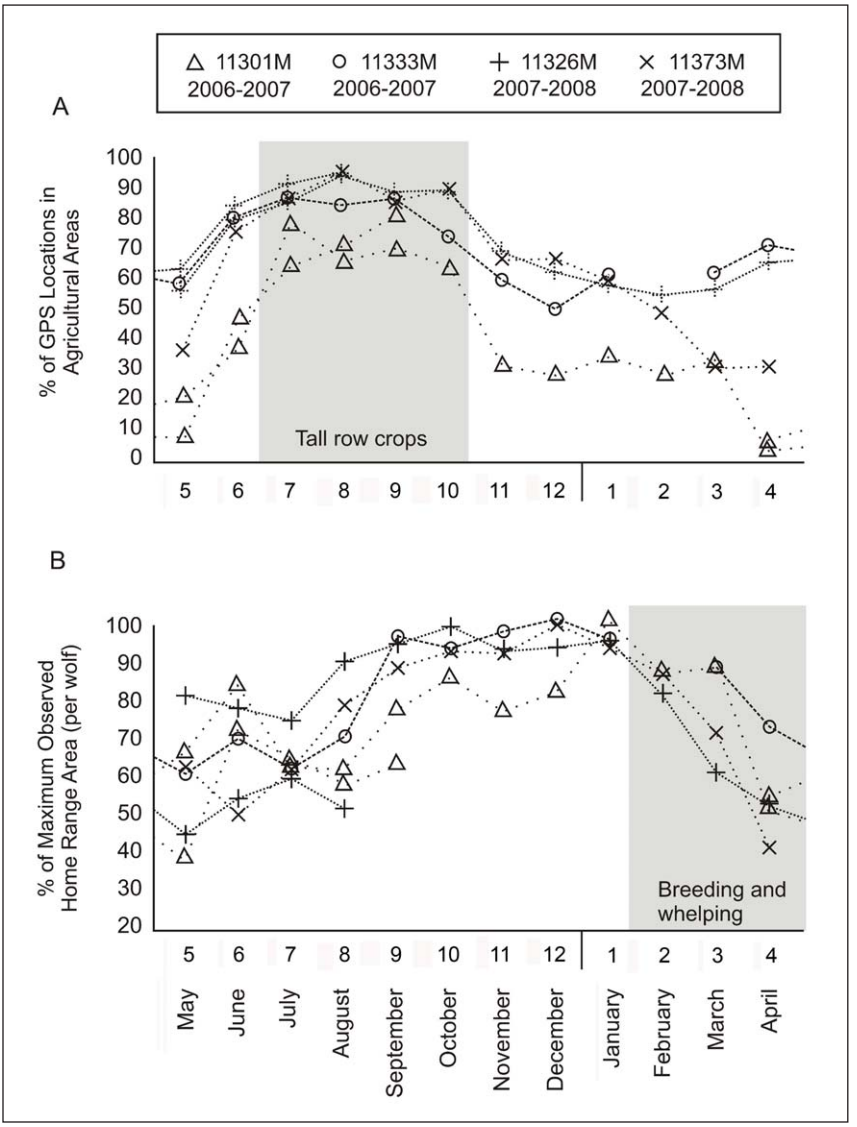


Figure 3. Time series of the proportions of GPS locations in agricultural land-use areas (A) and home-range areas (B) for the 4 Red Wolves in this study, Albemarle Peninsula, NC, 2006–2008. Graphs start in period 5 (May). (A) Monthly proportions of locations within mapped agricultural regions were seasonally cyclic and similar among the study Wolves, with maxima reached in summer months when row crops were tallest (gray area). (B) Monthly home-range areas, shown as the percentage of the maximum observed area for each Wolf. Home ranges generally were smaller in the spring, during whelping and pup-rearing periods (gray area), followed by a gradual increase in size during summer and autumn, and were largest in late autumn and winter. For all 4 Wolves, home ranges were 94–100% of their observed maxima in January.

11326M and 11373M were in the same family group, their temporal patterns were similar to those of the other 2 Wolves, which occurred in different family groups and occupied separate home-range areas. Thus, our data may be suggestive of population-wide spatio-temporal patterns of Red Wolf movements and land use.

The observed shift from use of row-crop agriculture fields to other cover types in November coincided with intense agricultural harvesting of tall (>1 m) row crops. Corn harvesting began in September of each year, but agricultural cover was not completely removed until soybean and cotton harvesting was completed in November. Hunting seasons for various game animals also began in November, and the combination of the removal of tall agricultural cover and human disturbance may have forced the Wolves to increase their occupation of areas with year-round vegetation, which often occurred on the periphery of agricultural fields. The growth and harvest cycles of agricultural vegetation may also influence the primary prey species of Red Wolves, such as *Odocoileus virginianus* Boddaert (White-tailed Deer), which also may have contributed to the seasonal shifts in habitat use we observed. Additional studies will be required to fully characterize the temporal patterns of habitat use we observed, including those of Wolves that do not occupy agricultural fields.

Animal home ranges can be influenced by many factors (e.g., human activities, prey availability, conflicts with other animals, injuries; Wingfield 2005), but a seasonal pattern was apparent in our study. We observed a gradual increase in the extent of home ranges from May–June to January, when all home ranges were at or near their maximum annual size (Fig. 3B). The decline in home-range size after January coincided with mating, den preparation, and whelping during February–April, and the presence of relatively immobile pups and frequent visits to den sites by adults until early summer (C. Lucash, pers. comm.). Home ranges then gradually increased in size until autumn, when pups start fully participating in hunting activities with adults. This interpretation is consistent with studies of other canids. *Canis lupus* Richardson (Gray Wolf) exhibit lower mobility and more restricted activity near den sites during denning periods (Ballard et al. 1991, Harrington and Mech 1982, Walton et al. 2001). Home ranges of *Canis latrans* Say (Coyote) also vary seasonally (Laundré and Keller 1984).

The ≈10% reduction in successful GPS location acquisitions during July and August likely resulted in an underestimate of home-range size and use of agricultural areas. Previous studies have shown that thick summer vegetation can block GPS signals, resulting in fewer successful satellite fixes (Dussault et al. 2001, Rempel et al. 1995). The Wolves may have spent more time during these warmer months in a supine position in dense vegetation, which would have decreased the number of acquired locations.

The results of our pilot study indicated that home ranges of the 4 Wolves were not static over the course of a year and thus could not be fully

characterized by short-term (days or weeks to a few months) observations. We suggest that future studies of the spatial behavior and habitat use of Red Wolves should be at least 1 year in duration. In-depth knowledge of Red Wolf spatial characteristics can be used to improve current management practices in the Albemarle reintroduction area and enhance the success of future reintroduction projects elsewhere within their historic range. For example, Coyote introgression and hybridization with Red Wolves has become one of the most urgent management problems in the recovery area, as the numbers of Coyotes continue to increase in eastern North America (Kelly et al. 1999, Phillips et al. 2003) and are increasingly observed and trapped within the Red Wolf management area (C. Lucash, pers. comm.). If the contraction of home ranges observed during the spring is common among Red Wolves with established home ranges, this could result in a temporary increase of the extent of unoccupied areas between home ranges. We speculate these temporarily unoccupied areas may be exploited by Coyotes during spring and summer months to enter the management area, possibly exacerbating this significant management problem. Future studies should acquire simultaneous location data from both Wolves and Coyotes in the Red Wolf management area to test this hypothesis and to better understand how the two species interact.

Conclusions

GPS locations (4 location attempts/day) from 4 Red Wolves acquired during 2006–2008 showed that land use and home-range sizes were highly variable over time. Long-term (>1 yr) location data would be necessary to fully characterize the variability and complexity of space use and movements of the species. Based on land-use data from satellite imagery, all 4 Wolves increased their use of agricultural areas when tall (>1 m) crops were present from summer to early autumn, and increased their use of natural, tall grass-brush areas when tall crops were not present (late autumn to spring). Home-range areas based on short-term data (30 days) also varied seasonally, and the temporal patterns were similar among the 4 Wolves. Home ranges were largest during late summer to winter, followed by a 40 to 63% reduction in size during the mating and whelping periods in spring, with a gradual increase in size over the summer.

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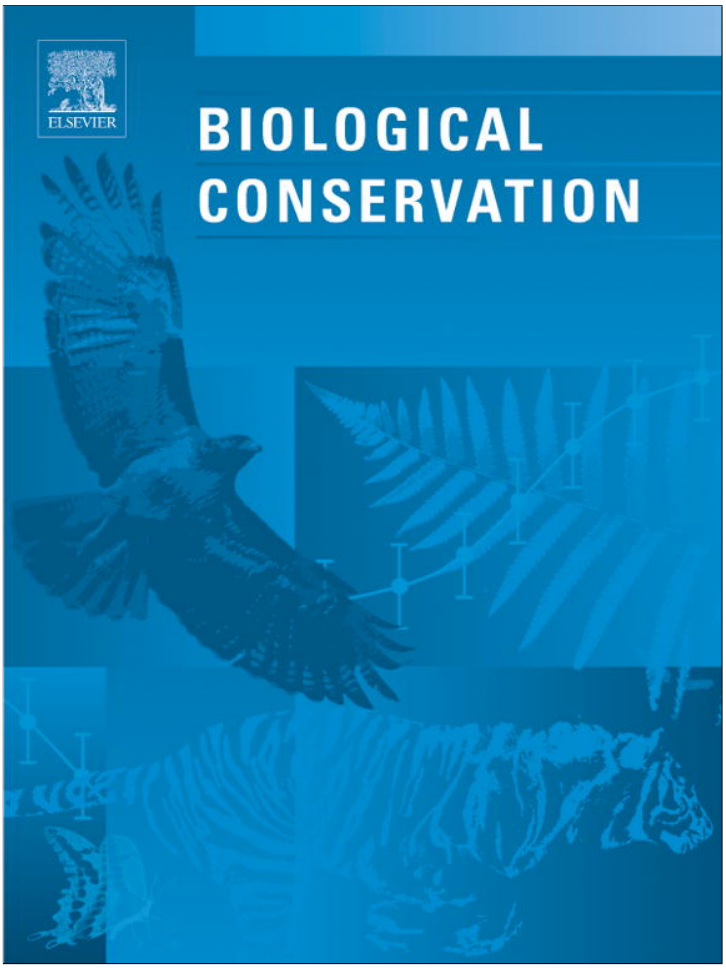
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Habitat selection of a large carnivore, the red wolf, in a human-altered landscape

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ABSTRACT

Large carnivores, with their expansive home range and resource requirements, are a good model for understanding how animal populations alter habitat selection and use as human densities and development increase. We examined the habitat selection of red wolves (*Canis rufus*) in North Carolina, USA, where the population of red wolves resides in a mosaic of naturally occurring and human-associated land cover. We used locations from 20 GPS-collared red wolves, monitored over 3 years, to develop resource selection functions at the landscape level. Red wolves selected for human-associated land-cover over other land-cover types. Red wolves also selected areas near secondary roads. However, red wolves avoided areas with high human density, and avoidance of natural land-cover types decreased as human density increased; this interaction was strong enough that red wolves selected for natural land-cover types over human-associated land-cover types at relatively high human density. Similarly, avoidance of natural land-cover types decreased when they were near secondary roads. These results suggest that red wolves will use human-associated landscapes, but modify their habitat selection patterns with increased human presence. Such findings suggest that large carnivores such as the red wolf may not strictly require habitats devoid of humans. In a world with rapid human-alteration of habitat, understanding how increasing human density and development impact habitat selection is vital to managing for population persistence of large carnivores and maintaining top-down ecological processes.

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1. Introduction

As human populations and development increase, animal populations must either be confined to diminishing areas of natural habitat or adapt and persist in a mosaic of human-altered and naturally occurring habitats. Large carnivores are highly susceptible to human-associated change in habitat due to their expansive home ranges and longer generation times (Mladenoff et al., 1997). Thus, some populations of large carnivores will need to persist in a mosaic of human-altered and naturally occurring habitats. Species unable to survive in human-altered habitats are likely to require constant management including intensive monitoring of individuals, population trends, and biological seasons. Thus, an understanding of how large carnivores select habitats in a mosaic of human-altered and naturally occurring land cover is critical to the appropriate allocation of resources for conservation and management of such populations. Furthermore, such information may be useful for identifying areas with high potential for species persistence.

Red wolves (*Canis rufus*) once ranged across eastern North America from Florida to southern Canada and central Texas to the Atlantic Ocean (Phillips et al., 2003). Currently, most of the historic range of red wolves contains high human densities and vast expanses of human-altered habitat. Only a single reintroduced population of <150 red wolves designated as nonessential experimental by the US Fish and Wildlife Service currently exists in the wild in a habitat mosaic consisting of naturally occurring and human-associated land cover (Phillips et al., 2003). Basic ecological research on habitat selection by red wolves in the wild prior to reintroduction was limited due to small population size and difficulties in differentiating the few remaining red wolves from hybrids and coyotes *Canis latrans* (Phillips et al., 2003). Previous researchers suggested that red wolves historically occupied moist, densely vegetated habitats, including virgin pine and lowland hardwood forests, coastal prairies, and marshes (Phillips et al., 2003). However, these studies of red wolf habitat selection were conducted on small, remnant populations persisting in limited naturally occurring environments. More recent studies have attempted to understand habitat selection of red wolves in their more current, human-dominated habitat (Chadwick et al., 2010; Hinton and Chamberlain, 2010). However, no study has examined how habitat selection by red wolves is influenced by natural and anthropogenic landscape attributes. A better understanding of

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how red wolves select resources in a mosaic of human-altered and naturally occurring habitat is critical to management of the current population and to future reintroductions of red wolves.

A great deal of research has examined habitat use by gray wolves *Canis lupus* and the potential for expansion of reintroduced and fragmented populations to adjacent areas (Corsi et al., 1999; Harrison and Chapin, 1998; Mladenoff et al., 1995, 1997, 1999; Wydeven et al., 2001). The major consensus among these studies is that large social carnivores like wolves are unable to persist in areas of high human and road densities (Mech, 2006; Mladenoff et al., 1995, 1999; Oakleaf et al., 2006; Wydeven et al., 2001), putatively due to high wolf mortalities in such areas (Corsi et al., 1999). Studies in Europe suggested that such variables mask a prevailing negative human attitude towards wolves. Instead increasing human and road densities themselves do not prohibit colonization and persistence of wolves (Corsi et al., 1999), but rather it is the ill intentions of humans that limit wolves in such areas (Wydeven et al., 2001; Murray et al., 2010; Rutledge et al., 2010). Indeed, wolves may select human-altered as readily as naturally occurring land-cover (Treves et al., 2004; Mech, 2006) if the selection process is unimpeded by such things as negative human actions against wolves (Mladenoff et al., 1997). Several studies have suggested that wolves are highly capable of persisting in human-altered landscapes and possibly even perceiving increased mortality risk associated with human density and development and adjusting habitat use accordingly (Bateman and Fleming, 2012; Lesmerises et al., 2012; Llaneza et al., 2012). Since being reintroduced in 1987, red wolves have selected among various human-altered and naturally occurring land-cover types, with population levels increasing for the first decade and here lately having stabilized due to the population likely having reached the carrying capacity of the recovery area (Phillips et al., 2003). Preliminary evidence suggests that red wolves, if unimpeded by human actions, will readily select human-altered land-cover (Chadwick et al., 2010); such evidence agrees with selection patterns of gray wolves (Mech, 2006).

We examined 2nd order habitat selection (Johnson, 1980) of red wolves in the sole remaining wild population, with the intent of understanding how red wolves select and use habitats associated with humans. Specifically, we studied habitat selection by red wolves over several seasons, determined how habitat selection varied with human density and development, and examined how these environmental factors influence habitat selection by red wolves at the landscape level. We predicted that red wolves would select agricultural fields over other land-cover types due to concentration of white-tailed deer (*Odocoileus virginianus*), the primary prey of red wolves (Dellinger et al., 2011), in agricultural fields as a consequence of a nearly year round growing season. We also predicted that red wolves would avoid areas of increasing human density but likely select areas near secondary roads (e.g., dirt and gravel roads), which coincides with recent findings (Lesmerises et al., 2012; Llaneza et al., 2012), potentially due to ease of travel and increased visibility for hunting.

2. Study area

This study occurred within the Red Wolf Recovery Experimental Population Area (RWREPA) on the Albemarle Peninsula in northeastern North Carolina (Fig. 1). The RWREPA is currently home to the only wild population of red wolves in the world. The study area consisted of >4900 km^2 of federal, state, and private lands in five counties (Hyde, Tyrrell, and parts of Dare, Washington, and Beaufort). Federal lands within the study area included Alligator River National Wildlife Refuge, Pocosin Lakes National Wildlife Refuge, Swan Quarter National Wildlife Refuge, Mattamuskeet National Wildlife Refuge, and a bombing range shared by the United States

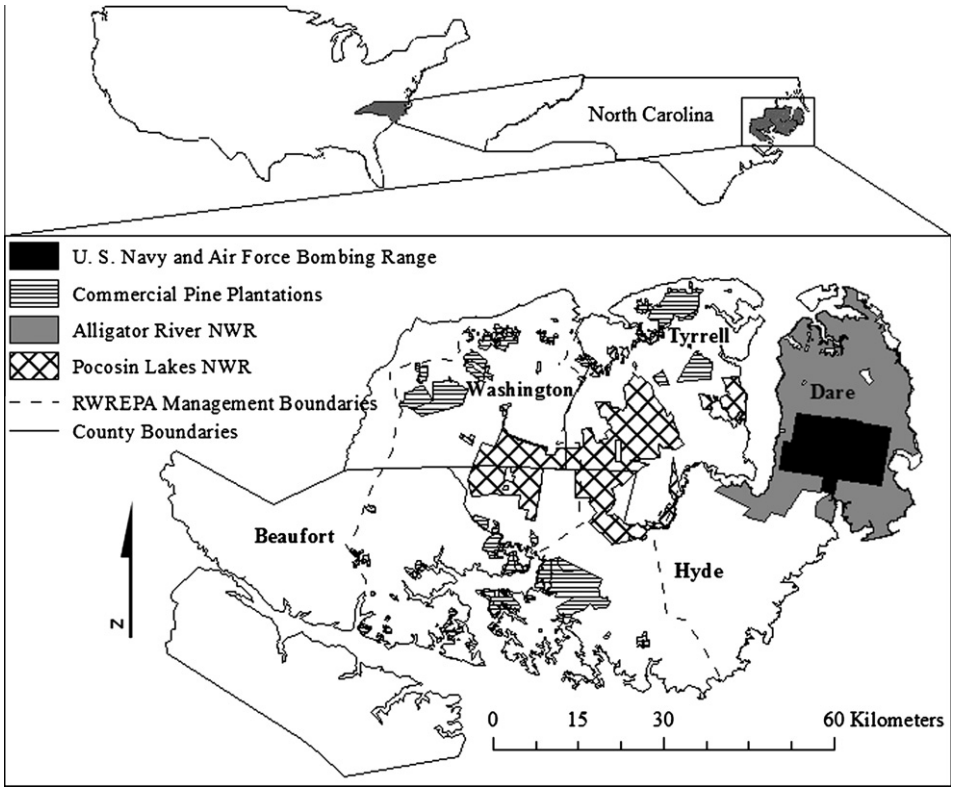


Fig. 1. Map of RWREPA in northeastern North Carolina with county boundaries, RWREPA management boundaries, and location of federal, commercial, and private lands (white areas), 2007–2011.

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Navy and Air Force. State lands included numerous game management properties, while private lands were primarily timber plantations and agricultural fields.

Land cover in the study area included several human-associated types: agricultural fields (30%); early successional fields (20%); and commerical pine plantations (15%); as well as a few naturally occuring types: pocosin *Pinus serotina* and *Persea palustris* (15%); lowland forests *Nyssa* spp., *Liquidambar styraciflua*, *Acer rubrum,* and *Chamaecyparis thyoides* (10%); and wetlands (10%). Climate was characterized by four full seasons of nearly equal length with annual precipitation averaging 127 cm. Temperatures averaged 5 °C in winter and 27 °C in summer. Elevation ranged from sea level to 50 m (Hinton and Chamberlain, 2010). Human density averaged 5.75 people/km^2 and ranged from 0 to 795 people/km^2 (US Census Bureau).

3. Materials and methods

3.1. Capturing and radio-collaring of animals

During July 2007 to March 2010, United States Fish and Wildlife Service (USFWS) biologists used padded, number 3, foot-hold traps to capture adult and juvenile red wolves. USFWS biologists fitted red wolves with mortality-sensitive, Lotek GPS 4400S radio-collars (Lotek Wireless, Inc., Newmarket, Ontario, Canada). Red wolves >2 years old were classified as adults, between 9 months and 2 years old as juveniles, and <9 months old as pups. Radio collars were not fitted on pups because pups were too small to safely wear the collars. Following deployment, radio-collars recorded locations every 5 h. Every collar emitted a VHF beacon each day during 0900–1200 h, which allowed animals to be located every 4–8 weeks for remote retrieval of data.

3.2. Home range analyses

We used adaptive nearest neighbor convex hull methods (α-NNCH; Getz et al., 2007) to construct 95% home ranges for each radio-collared animal. We developed rarefaction curves of estimated home range size for each animal to determine if radio-collars had been deployed long enough for estimated home range size to stabilize. Specifically, rarefaction curves were developed such that home range size was calculated for the first week the collar was deployed, the first two weeks, and so on, until all the data for that animal had been included. The home range estimate was deemed to have stabilized if home range size increased <5% with each additional week for at least 12 weeks to at least ensure a seasonal stabilization in home range size.

Because individual wolves within a pack likely exhibit habitat selection patterns that are not independent from each other we only calculated selection coefficients for one individual in each pack. If packs contained multiple radio-collared animals, and one was an alpha animal, then locations from the alpha were used to assess habitat selection. If estimated home range size of the alpha did not stabilize, or an alpha animal was not radio-collared, then locations from the animal monitored for the longest period of time were used to assess habitat selection, conditioned on a stabilized estimate of home range size for that individual. Two packs had no individuals for which cumulative weekly home range size stabilized, likely due to brief monitoring periods, and thus were excluded from analyses of habitat selection. GPS locations from radio-collared individuals not belonging to a pack were included in analyses of habitat selection if individuals were monitored for a sufficient period of time to generate stability in their movements and home range size.

3.3. Habitat selection analyses

We analyzed habitat use at the home range level using a use versus availability approach to determine which habitats had a higher likelihood of being selected by red wolves. Specifically we examined 2nd order habitat selection (Johnson, 1980) by red wolves using resource selection functions (RSFs) which assume that habitat selection patterns are revealed by comparing known (GPS points) to random available locations taken from across the landscape (Manly et al., 2002). We considered used habitats to be all GPS locations from each radio-collared animal that occurred within its respective 95% home range isopleth (McLoughlin et al., 2004). We considered the entire RWREPA as available habitat from which random locations could be taken. Red wolves were well distributed throughout the RWREPA, justifying use of the entire area as available habitat. The number of randomly selected available locations equaled the number of used locations (Klar et al., 2008). Distance to road and water, human density (US Census Bureau, 2010), and land cover type were determined for all locations using GIS. We did not differentiate between primary paved and secondary unpaved roads due to the low density of primary roads (0.12 km/km^2) in the RWREPA. Such a low density of primary roads was thought to have little potential as a meaningful variable for landscape level habitat selection analyses. Land cover types included agricultural fields, wetlands, pine plantations, lowland forests, early successional fields, and pocosin (upland areas covered with evergreen vegetation and inundated with water; McKerrow et al., 2006). Agricultural fields, pine plantations, and early successional fields were human-altered habitats while lowland forests, wetlands, and pocosin were naturally occurring habitats. Our global RSF for habitat selection contained each of the land-cover-type, distance to roads and water, and human density variables, measured at the landscape level, as well as all biologically meaningful interactions (land-cover type by distance to roads, land-cover type by human density, and distance to roads by human density). We designated agricultural fields as the reference land-cover type in the global RSF. Note that no collinearity was found amongst any combination of any of the variables above.

All used or available locations were combined across individuals for analysis. Because we monitored animals for varying lengths of time, and therefore had different numbers of locations, each animal potentially could have influenced the RSFs more or less than other animals (Manly et al., 2002; Klar et al., 2008)). Thus to make sure that no animal biased the global RSFs, we developed preliminary RSFs and used a sampling with replacement method in which each animal was excluded once from calculation of a RSF while all other animals were included. We then compared signs of coefficient estimates of preliminary RSFs to signs of coefficient estimates of the global RSFs. If the signs were the same between coefficient estimates of preliminary and global RSFs, and coefficient estimates of preliminary RSFs were contained within the 95% confidence intervals of the global RSF, then the animal excluded from the preliminary RSF was not deemed to bias the global RSF relative to other animals with respect to the given variable (Gillingham and Parker, 2008).

Akaike's information criterion corrected for small sample sizes (AICc) was used to choose the best RSF from the global model and all possible subsets (Burnham and Anderson, 2002). We excluded 25% of used and random locations from being used in developing the global RSFs and all possible subsets. We used excluded locations to perform a cross-validation and evaluate fit of the best RSFs, as determined by AICc (Johnson et al., 2006). This cross-validation method, shown to be the most appropriate for use-availability RSF models (Johnson et al., 2006), involved first projecting the best-fit RSFs constructed with 75% of the data in a GIS. Next we reclassified RSF values, which ranged from 0 to 1, into 10

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equally sized ordinal classes (e.g., 0.0–0.1, 0.1–0.2, etc.) and determined utilization values, based on the mean value and area, for each ordinal class (Johnson et al., 2006). Then we counted the number of used locations in the withheld data that fell in each class and estimated the expected the number of used locations for each class by overlaying the withheld data onto the projected RSF. Finally we performed linear regression and χ^2-square tests to compare expected to observed number of used locations in each class (Johnson et al., 2006). We considered that there was strong agreement between observed versus expected number of used locations, indicating the RSF model was proportional to probability of selection, if the observed versus expected linear regression had a slope significantly different from 0 (i.e., use was not equal to availability) but not significantly different from 1 and the *y*-intercept was not significantly different from 0 (i.e., the modeled RSF was directly proportional to probability of use). Finally, we considered that a good RSF model would have a high R^2, derived from the linear regression of proportion of observed versus expected number of used locations, and a high Spearman rank correlation coefficient (Johnson et al., 2006).

All statistical analyses were conducted in R 2.11.1 (R Development Core Team, 2010), while spatial analyses were conducted in ArcGIS 10 (Redlands, CA, Copyright 1999–2010 ESRI) and Geospatial Modelling Environment 0.5.3 (Beyer, H.L., Copyright 2001–2010 Spatial Ecology).

4. Results

During July 2007 to March 2010, 17 adult (12 males, 6 females) and 17 juvenile (9 males, 7 females) red wolves were fitted with GPS collars and monitored for between 2 and 30 months, with an average monitoring period of 13 months. The radio-collared animals represented 13 packs and 9 lone individuals that still showed site fidelity as evidenced by stabilized cumulative weekly home ranges.

Rarefaction curves of 95% home range isopleths (Getz et al., 2007) stabilized for all but two animals, data from these 2 animals was not included in RSF calculations. Thus, habitat selection was done based on GPS locations from 20 animals. Signs of all coefficient estimates of all preliminary 2nd order RSFs were no different from signs of coefficient estimates of the global 2nd order RSF. Furthermore, all coefficient estimates of preliminary RSFs were contained within the 95% confidence intervals of the coefficient estimates of the global RSF, indicating no one animal unduly biased the global RSF (Gillingham and Parker, 2008).

We used 32,802 red wolf locations, and an equal number of randomly selected available locations, to construct the RSFs. The best RSF among those considered, as determined by AICc, contained variables for all individual land-cover types, distance to roads and water, human density, an interaction between distance to road and land-cover type (lowland forests, pocosin, and wetlands), and an interaction between human density and land-cover type (pine plantations, lowland forests, and wetlands; Table 1). The AICc weight of the best RSF was 0.28. The three next best RSFs had delta AICc values of <2, suggesting that any of our top four RSFs could potentially be the best RSF (Table 1). Given the similarity and the small delta AICc values of the top four RSFs (Table 1) we averaged the coefficient estimates of the top four RSFs (Table 2; Burnham and Anderson, 2002). Furthermore, given the treatment of each of these RSFs as potentially the best, it is also reasonable to combine AICc weights of these four RSFs which is 0.88, demonstrating a strong ability to predict red wolf habitat use in the RWREPA. Agricultural fields (the reference land-cover type in the model) were selected over all other land-cover types at low human density and in areas close to roads. Odds of habitat being used by red wolves decreased as human density increased, distance to roads increased, and distance to water decreased (Table 2). As distance to roads increased, avoidance of lowland forest, pocosin, and wetland land-cover types by red wolves, relative to other land-cover types, further increased (Table 2). Similarly, as human density increased, avoidance of pine plantations, lowland forests, and wetlands by red wolves, relative to other land-cover type types, decreased (Table 2). However, the interaction between lowland forests and human density only occurs in two of the top four RSFs (Table 1), suggesting that this variable is important but only moderately so relative to the other variables. Coefficient estimates suggest that at 11.1, 27.7, and 10.4 people per km^2, selection for agricultural fields over pine plantations, lowland forests, and wetlands, respectively, switched such that red wolves selected for pine plantations, lowland forests, and wetlands over agricultural fields. The best RSF predicts a patchy distribution of red wolves across the RWREPA (Fig. 2).

We used 10,934 red wolf locations, and an equal number of randomly selected available locations to cross validate our model averaged RSF coefficient estimates (Table 2). For the model averaged RSF, the slope of the linear regression of proportion of observed versus expected locations in each ordinal class was significantly different from 0 (coef. est. = 1.14, SE = 0.18, $t_{16} = 6.4$, $p < 0.01$), but not significantly different from 1 ($t_{16} = 0.79$, $p = 0.44$). This demonstrates that the model averaged coefficient estimates were proportional to the probability of habitat selection by red wolves and that red wolves do not use habitat in proportion to availability but rather demonstrate habitat selection. Also the Y-intercept of the linear regression was not significantly different

Table 1
Comparison of AICc, ΔAICc, AICc weights, and number of parameters of top 2nd order RSF models.

Model	AICc	ΔAICc	Weights	Parameters
$1^a - 2^b - 3^c - 4^d - 5^e - 6^f + 7^g - 8^h - (2\times6) - (3\times6) - (4\times6) + (3\times8) + (4\times8) + (5\times8)$	21422.93	0.00	0.28	14
$1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - (2\times6) - (3\times6) - (4\times6) + (3\times8) + (5\times8)$	21423.14	0.21	0.25	13
$1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - (2\times6) - (3\times6) - (4\times6) + (3\times8) + (4\times8) + (5\times8) + (6\times8)$	21424.06	1.13	0.16	15
$1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - (2\times6) - (3\times6) - (4\times6) + (3\times8) + (5\times8) + (6\times8)$	21424.69	1.76	0.12	14
$1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - (2\times6) - (3\times6) - (4\times6) - (2\times8) + (3\times8) + (4\times8) + (5\times8)$	21425.93	3.00	0.06	15
$1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - (2\times6) - (3\times6) - (4\times6) - (2\times8) + (3\times8) + (5\times8)$	21426.14	3.21	0.06	14

[a] Successional fields.
[b] Pocosin.
[c] Wetlands.
[d] Lowland forests.
[e] Pine plantations.
[f] Distance to roads.
[g] Distance to water.
[h] Human density.

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Table 2
2nd Order RSF model averaged coefficient estimates for top four RSFs according to AICc, for habitat use of red wolves in the RWREPA from 2007 to 2011.

2nd Order RSFs		
Coefficient	Estimate	SE
Intercept	0.62	0.04
SF[a]	−0.21	0.09
PC[b]	−0.67	0.09
WL[c]	−0.81	0.08
LF[d]	−0.82	0.11
PP[e]	−0.95	0.08
D2R[f]	-1.29×10^{-03}	1.10×10^{-04}
D2W[g]	2.85×10^{-03}	0.04
HD[h]	−0.08	5.00×10^{-03}
D2R × LF	-2.70×10^{-03}	3.40×10^{-04}
D2R × PC	-2.79×10^{-03}	2.16×10^{-04}
D2R × WL	-2.48×10^{-03}	2.08×10^{-04}
HD × D2R	4.146×10^{-07}	1.87×10^{-04}
HD × PP	0.09	0.01
HD × LF	0.03	0.01
HD × WL	0.08	0.01
HD × PC	-6.29×10^{-03}	0.02

[a] Successional fields.
[b] Pocosin.
[c] Wetlands.
[d] Lowland forests.
[e] Pine plantations.
[f] Distance to roads.
[g] Distance to water.
[h] Human density.

from 0 (coef. est. = −0.01, SE = 0.02, $t_{16} = -0.55$, $p = 0.59$), again indicating that the model averaged RSF was proportional to the probability of habitat selection by red wolves. Agreement between proportion of observed and expected locations within each ordinal class was high with a $R^2 = 0.84$ and $r_s = 0.98$ ($p < 0.01$) demonstrating that the model averaged RSF was able to predict habitat selection by red wolves other than those used to build the RSFs (Johnson et al., 2006).

5. Discussion

The ecology and spatial requirements of many large carnivores, like the red wolf, suggest that recovery and persistence of viable populations, if possible, will likely occur not in small patches of protected habitat, but in a mosaic of protected, managed, and largely human-altered habitats. Simply avoiding human-associated land-cover types may not be possible for such species, as available naturally occurring land-cover types are limited, and often in decline. Thus, large carnivores may be forced to utilize human-associated land-cover types while avoiding negative interactions with humans.

As we predicted, our best RSFs indicated that at the 2nd order level of habitat selection red wolves did avoid areas with high human density. Several studies report avoidance of areas of increasing human densities by gray wolves (Corsi et al., 1999; Oakleaf et al., 2006). Moreover, at low human densities, red wolves selected agricultural fields and cut-over regenerating forests over all other, naturally occurring land-cover types (Table 2). This result is as we predicted but still interesting in itself given that agricultural fields represent human-altered habitat. Selection of human-altered habitats over natural habitats by red wolves could be due to agricultural and early successional fields providing higher food resources to prey species such as white-tailed deer relative to other habitat types, thus helping to concentrate prey species important to red wolves (Dellinger et al., 2011). Recent research in Minnesota and Wisconsin, USA, report gray wolves denning in the middle of hay fields and other areas associated with human activity (Mech, 2006). Red wolves have also been reported denning in agricultural fields near areas of high human activity (Hinton and Chamberlain, 2010).

Similarly, our 2nd order best RSFs also indicated that red wolves prefer areas close to roads (Table 2). This supports our original predictions and recent research (Lesmerises et al., 2012; Llaneza et al., 2012). Most roads in the RWREPA are secondary gravel or dirt roads used for agricultural purposes. Red wolves likely select these secondary roads for hunting due to the greater visibility and mobility

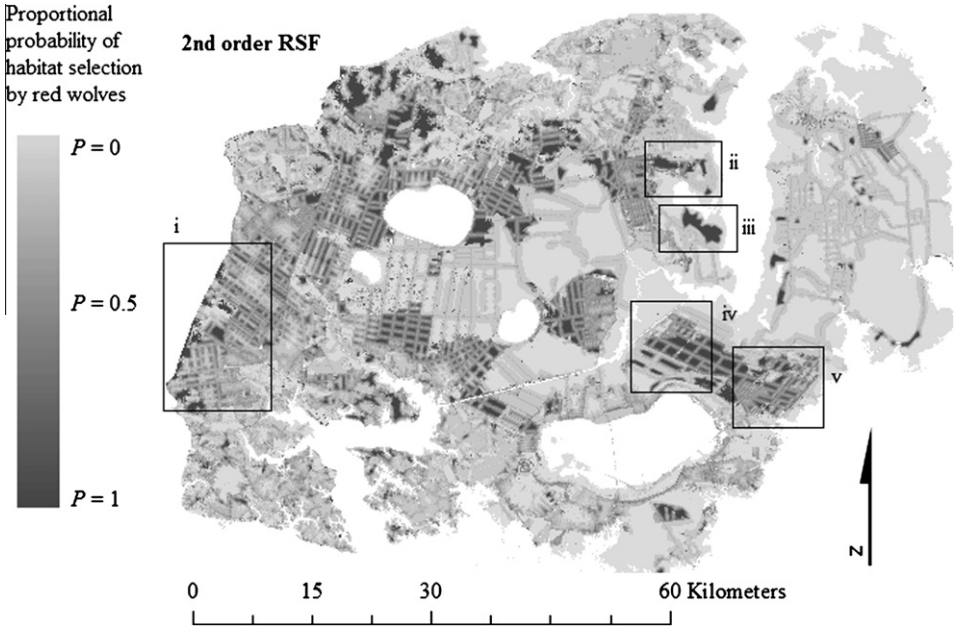


Fig. 2. Proportional probability of habitat selection by red wolves (*Canis rufus*) across the RWREPA in northeastern North Carolina with respect to 2nd order habitat selection, 2007–2011. Map represents our 2nd order RSF model averaged coefficient estimates for top four RSFs according to AICc. (i) Relative location of packs no longer in existence but identified as habitat with high relative probability of occurrence of red wolves; (ii–v) relative location of packs not represented in our dataset but in existence at the time of this study, indicating our top 2nd order RSF can predict potential location of packs not regularly monitored or places where dispersing animals might establish home ranges.

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such roads provide a cursorial predator like red wolves. Our third and fourth best RSF included a positive interaction between human density and distance to road (Table 1), suggesting that as human density increased red wolves selected areas further away from roads. It is likely that increasing human density is positively correlated with primary paved roads. These results imply that red wolves can differentiate between high and low traffic roads. But a lack of differentiation between primary and secondary roads in our analyses makes such an interaction difficult to interpret. Gray wolves in Alaska were found to avoid high traffic roads while selecting areas close to secondary roads, presumably for ease of travel and low human use of secondary roads (Thurber et al., 1994).

However, our study revealed that habitat selection by red wolves is influenced by changes in human density and development (i.e., presence of secondary roads). According to our best RSF, as human density increased, strength of avoidance of pine plantations, lowland forests, and wetlands decreased, relative to other land-cover types, including human-associated land cover (Table 2). Thus given this interaction between human density and land-cover type, it is possible that red wolves exhibit some tolerance towards increasing human densities and this trait, if selected for, may permit red wolves to persist within a mosaic of human-altered and naturally occurring habitat. It is possible that this decreased avoidance of normally avoided habitats and, at relatively high human densities, eventual selection of these habitat types over agricultural and early successional fields (Table 2) may indicate a reaction to an increase in potential human-red wolf conflict. Agricultural fields and early successional fields are very open habitats with high visibility. Pine plantations, lowland forests, and wetlands are more heavily vegetated with lower visibility. Red wolves, like other carnivores, may prefer such habitats in relatively higher human density areas where human-red wolf conflicts are possibly more likely (Conde et al., 2010; Lesmerises et al., 2012). Similarly, as distance to roads decreased, avoidance of lowland forests, pocosin, and wetlands decreased relative to other land-cover types (Table 2). Much of the RWREPA is subject to periodic rise in water levels due to proximity to the Atlantic Ocean, resulting in many areas being inundated frequently. Such areas, when inundated, are difficult for red wolves to move through and are also likely avoided by primary prey like white-tailed deer. The above interaction is likely an interaction between distance to roads and surrounding water levels in a given area. Thus, habitats often inundated with water are selected primarily when bisected by roads (Table 2). Where roads are present, these habitats could serve as travel corridors and allow for red wolves to persist in areas where low and high quality habitats are highly interspersed and large parcels of high quality habitats are few. For large carnivores in general, sub-optimal habitats might serve as important routes of dispersal for young adults or travel corridors within an animal's home range, linking habitats necessary for survival and reproduction (Corsi et al., 1999; Harrison and Chapin, 1998; Mech, 2006). Furthermore, large areas of intact high quality habitat may not be as necessary for conservation of some species of large carnivores, if such areas are adequately connected (Harrison and Chapin, 1998; Mech, 2006; Mladenoff et al., 1997).

Research on whether selection of particular land-cover types by large carnivores is affected by human density or roads has been limited. Several previous studies have shown that habitat selection by gray wolves is influenced by human and road densities (Cayuela, 2004; Corsi et al., 1999; Lesmerises et al., 2012; Llaneza et al., 2012; Mladenoff et al., 1999; Oakleaf et al., 2006; Thurber et al., 1994). However, these studies only went as far as to demonstrate that wolves were at higher risks of mortality in areas of high human density and development and actively avoided these areas. We do not suggest negative human attitudes and actions as the sole reason for the limited recovery and conservation of large carnivores. However, we do suggest that large carnivores may select human-altered land-cover types if unimpeded, thus increasing likelihood of recovery in areas in close proximity with humans. Understanding how habitat selection by wolves is affected by changes in human density and overall development could help identify areas of potential human-wolf conflict or direct management for fostering recolonization of large carnivores such as wolves; if public perception allows for such management. Research on gray wolves in the Great Lakes area of the USA revealed that changes in human and road density, and transition from natural to human-altered land-cover types were good predictors of depredation of livestock by gray wolves (Treves et al., 2004). Such an understanding could be used to adjust livestock husbandry practices to reduce human-wolf conflict in such areas.

6. Conclusion

Given that a large percentage of the historic range of the red wolf, and the naturally occurring land-cover therein, has been altered by human activities, future reintroductions and persistence of red wolves will likely require populations to persist in areas dominated by human presence and development. Our results indicate that red wolves will use human-associated land cover types. Red wolves were also shown to shift habitat use as human density and development increased, suggesting they can adjust to changes in these variables. These results also provide support for the idea that other large carnivores can persist in parts of their historic range where a habitat mosaic of human-altered and natural land-cover types now exists. Such results, inherently applicable to the management and conservation of other pack forming large carnivores, can also be applied to solitary large carnivores if one considers that red wolf packs have the same drives and needs as solitary large carnivores: to obtain food, reproduce and raise young, and establish a home range; implying that social and solitary large carnivores can be viewed similarly as units, making our results applicable to all types of large carnivores for conservation and management. Though in the case of large carnivores, including the red wolf, serious conservation efforts are needed to assist the species in recolonizing such areas. These conservation efforts would not only need to assist the given species by way of reintroductions but also serve as mediators; interacting with the local peoples in an attempt to reduce negative social perceptions that are generally associated with such efforts (Oakleaf et al., 2006). We cannot be certain that all large carnivores are capable of persisting in such circumstances. However, our study demonstrates that one large carnivore, the red wolf, is adaptable enough to at least respond to human-related changes in its environment. Managers and conservationists working with large carnivores elsewhere could benefit from understanding how changes in human density and development impact habitat use. The next step is to understand, for species such as the red wolf, the implications of shifts in habitat use in response to changes in human density and development on survival and reproduction.

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DISTRIBUTION AND RELATIVE DENSITY OF THE RED WOLF IN TEXAS *

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ABSTRACT

Summer and winter transects were run throughout the range of the red wolf (*Canis rufus*) along the Texas Gulf Coast utilizing a hand-cranked siren to elicit howling. The red wolf could be distinguished from the coyote (*C. latrans*) by its patterns of vocalization. Slight confusion was caused by wolves which, located close to the siren barked like domestic dogs.

No significant differences were detected between the effectiveness of the technique in winter or summer or between two or four-mile spacings of the howling posts along transects. Heavy fog did cause a significant decrease in the number of responses and high winds probably limited the effectiveness of the technique.

Many areas thought to be occupied by red wolves were found to contain only coyotes. The coyote appears to be expanding its range into the marshes and coastal prairies which are the last stronghold of the red wolf. Isolated wolf populations were located in Harris and Brazoria Counties along with the major population grouping in Liberty, Chambers and Jefferson Counties. Highest densities of wolves are found on the prairie. There appears to be no genetic linkage between Texas and Louisiana populations because of a canid-free zone surrounding Lake Sabine.

Populations of wolves appear to be rapidly disappearing and without rapid protection and aid it is likely that the species will become extinct in the wild within the decade.

INTRODUCTION

The red wolf once ranged throughout the entire southeastern United States from Florida to central Texas (Young and Goldman 1944). Little concern accompanied its decline because the animal was replaced by large coyote-like canids throughout the western half of its range. Perhaps it would have passed out of existence unnoticed had McCarley (1962) not become concerned over his inability to find "good" red wolf skulls from areas where the animal was considered abundant. Unfortunately, McCarley's paper was not widely read and Cahalane (1964), on the basis of questionnaire replies from southeastern state game and fish personnel, estimated that "several thousand" red wolves remained in Texas, Louisiana and Arkansas. This confusion was no doubt due to the replacement of red wolves with coyote-like canids.

McCarley's paper came to the attention of two Canadians, Pimlott and Joslin, who were experienced workers with grey wolves (*C. lupus*). Subsequently, these investigators conducted a status survey of the red wolf using their howl-response technique which had been developed for use on grey wolves. Pimlott and Joslin (1968) positively identified red wolves only on Pitman and Davis Islands along the Mississippi River, and in one area in north-central Louisiana, and in Jefferson, Chambers and Liberty Counties in Texas. As a result of this survey, the red wolf was placed in the Red Data Book of the International Union for the Conservation of Nature and Natural Resources and on the endangered species list of the U. S. Fish and Wildlife Service.

* A contribution of Federal Aid in Wildlife Restoration Texas W-103-R.

The Texas Parks and Wildlife Department, using a modified howl-response technique, instigated a status survey of the red wolf in Texas in 1970. The aim was to establish the distribution and relative density of this species in a way that would enable the monitoring of future changes in the populations. This is a report of that survey.

The remaining red wolf range in Texas may be broken into three broad habitat types: marshlands, prairie grasslands, and woodlands (Fig. 1). Marshlands grade from salt marshes generally found within 5 miles of the coast to completely fresh marshes inland as far as 15 miles. Vegetation correspondingly grades from cordgrass (*Spartina* spp.), seepweed (*Suaeda* sp.), and sea-oxeye (*Borrichia* sp.) in the more saline areas, through saltgrass (*Distichlis* sp.) brackish marshes into bullrush (*Scirpus* sp.), cattail (*Typha agustifolia*), and sloughgrass (*Beckmannia syzigachne*) in completely fresh marshes. Most of the areas are exposed to light cattle grazing, but their primary values stem from waterfowl hunting and fur trapping.

A large portion of the upper Texas coast consists of rice farms and the prairie grasslands to which these farms revert when allowed to lie fallow. Characteristic vegetation includes the bluestems (*Andropogon* sp.) and Indian grass (*Sorgastrum nutans*), broadly interspersed with hackberry (*Celtis laevigata*) and oak (Quercus sp.) in the east and mesquite (*Prosopis* sp.) and pricklypear (*Opuntia* sp.) to the south and west. Waterfowl abound in the winter ponds of the area. The chief agricultural pursuit is alternate pasturage and rice farming wherein any given piece of land is allowed to lie fallow 2 or 3 years following a rice crop. Much of the land has been converted to housing and industrial developments, and the trend is steadily increasing.

Woodlands of the region range from cypress (*Taxodium* sp.) swamps with water oak (*Q. nigra*), palmetto (*Sabal* sp.), and sweetbay (*Magnolia virginiana*) through mesophytic hardwoods into well-drained uplands of loblolly (*Pinus taeda*) and shortleaf (*P. echinata*) pines, hickory (*Carya* sp.) and various oaks. Local but limited operations for commercial firewood, pulpwood, and timber exist, and most woodlands are subjected to moderate grazing.

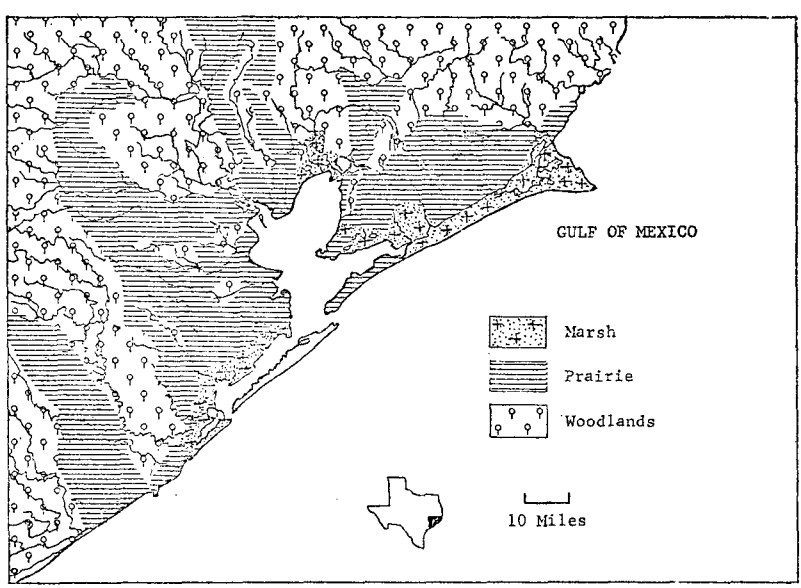


FIGURE 1. Habitat types found within the range of the red wolf in Texas.

METHODS AND MATERIALS

Three methods were considered for eliciting howling responses: human vocal imitations, tape-recorded howls, and hand-cranked air-raid sirens. Problems immediately arose with human vocal imitations. Serious straining of the vocal cords resulted, and neither of the authors was particularly successful in evoking responses from wild canids. With the right talent, this technique might be suitable for locating populations, but because of the variations in the skills of different investigators, it cannot be standardized.

Consideration was given to the use of tape-recorded howls which could be easily standardized. However, Joslin (pers. comm.) recommended that recordings not be used since they did not appear to be as effective as human vocal imitations. This technique was, therefore, discarded.

After preliminary tests, we decided that the hand-cranked air-raid siren would give a reasonably high level of success and could be easily standardized, thus permitting follow-up censuses to be carried out by other workers, regardless of their skill. Sirens used were military models producing a high-pitched wail of approximately 600 cycles per second and a maximum volume approaching 105 decibels at 100 RPM crank speed. At each stop, a siren was cranked for exactly 30 seconds and the investigator would then wait 2 minutes for responses. We believe that the 30-second siren blast will elicit maximum responses, yet will not obscure early responding howls as longer operational periods might.

Census strips were laid out along state highways, farm-to-market roads, and county and private shell roads throughout the area to be censused. The only condition for utilization of a given road was that it lie at least 4 miles from the next census strip. Along each strip the siren was sounded at 2-mile intervals during the summer and 2-and 4-mile intervals during the winter census. The investigator would then record howls, if any, as to number, direction and species. Surveys were always carried out between sunset and sunrise, not so much because of wolf activity, but because of reduced disturbance from passing vehicles.

RESULTS

Pimlot and Joslin (1968) determined that the answering call of the red wolf was similar to that of the grey wolf. The sonogram in Figure 2 is representative of the beginning of a red wolf howl. Although it resembles closely the sonograms of grey wolves (see Theberge and Falls 1967); it differs somewhat in that the pitch of the second and higher harmonics is slightly higher at the beginning and becomes higher throughout the call. One sudden drop in pitch is shown in Figure 2

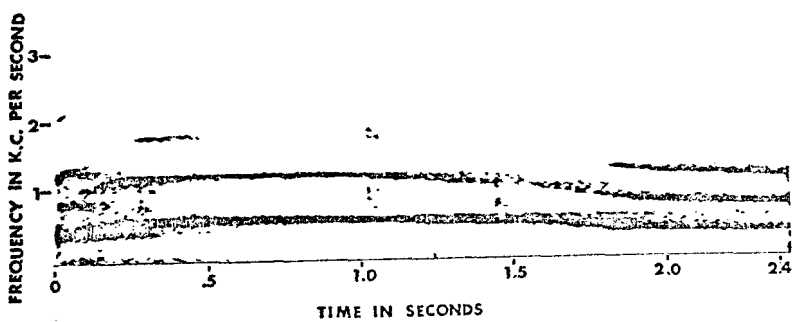


FIGURE 2. Sonogram of the beginning of the howl of a red wolf. Note the pitch change which occurs at intervals throughout the calls. Six harmonics are readily visible in this sonogram and more can be detected in others.

and there may be up to four such drops and rises with each full call of 4 to 16 seconds duration.

Coyote howls are generally higher pitched than those of either the red wolf or the grey wolf and are generally easily distinguished from wolf howls by their frequent sharp rises in pitch (yaps) that occur at 3 to 5 second intervals. The coyote, grey wolf, red wolf and dog (*C. familiaris*) are all known to bark. Barking in red wolves was noted only when the animals happened to be in close proximity to the siren and this may represent an alarm reaction rather than a "normal" response. Dogs, on the other hand, almost always combined their howling with barking. Often we were able to check for dogs by the location of farm houses and many times actually saw the dogs that had been barking. Thus, we were able to check ourselves until we felt certain that we could distinguish between the response of the wolf and that of the dog. In some cases, coyotes ended their yodeling sessions with sharp barking, readily discernible from wolf and dog vocalizations.

A portion of Chambers County was surveyed three times during the summer of 1970 and three times during the winter of 1970-1971. Results of this survey are shown in Table 1.

TABLE 1. Distribution of returns on 6 replicates of survey lines in southern Chambers County taken in summer of 1970 and in winter of 1970-1971.

Summer Replicate					Winter Replicate				
No. Responding	1	2	3	Total	No. Responding	1	2	3	Total
0	52	53	51	156	0	54	52	51	157
1	6	4	8	18	4	2	5	7	14
2	2	3	1	6	2	3	3	1	7
3	1	1	1	3	3	1	1	2	4
4	0	0	0	0	4	1	0	0	1

Grouped into an overall distribution the data were fitted to a negative binomial distribution (Bliss 1953) and tested by a X^2 goodness of fit (X^2=100, df=1, P>.25).

The transformation y:log (Xi + K/2) from Moyle and Lound (1960) was used to normalize the residuals for analysis of variance. An analysis of variance table for nested classifications (Snedecor and Cochran 1967) is as follows:

Source of Variation	df	SS	MS	F
Seasons	1	0.00390824	0.00390824	5.65
Counts in Seasons	4	0.00276647	0.000691670	0.06
Stops in Counts	360	3.94769505	0.010965819	. . .
Total	365	3.95436976	. . . . .	. . .

Therefore, it appears that the technique will give uniform results when used over standardized transect routes regardless of the season if a stable population is assumed.

A similar portion of Brazoria County was censused twice with intervals between stops being 2 and 4 miles, respectively. The change in spacing did not cause a significant difference in the number of animals located. A compensating factor may have functioned in the spacing change, however, because once a wolf has answered it cannot be coaxed into howling again for some time. This means that when approached along a transect, the wolf may answer at too great a distance for the

investigator to hear and will not respond again when the investigator moves closer. A Labrador retriever belonging to the senior author frequently was able to hear canids before his master could detect them and sometimes appeared to hear canids never detected.

High wind and fog appeared to limit severely the effectiveness of this technique. It seems only logical that high winds would greatly hamper the hearing of both wolves and investigators. Fog seriously limits howling responses and may prevent them altogether. No howls were recorded during heavy fog even though special efforts were made to locate animals on several such nights.

Table 2 shows the relative densities of red wolves in the three coastal habitat types. Highest densities were found along marsh edges and in the prairie and rice field land further inland (Figure 3). Few wolves could be located in the woodlands which, incidentally, harbor fairly abundant coyotes. The only wolves found in woodlands were those situated near Lake Houston in an area of oak savanna surrounded by pine uplands.

TABLE 2. Relative abundance of the red wolf in three habitat types along its range on the Texas Gulf Coast.
(Summer and Winter surveys combined.)

	No. Stops	No. Responses	Responses/100 Stops	Acres in Habitat Type
Marsh	146	26	18	556,400
Prairie	470	107	23	984,020
Woodland	168	19	11	491,800

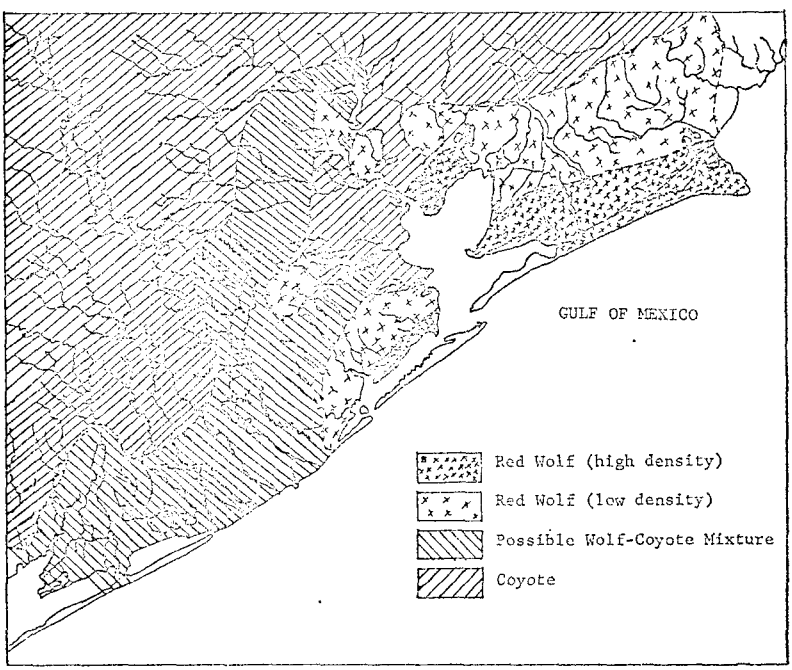


FIGURE 3. Range of the red wolf in Texas as determined by howling census with location of areas in which only coyotes were detected but which may have recently been wolf range.

Minimum densities based on winter counts alone range from one animal per some 12,300 acres in southern Chambers County to one animal per approximately 66,600 acres in eastern Jefferson County. This survey indicated a minimum red wolf population of approximately 92 animals for the State of Texas.

DISCUSSION

We have presented evidence elsewhere (Russell and Shaw 1971) that the red wolf ranged throughout much of east Texas as recently as 1940. Davis (1966) gave the range of this species in Texas as an area extending inland about 100 miles from Orange County on the Louisiana border into South Texas as far south as Kenedy County. No wolves were located in this study farther south than Brazoria County even though spot checks were made as far south as Aransas County. Within their remaining range, red wolves were not found more than 50 miles inland. Thus, we see that the range of the red wolf is still declining.

Population fluctuations have been apparent within the remaining range during the past few years. The high Jefferson County population experienced a severe decline in 1969, perhaps due to density-dependent parasites and diseases. This decline was accompanied by severe cases of sarcopic mange (*Sarcoptes scabei*) noted in several wolves (Riley pers. comm.). The Chambers County population, on the other hand, seems to have rallied since 1964 when a trapper took 46 wolves within a 30-day period (Russel Clapper pers. comm.).

The authors know of no recent verification of Pimlott and Joslin's reports of red wolves in certain parts of Louisiana. However, reliable sources have found red wolves on the Moore Ranch in Cameron Parish, Louisiana at densities comparable to those in southern Chambers County (Glynn Riley, pers. comm.). Because of the heavily industrialized and canid-free zone around Lake Sabine, no gene flow is thought to occur between Texas and Louisiana populations.

The threat that red wolf x coyote or red wolf x dog hybridization poses to the survival of the remaining red wolves has been outlined by several authors (McCarley 1962, Nowak 1970, Paradiso 1968). "Strange-looking canids and smaller animals" have recently been seen and trapped within the last stronghold of the red wolf (Glynn Riley, pers. comm.). Interestingly enough, we heard no intermediate or indistinguishable howls in all of our survey; all were distinctly coyote, red wolf or dog.

With problems of range reduction, habitat loss, hunting and trapping pressure, and the possible infusion of foreign genes, the survival of the red wolf in Texas is in critical danger. The animal is totally unprotected and its endangered status is not generally known to the public, even in those areas in which it still occurs. Unless the serious plight of the red wolf is much better publicized, and unless some protective measures and management plans are instigated very soon, we believe that this species, once indigenous to the entire southeastern United States, will completely disappear within this decade.

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"DOVE" PROSO MILLET—NEW MOURNING DOVE FOOD?

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ABSTRACT

"Dove" proso millet (*Panicum miliaceum* L.), a new variety of proso millet, is being planted to attract doves in the Southeast. A food habit study was initiated to determine the desirability of dove proso as a mourning dove (*Zenaidura macroura*) food as compared with browntop millet (*Panicum ramosum* L.). Field trial plantings of equal acreages of dove proso and browntop millet were made in nine counties of South Carolina from 1966-1970. Crops of 152 mourning doves were collected and analyzed. Eighty-six of the crops were collected from a single trial field on Oakland Club, Berkeley County. Volumetrically, dove proso comprised 25.4 percent and browntop millet 13.4 percent of the total food consumed. The percent frequency of use was not significantly different. The frequencies of use of dove proso and browntop millet were 53.3 percent and 50.7 percent respectively. The method of planting dove proso is described, with some of the problems encountered with dove proso in dove fields.

INTRODUCTION

"Dove" proso millet, introduced from India by plant materials specialists of the Soil Conservation Service, is being planted in fields to attract mourning doves in the Southeast. This study compared dove proso with browntop millet to determine if dove proso is as choice a dove food as browntop millet. Mourning doves were collected from dove fields with approximately equal plantings of dove proso and browntop millet. A crop analysis was the method of making the comparison. Browntop millet is reported by Neely (1961) to be a choice food for attracting doves and produces successful dove fields that are economical. Dove proso seed is presently more expensive than browntop millet seed and if dove proso is not as choice a dove food as browntop millet, it would be uneconomical to continue to plant the dove proso.

A habitat suitability analysis for the red wolf across its historic range

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August 2, 2016



Goals

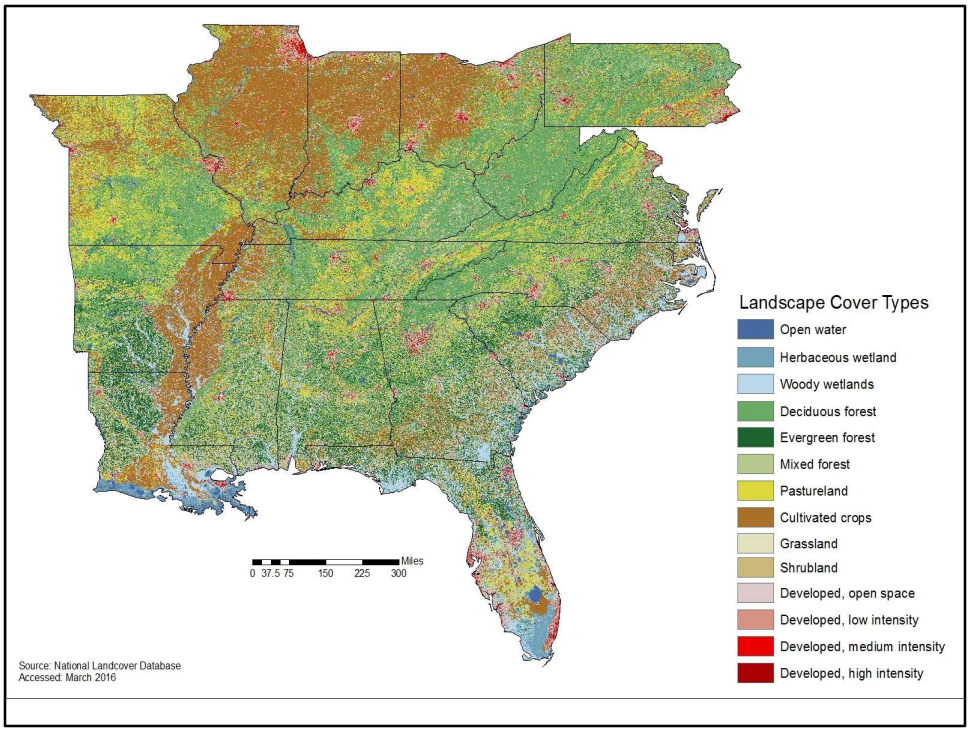
1. Provide coherent analysis of available data to identify suitable habitat sites for the critically endangered red wolf

2. Evaluate the role that human perception towards carnivores/red wolves may have in the ranking of suitable habitat.

Methodology

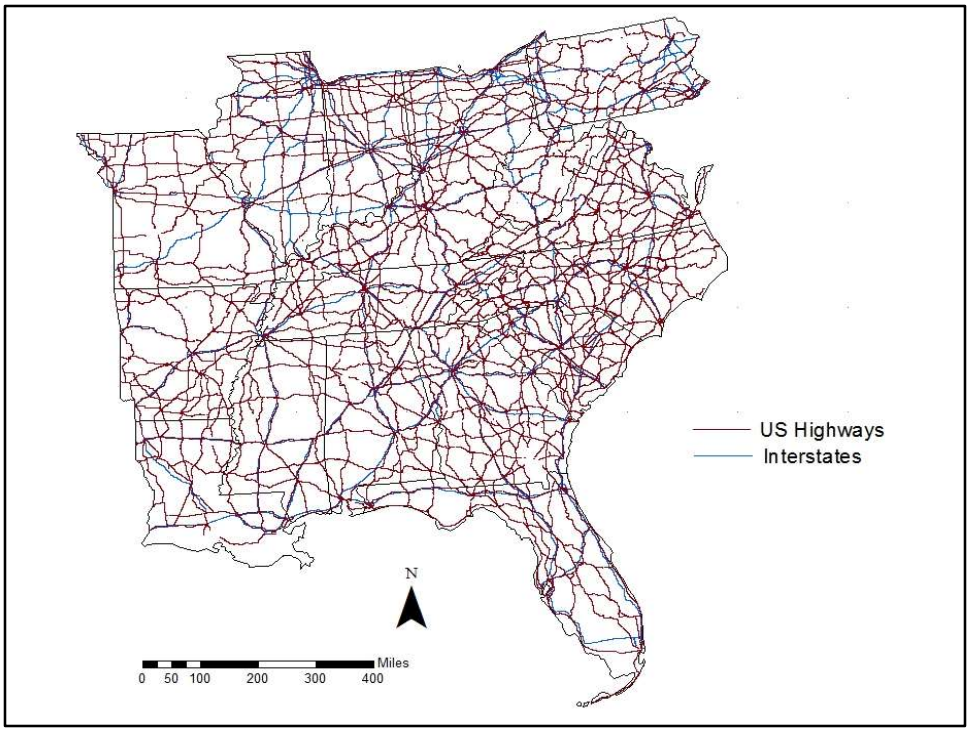
- **A majority of red wolf space use studies have been conducted only in the current range.**
- **Information gained through 22 published government documents, journal articles, theses, and dissertations that focused on red wolf habitat and space use.**
- **Red wolves are habitat generalists.**
- **I examined three variables:**
  - **Roads -> Interstate and Highway**
  - **Human Population -> Cities and Towns**
  - **Landscape**

Land variables came from one shapefile
Road variables came from separate shapefiles



I obtained landscape data for the 17 state region (National Landcover Data Set) and created a weighted index of habitat use.
I wanted to create this weighted index based on the information I read along with utilizing information obtained from a habitat use poll I sent to several people I considered knowledgeable in red wolf habitat use. Three people got back to me so I mostly relied on published analyses and correspondence with Joey Hinton and Justin Dellinger.

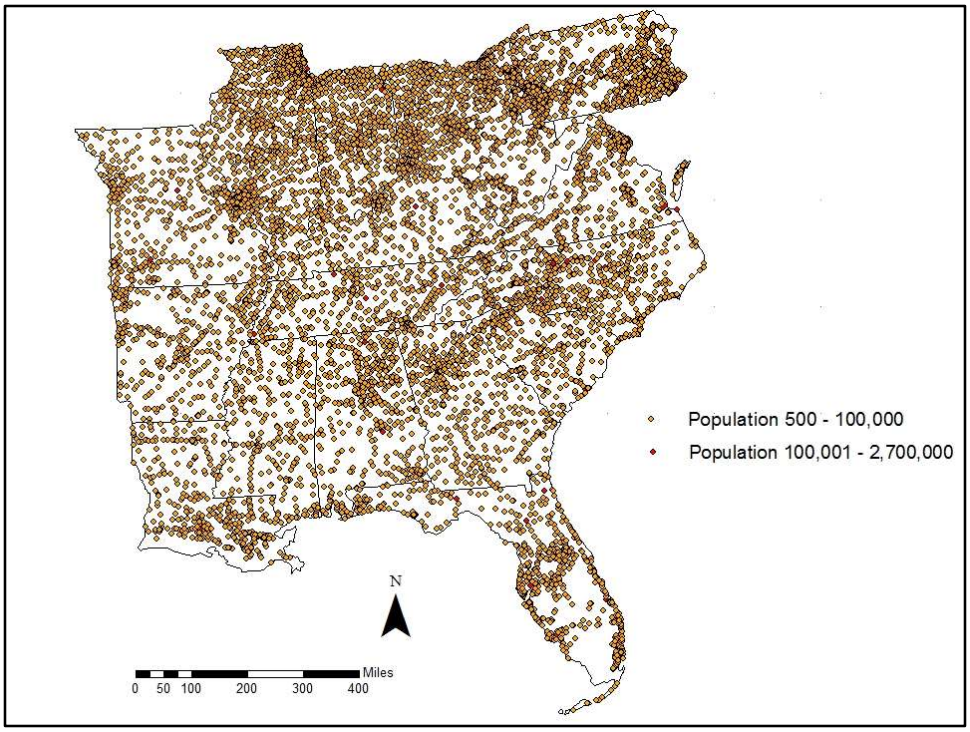
Habitat Weighted Index:
Forest: 91, this was ranked the highest
Grassland: 82
Cropland: 64



I obtained data from the US Census Bureau describing interstates and highways. Rather than looking at the density of roads within a particular area, I wanted to look at how far a particular area was from a road. Landscape between 0-1km from a highway and 0-2km from an interstate was deemed unsuitable. While you cannot police a wolf from crossing a road, putting buffers into a model will help determine landscape that has minimal roads/can determine potential barriers.

1km and 2km values were chosen: 1km Shaffer, 2007 (and used in Jacobs 2009 thesis about GIS Analysis of the DBNF for potential Red Wolf Restoration);
Avoided primary (2km) and secondary roads (0.5km): Eggerman, 2010 (Presence of wolf in relation to land cover, livestock, and human influence- gray wolf study)
Generally wolf dens were located >1km away from paved roads from Bassi, 2015, (Predicting Spatial Distribution of Wolf Breeding Areas- gray wolf study)

Utilized Euclidean Distance and Reclassify tools in ArcMap



Because my study area is so large, I utilized areas of human populations rather than population density. I separated populations of 500 – 100,000 individuals and 100,001 - 2,700,000 individuals and created two separate layers.

Again, I wanted to look at how far a particular area was from a population. Areas <2km from 500 – 100,000 individuals and <5km from 100,001 - 2,700,000 individuals were deemed unsuitable. (Citation: 2.0 km from towns –Shaffer 2007 and cited in Jacobs 2009 , no definition of town was provided so I created my own).

While it is probable that red wolves could survive in a human environment, humans may not be welcoming of wolves in an urban setting, hence why unsuitable areas were chosen.

Methodology

- **Utilized a weighted model**
  - **Allows for indices to be modified**
  - **Simple and customizable**
- **Determined variables**
  - **Abiotic: Major Roads and Human Populations**
  - **Biotic: Landscape types**
- **Indices were created with the information obtained from**
  - **Literature- to determine variables**
  - **Expert Opinion- to rank biotic variables**

This model can be modified for other species, indices can be modified depending on their habitat use/preference.
Kept simple bc we don't really know anything about this species so how can we justify using info from the NC or GSM population and translate it to other areas?

An idea: In regards to the model itself, no one is going to understand what that model is (what the numbers are, etc.) Set up a slide that walks through the model aka split methodology into two slides. First slide: approach- used expert opinion on parameters that I selected and used this particular model approach. The bullet points are expert opinion, modeling approach, etc. Once I built the model, I then ranked the sites. The second breaks down the model itself. So, put more info into the model slide.

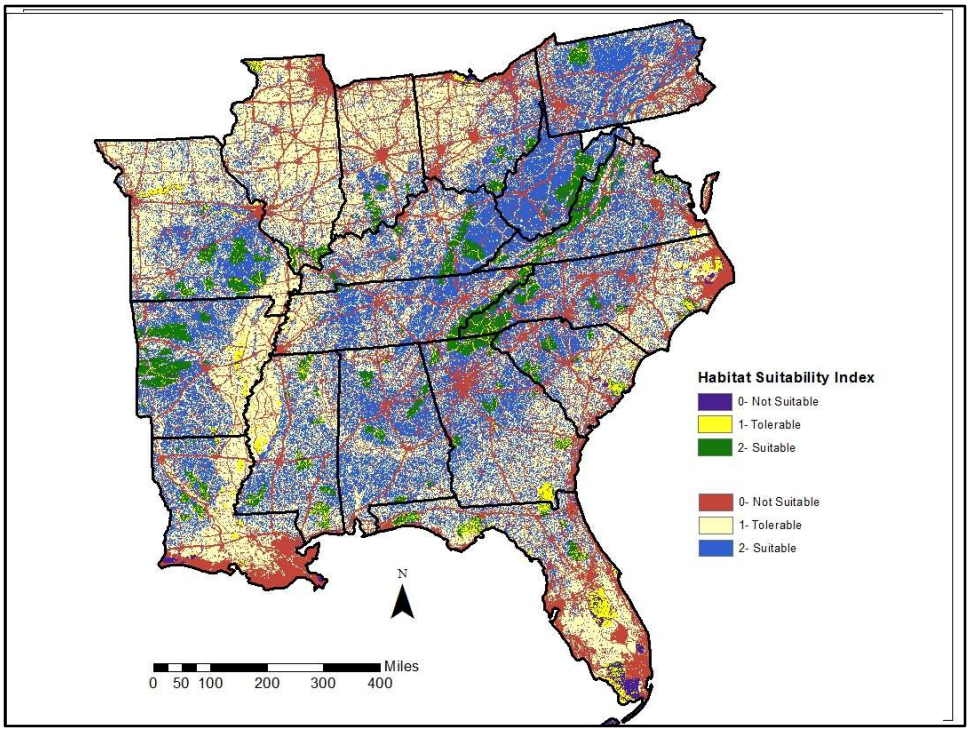
Methodology

Forest_91 + Grassland_82 + Wetlands_73 + Cropland_64 + Shrubland_64 + Pasture_64 – Interstate_19 - City_19 – Highway_37 – Towns_28

****Indices are based on a numbers range****

- **The larger the range, the heavier the weight**
- **The higher the number is in the 10s position, the heavier the weight**

Biotic variables were places first. They are all considered positive because each landscape has potential to be used by a red wolf, however they are weighted differently. (91 is highest, 64 is lowest). Human development is a negative for the red wolf so all abiotic variables are considered negative. 19 is the lowest index possible.



I am looking at habitats that have federal jurisdiction. Because we can't purchase every private landscape, I looked at releasing wolves in areas that already have federal jurisdiction.

Let's take a look further by highlighting areas of federally owned lands.

RANKED AS SIZE OF THE SUITABLE HABITAT AND PERCENT OF SUITABLE HABITAT WITHIN THAT AREA.
Kentucky BSF
Tennessee BSF
Arkansas NF
West Virginia NF
Alabama NP
Virginia NF
Kentucky NF
Pennsylvania NF
Alabama NF
Georgia NF
Ohio NF-> Wayne National Forest segmented into 3 sections. 971 Km2 total, 272 km2 Athens area.

Largest areas with high percentages:
Arkansas
Virginia
Missouri
West Virginia
Kentucky

Suitable Habitat <1,000 km^2

State	Agency	Area (km^2)	% **Suitable**/Tolerable/Unsuitable
Kentucky/Tennessee	Big South Fork NP	525	**92.9**/3.4/3.7
Kentucky/Tennessee	Land Between the Lakes NF	687	**82.3**/10.6/7.5
Alabama	William B Bankhead NF	733	**79.8**/14.4/5.9
West Virginia	New River Gorge NP	283	**78.1**/3.7/18.2
Indiana	Hoosier NF	821	**74.2**/15.9/10.0
Virginia	Shenandoah NP	809	**73.2**/10.8/16.0
Arkansas	Fort Chaffee	275	**68**/13.5/18.5
Missouri	Fort Leonard Wood	246	**66.2**/6.5/27.3
Kentucky/Tennessee	Fort Campbell	424	**60.5**/18.8/20.6
Georgia	Fort Benning	736	**56.1**/29.6/14.3

Arkansas Ft Chaffee is located in the west between the national forests.

I am looking at habitats that have federal jurisdiction. Because we can't purchase every private landscape, I looked at releasing wolves in areas that already have federal jurisdiction.

Red wolf pack size is estimated to be between 125km2 and 185km2 so this area could work in the beginning but there are no protected areas within close proximity that would be large enough to continue sustaining a growing population without a high probability of encountering human disturbance.

Suitable Habitat >1,000 km^2

State	Agency	Area (km^2)	% **Suitable**/Tolerable/ Unsuitable
Arkansas	Ozark and Ouachita NFs	12,140	**87.1**/8.1/4.8
West Virginia	Monongahela NF	3,727	**86.5**/8.3/5.2
Virginia	Washington & Jefferson NFs	6,694	**80.9**/10.4/8.7
Kentucky	Daniel Boone NF	2,865	**80.7**/9.3/10.0
Pennsylvania	Allegheny NF	1,873	**80.6**/14.3/5.1
Alabama	Talladega NF	1,588	**79.8**/14.4/5.9
Georgia	Chattahoochee NF	3,508	**78.7**/12.8/8.6
Ohio	Wayne NF	974/3375	**78.6**/14.0/7.4
Missouri	Mark Twain NF	6,070	**78.5**/14.0/7.4
Tennessee	Cherokee NF	2,652	**77.5**/12.0/10.5

WNF: 974 = the Wayne; 3375 = proclamation boundary (http://www.fs.usda.gov/detailfull/wayne/about-forest/?cid=fsm9_006090&width=full)

Federal Land	% Suitability
Big South Fork NP	92.9%
Ozark/Ouachita NF*	87.1%
Monongahela NF*	86.5%
Land Between the Lakes	82.3%
Washington and Jefferson NP*	80.9
Allegheny NF*	80.6%
William B Bankhead NF	79.8%
Chattahoochee NF*	78.7%
Wayne NF*	78.6%
Mark Twain NF*	78.5%
Cherokee NF*	76.1%
Hoosier NF	74.2%
GSMNP	76.1%
Shenandoah NP*	73.2%
Nantahala and Pisgah NF	66.2%

Region	Composite Index
E West Virginia	0.926
SW Mississippi	0.905
N Mississippi	0.875
S Missouri	0.875
NW Arkansas	0.833
Okefenokee	0.833
N Pennsylvania	0.815
SW Arkansas	0.795
W Virginia	0.794
S Indiana	0.792
C Fl panhandle	0.778
SW North Carolina	0.778
S Illinois	0.767
SW Kentucky-NW Tennessee	0.750

Note to Emily: a screenshot of the original slide is attached in the email for easier reading purposes.

WBBankhead and Talladega rank the same in Alabama

Compared to the list presented in Van Manen: covers the top sites (NW AL, E WV, SW MI, N MI, S MO, NW AR, N PN) -> different methods of obtaining similar results.

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Discussion

- **There is still habitat available for three distinct red wolf populations.**
- **Several federally managed landscapes reside within suitable habitat.**
- **Federally managed landscapes vary in size and amount of suitability.**
- **Areas to look further into:**
  - **Missouri/Arkansas**
  - **West Virginia/Virginia**
  - **Kentucky**
  - **Ohio**

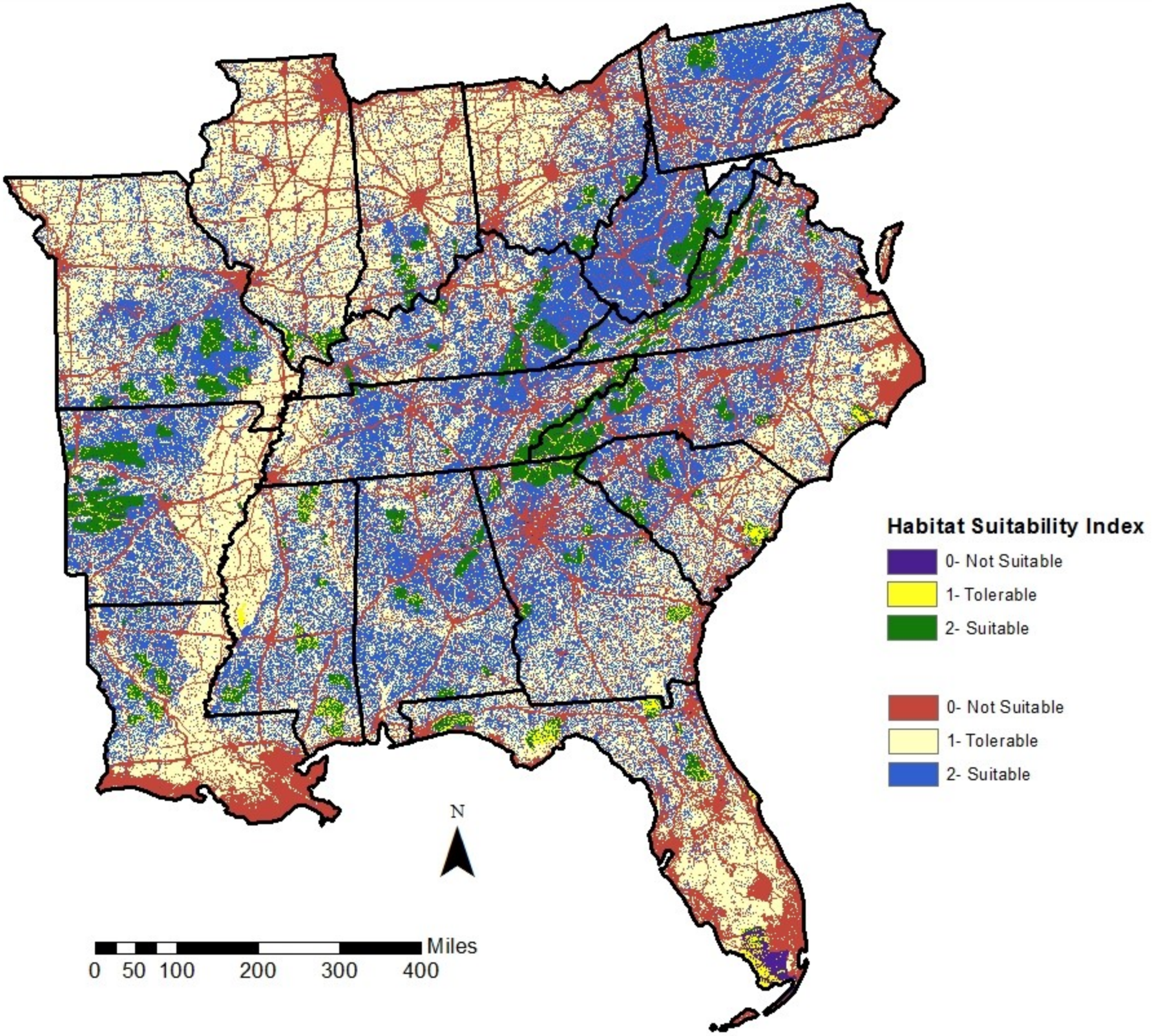
The states listed all have areas of suitability and can serve as corridors for populations.

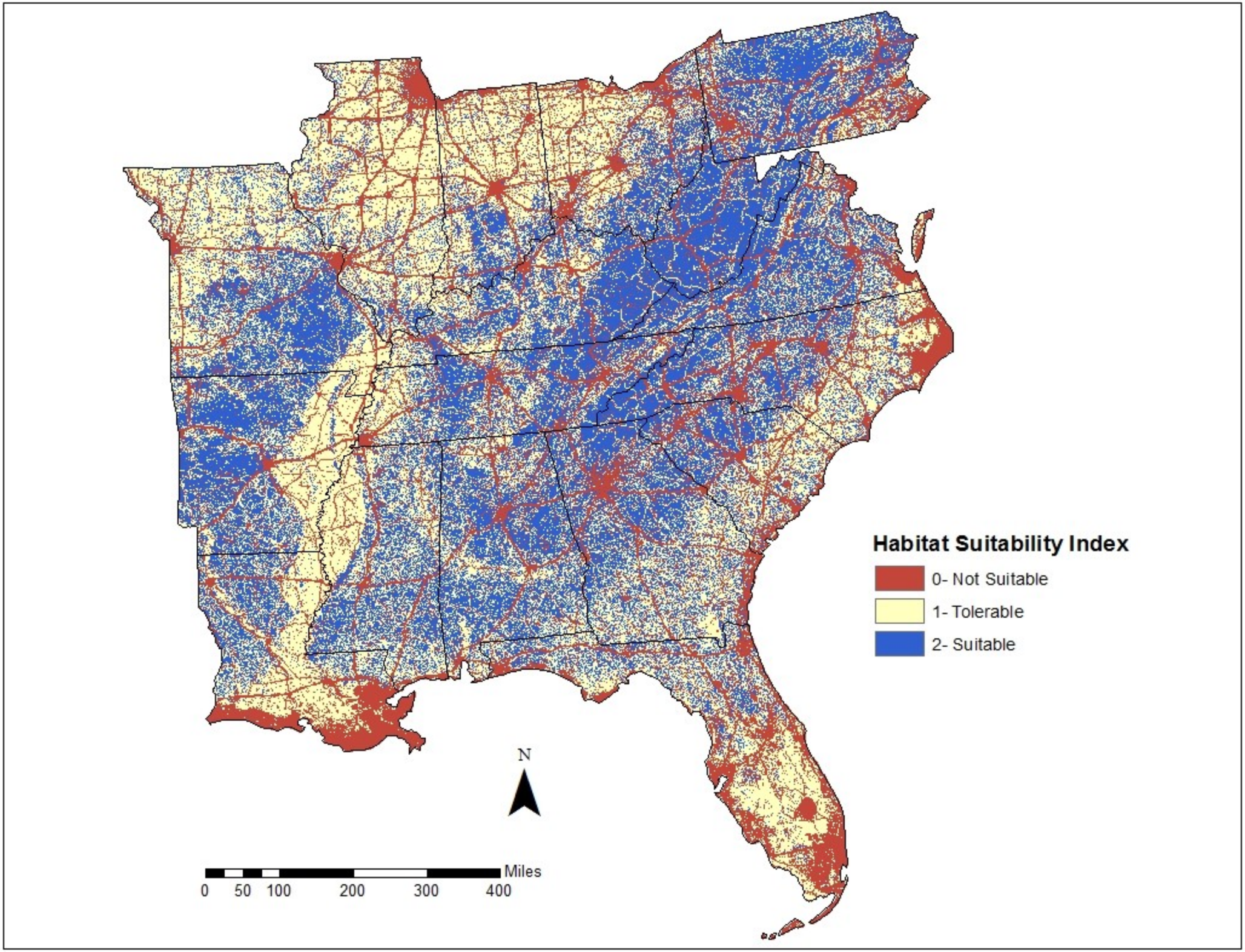
The Next Step

Before any reintroduction process, especially with carnivores, assessing knowledge and engaging the local population is essential.

- **Run education programs in areas near sites of suitable habitat.**
  - **Focus on carnivores as a whole, the red wolf will be used as an example.**
  - **Test whether or not education can affect human perception of carnivores.**
- **Along with educational programs, surveys will be distributed to as many populations within suitable areas.**
  - **Surveys will address: Basic demographics, use of closest suitable area, different questions relating to carnivore knowledge and interest**

Currently, surveys will be sent via email to different organizations within an area: Nature groups, hunters' groups, church groups, special interest groups, Democrat/Republican organizations, etc.


Habitat Suitability Index
0- Not Suitable
1- Tolerable
2- Suitable
0- Not Suitable
1- Tolerable
2- Suitable
N
Miles
0 50 100 200 300 400


Habitat Suitability Index
0- Not Suitable
1- Tolerable
2- Suitable
N
Miles
0 50 100 200 300 400

Paleontological, archaeological, and biogeographical evidence concerning the Genus *Canis* in eastern North America

The findings from differing disciplines need to be brought into the continuing debate on the relationships of present-day members of the genus *Canis* in North America. Regardless of which group of researchers is involved in recent genetic studies, there seems to be virtually no reference to these differing disciplines, including providing a sound rationale as to why information based on fossil and archaeological specimens as well as the notes of the early naturalists and more modern-day mammalogists may be suspect or not relevant to the existing investigations. Here I present core findings from past understandings of canid relationships in North America since from the Pleistocene (and potentially with the actual common ancestor for gray wolf [*Canis lupus*] and coyote stretching back into the Pliocene, about 10 million ybp) to the present day, and specify the contextual meaning with respect to findings within the canids now under discussion in the Southeastern U.S.

The application of non-genetic lines of evidence can be brought to bear to sort through and evaluate the validity of genetic-based evidence regarding red wolf, eastern wolf (*Canis lycaon*), gray wolf and coyote. In particular, several unresolved issues were not addressed by vonHoldt et al. (2016) with specific relevance to at least the red wolf taxonomic discussion:

(1) A provocative claim is made by vanHoldt (2016) for a chronologically "much later" than expected time estimate of divergence from a common ancestor which speculatively occurred in Eurasia, and with both gray wolf and coyote then migrating to North America. This is in direct contrast to many decades of understanding with respect to the origins of these two species and their respective presence in North America. Meanwhile the authors of this study appear dismissive of the presence of "coyote- and wolf-like forms" documented by fossil evidence occurring in North America long before their genetic based findings implying these forms were not direct ancestors for modern day gray wolf, coyote, or one or more small wolf-like forms in eastern North America.

(2) vonHoldt et al. fail to explain how it was possible for a hybrid swarm with wolves and coyotes in eastern North America to have formed either during the later Pleistocene and early Holocene or during more modern times, given the available fossil and archaeological data demonstrating no morphological overlap among red wolf and the two purported parental species that would have been expected from a true hybrid swarm. Also, unaddressed are the accounts from the earliest European naturalists of the only canids known from the Southeast U.S. that when described are best assigned as modern red wolves, but these were in the complete absence of coyote east of the Great Plains, with this absence well documented by mammalogists until the mid-to-late 1900s. It is also questionable that gray wolf ever ventured south of eastern Canada (and even so these

wolves were most likely eastern wolves [Wilson et al. 2000, 2003, Chamber et al. 2012] or possible hybrids between gray wolf and northern populations of red wolf [Nowak 2002] during these same time periods based on fossil evidence.

(3) If we concede that in eastern U.S. prior to 1900 it was possible for remaining and widely scattered wolves (surviving from European settler efforts to eradicate them) were hybridizing with a very small number of coyotes that may have slipped eastward of the Great Plains, why is it that no such hybrid swarm occurred in western North America?

Each of these three issues is expanded upon in more detail below:

What does all the evidence suggest regarding divergence times among North American *Canis*?

It is safe to say that the taxonomic relationship of North American canids is extremely complicated and the subject of many monographs and journal publications. Taking into account all the potential findings specifically from genetic research there may be at least five possible interpretations for how many species in the Genus *Canis* occur presently in North America (not including dogs ["*Canis familiaris*"] which have occurred in North America for at least 10,000 ybp and are variously treated as conspecific with gray wolf and have interbreed with all other wild forms of canids]:

(1) Only one species (where gray wolf [including eastern and red] and coyote are not genetically divergent enough to qualify as separate species; one possible interpretation from vanHoldt et al. 2016),
(2) two species (gray wolf and coyote, vanHoldt et al. 2016),
(3) three species (gray [including eastern] wolf, red wolf, and coyote; Nowak 1979, 2002)
(4) three species (gray wolf, and eastern [including red] wolf, and coyote; Wilson et al. 2000, 2003), or
(5) four species (three species of wolves and coyote; Chambers et al. 2012).

For evidence regarding the first possibility suggested above, that gray wolf and coyote could be not divergent enough genetically to be generally considered separate species, see vonHoldt et al. (2016:3):

> … If we assume a generation time of 3 years, and an effective population size of 45,000, then this corresponds to a divergence time of 50.8 to 52.1 thousand years ago (ka), roughly the same as previous estimates of the divergence time of extant wolves. Thus, the amount of genetic differentiation between gray wolves and coyotes is low and not much greater than the amount of differentiation within each species (for example, Eurasian versus North American gray wolf…). This result contradicts molecular clock calculations based on short mitochondrial region sequences, which were calibrated using

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> a 1-Ma (million years ago) divergence time between gray wolves and coyotes. Despite body size and other phenotypic differences between the two species …and a long history of coyote- and wolf-like forms in North America, the genomic data suggest that modern coyotes and gray wolves are very close relatives with a recent common ancestry.

In fact, vonHoldt et al. (2016) point out that their pairwise divergence estimates collectively "…are comparable to those found among human populations…"

Species-level divergence is generally considered to be at minimum 1 million ybp between taxa (more certainty if over 2 million ybp), so with an estimate of only about 50,000 ybp (with a range in estimates from 6,000 to 117,000 ybp) between gray wolf and coyote an argument can be made that not only are gray wolf and coyote closely related, they may not warrant separate species-level status. For instance, of the four groups compared against each other in vonHoldt et al. (2016), the most divergent pairwise estimates were between red wolf and Eurasian gray wolf (followed closely by red wolf versus North American gray wolf, as well as by coyote versus both gray wolf groups).

In one news story, reported by Carl Zimmer for Science Times Newsletter (July 27, 2016), Dr. von Holdt was quoted as follows:

> The new study revealed that coyotes and North American wolves shared a remarkably recent common ancestor. Scientists had previously estimated their ancestor lived a million years ago, but the new study put the figure at just 50,000 years ago.
>
> "I could not have put money on it being so recent," Dr. vonHoldt said.
>
> That ancestor gave rise to two species — the predecessor of today's gray wolves and that of today's coyotes — somewhere in Eurasia. Dr. vonHoldt said that the two species then migrated into North America.
>
> There, coyotes evolved into small predators that specialize in taking down smaller prey. Wolves took a different path, relying on their larger size and great speed to prey on moose and other big mammals.

The vonHoldt et al. (2016) genetic based estimate of divergence between these two species of about 50,000 ybp is in stark variance to paleontological (fossil) evidence of modern coyotes and their ancestral species diverging from a common canid ancestor many hundreds of thousands to potentially 1.5 million ybp. In addition, fossil evidence suggests the modern gray wolf did in fact migrate from Eurasia to North America (perhaps in at least three separate waves), but much earlier than suggested by vonHoldt et al. (2016) as this species is first found in the fossil record in North America about 4-500,000 ybp, and with coyote already well established in North America at this time (Nowak 1979, Chambers et al. 2012). So either the genetics results of vonHoldt et al. (2106) are suspect or interpretations of fossils are suspect.

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Actually, there are several lines of evidence to be skeptical about the reported estimated time of divergence between gray wolf and coyote reported by vonHoldt et al. (2016), besides the odd comparison with human populations. First, they indicate that gray wolves and coyotes were sympatric when they started to develop their modern-day differences, whether in Eurasia or in North America, but there is no other evidence (or suggestion) that coyotes or their immediate ancestral species ever occurred in Eurasia (see discussion in Nowak 1979). Fossils attributable to coyotes have been described from the mid Pleistocene (the early Irvingtonian mammalian age between 1 and 1.5 million ybp). The most likely ancestral species to coyote according to Nowak (1979) is *Canis lepohagus*, described as a small coyote-like canid, was posssibly not restricted to North America with some suggested affinity with jackals and foxes of the Eastern Hemisphere) and occurred from the late Pliocene to the early Pleistocene (the Blancan mammalian age, from 1.5 to 3.7 million ybp), well before gray wolves emerged as a species in either hemisphere. vonHoldt et al. (2016) provide no evidence that would lead to a reinterpretation of the fossil record on the origins on modern-day coyotes as anything other than a species restricted to North American species with very long history (certainly longer than 50,000 ybp).

Similarly, the presently understood evolutionary history of gray wolf does not match well with the explanation given by vonHoldt et al. (2016). The Eurasian gray wolf according to Nowak (1979, see updated treatment in Nowak 2002) may have been derived from a relatively small wolf in North America, perhaps even a common ancestor with *Canis lepophagus*; with the root ancestor to all the North American and Eurasian canid taxa extending back between 3.7 and 10 million ybp during the Pliocene. Populations of ancestral Eurasian gray wolf evolved during the glacial ages and then returned based on fossil evidence to North America during the Irvingtonian mammalian age, presumably across the Bering Land Bridge during the Kansan Glacial Age (about 1 million ybp). However, there appear to have been separate waves of gray wolves coming from Eurasia (see Chambers et al. 2012) with the second such wave of modern gray wolf populations appearing in North America based on fossil evidence at about 4-500,000 ybp. Then another wave appears to have occurred during the Wisconsian Glacial Age (Rancho Lebrean mammalian age, 100 ybp) that would lead to establishment of gray wolf over most of North America (except apparently east of the Great Plains or south of the boreal forests of eastern Canada) at about the same time the very large "dire wolf" (*Canis dirus*) was becoming extinct after its "brief reign" (also during the Wisconsian Glacial Age, Rancho Lebrean mammalian age).

The extinction of dire wolf was at the same time many other megafauna became extinct at the end of the Pleistocene about 10,000 ybp. Interestingly many dire wolf fossils were found in the Southeast U.S., at the same time there were fossils representative of red wolf-like as well as a small coyote-like canids, but the very few fossils attributed in the past to gray wolf (Nowak 1979) have been now attributed to one or more extinct species that occurred in the Southeast U.S. (Nowak 2002).

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So the fossil evidence strongly contradicts a late divergence date for coyote of about 50,000 ybp and contradicts that coyotes have ever occurred in Eurasia (while a very distant precursor for coyotes could have occurred in Eurasia, it would have been likely have occurred more than 3.7 million ybp). Also, while it is documented that closely related taxa (i.e., subspecies, distinct populations) can show rapid divergence in size and behavior during relatively brief time periods (geologically speaking) this phenomenon most frequently occurs when the taxa are isolated from each other (such as on island versus continental populations, or with populations co-occurring in space but not in time, seasonally speaking). vonHoldt et al. (2016) suggested an explanation for their findings that has little support from the long history of evolutionary studies and is certainly contradicted by the present interpretation of fossil and archaeological evidence. One or the other lines of evidence is clearly flawed. While we should not doubt what vonHoldt et al. (2016) reported in their genetic study is what they found, we should be skeptical about the interpretation and require further work to seek better reconciliation with other lines of evidence.

<u>If there were hybrid swarms forming to explain the origin of red wolf, then how did coyotes and gray wolves escape documentation prior to such swarms and how did they escape documentation after such formation in eastern North America?</u>

The genetic findings from vonHoldt et al. 2016 (as well as the original genetics paper that intensified the on-going debate by Wayne and Jenks 1991) can only be explained by coyotes co-occurring widely with gray wolf at some point in eastern North America prior to the Twentieth Century. This assumption is made in stark contrast to existing fossil and archaeological evidence strongly suggesting coyotes were almost if not completely absent east of the Great Plains during most of the Pleistocene (the exception involved a very small form with most fossils dating from the late Pleistocene around 10,000 ybp). As mentioned above the only known wolf-like canid during both the later Pleistocene and continuing to occur through the Holocene within the Southeast U.S. was a "red wolf-like" canid, with dental and skull fragments essentially unchanged in size or morphology from individual red wolves we have today in the recovery program. The red wolf thus can be documented to have occurred in the southeastern U.S. in the near complete absence of gray wolf and with the extinction of the dire wolf as well as the extirpation of the "small" coyote-like canid after the Pleistocene (Nowak 2002).

And with respect to more modern times with human presence starting from 12-15,000 ybp, there is no evidence of coyotes (also referred to as the "prairie wolf;" Audubon and Bachman 1851) naturally occurring in eastern North America until the early 1900s in the Upper Midwest U.S., nor in the Southeast U.S. east of the Mississippi River until after the 1970s (west of the Mississippi River coyotes were absent in eastern Arkansas and through all of Louisiana until the 1950s, for the latter see Lowery 19740). At the time of European settlement (about 500 ybp), coyotes were either exceptionally rare or completely absent east of the Great Plains. In contrast, wolves (regardless of what kind of wolf, they were consistently described to match today's red

wolf) were well documented as persisting especially in the Southeast U.S. in the absence of coyotes, east of the Mississippi River at least into the early decades of the Twentieth Century. Wolves were extirpated from intense persecution in the absence of any naturally occurring coyotes along the Atlantic Coastal States by 1920 and the last verifiable specimens in Alabama from around 1944 and Mississippi by 1932. West of the Mississippi River, wolves existed essentially morphologically unchanged through most of Arkansas, Louisiana, southern Missouri, eastern Oklahoma, and eastern Texas, despite some co-occurring coyotes along the prairie edges at least until 1930. After 1930, increasing persecution took a heavy toll with the remaining wolf populations, with a notable increase of specimens illustrating hybridization with coyotes that continued well into the Twentieth Century. As we all know this sweep ended with the last remnant wolf population in the early 1970s, as the spread of coyotes eastward was now well underway west of the Mississippi River, in coastal Louisiana and the Upper Texas Coast with animals continuing to exhibit the range of morphological traits for red wolves represented from across the former range whose descendants are now within the recovery program. Since it is necessary to have both coyotes and wolves present to create a hybrid swarm, if coyotes were in fact present anywhere in eastern North America before 1900, where did they go and why did they completely disappear, only to reappear in the Southeast after over 50 years since wolf extirpation?

Also arguing against there ever being a hybrid swarm involving gray wolves and coyotes (even if they had been present, which data strongly suggest they were not), morphological data clearly indicate very distinct groupings of characteristics among the three taxa (Nowak 1979, 2002). If indeed there was a hybrid swarm the morphological data should indicate transitions and multiple overlapping measurements among the taxa as was demonstrated as coyotes replaced red wolves in Texas and Missouri after the 1930s (Nowak 1979, 2002). There is little doubt that some interbreeding occurred along the edge of the Great Plains where coyotes and red wolves co-occurred along the prairie-forest edges as in in Texas and Missouri, but it was not until after persecution greatly reduced red wolf populations that a hybrid swarm formed and shifted eastward (Nowak 1979).

<u>Why are there no such hybrid swarms in western North America, with similar persecution against wolves over the last 150 years?</u>

Why would remaining and widely scattered gray wolves in western North America, also systematically eliminated after the late 1800s, not also hybridize extensively with coyotes and form a hybrid swarm? While there is evidence that gray wolves and coyotes can in fact interbreed successfully under very controlled conditions (using artificial insemination), there is very sparse evidence that such interbreeding is actually occurring successfully in the wild as individual gray wolves are now found dispersing south of known packs in the western U.S. The only indication of hybridization in western North America is with three specimens examined by Nowak (1979; one each from Arizona, Chihuahua, and Veracruz) all within the present and

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former range of the Mexican wolf (*Canis lupus baileyi*), the smallest of the recognized gray wolf subspecies in North America (again, if one considers either eastern wolf a separate species or the result of hybridization historically with red wolf and more recently with coyote).

Mech (2011) with respect to the eastern wolf and the situation now involving the western Great Lakes region described non-genetic lines of evidence to suggest the origin of the eastern wolf would not seem likely to have occurred through hybridization:

Two schools of thought dominate the molecular-genetics literature on Canis spp. (wolves) in the western Great Lakes region of the US and Canada: (1) they are hybrids between Canis lupus (Gray Wolf) and Canis latrans (Coyote), or (2) they are hybrids between the Gray Wolf and Canis lycaon (Eastern Wolf). This article presents 3 types of non-genetic evidence that bears on the controversy and concludes that all 3 support the second interpretation.

Then in 2014, Mech et al. published the result of an experiment to cross gray wolves and coyotes in captivity:

Abstract

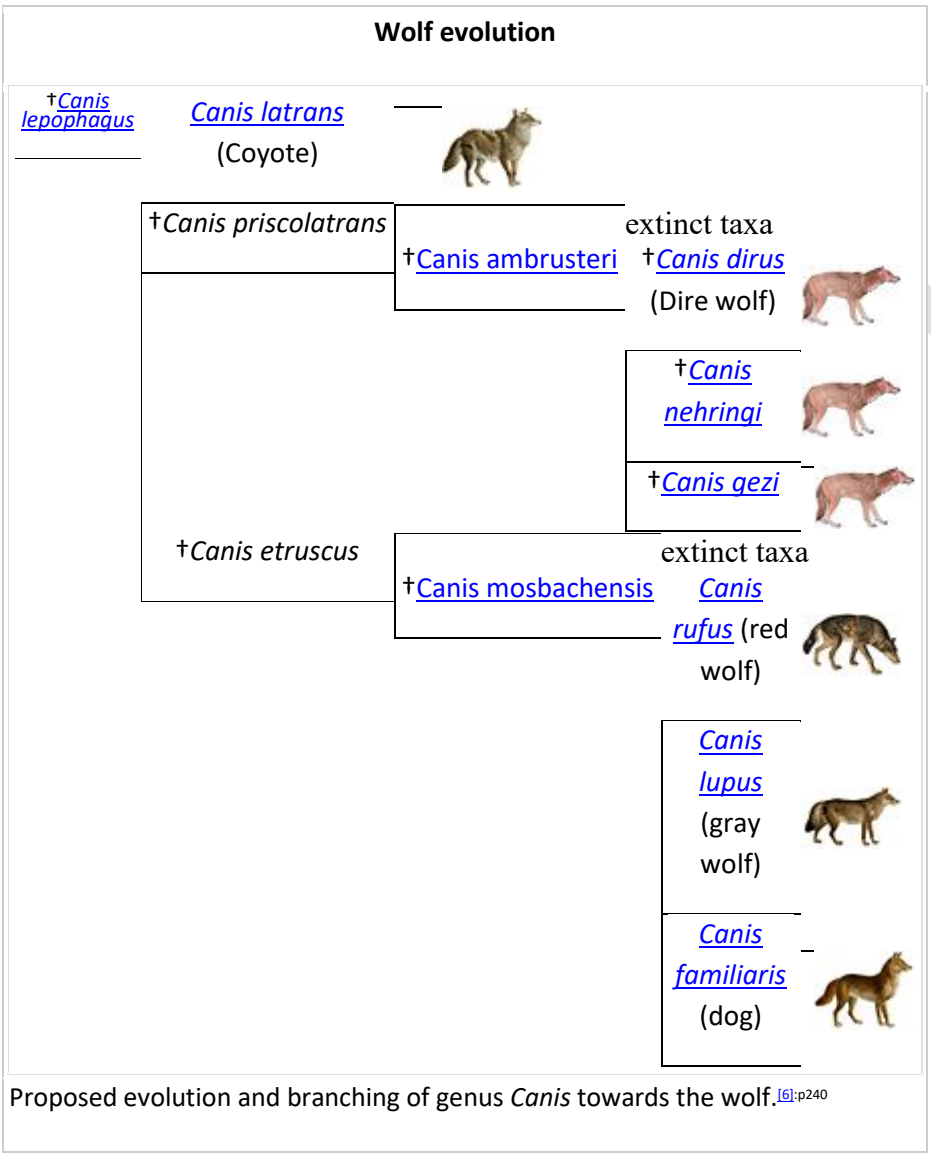
Using artificial insemination we attempted to produce hybrids between captive, male, western, gray wolves (*Canis lupus*) and female, western coyotes (*Canis latrans*) to determine whether their gametes would be compatible and the coyotes could produce and nurture offspring. The results contribute new information to an ongoing controversy over whether the eastern wolf (*Canis lycaon*) is a valid unique species that could be subject to the U. S. Endangered Species Act. Attempts with transcervically deposited wolf semen into nine coyotes over two breeding seasons yielded three coyote pregnancies. One coyote ate her pups, another produced a resorbed fetus and a dead fetus by C-section, and the third produced seven hybrids, six of which survived. **These results show that, although it might be unlikely for male western wolves to successfully produce offspring with female western coyotes under natural conditions, western-gray-wolf sperm are compatible with western-coyote ova and that at least one coyote could produce and nurture hybrid offspring.** This finding in turn **demonstrates that gamete incompatibility would not have prevented western, gray wolves from inseminating western coyotes and thus producing hybrids with coyote mtDNA**, a claim that counters the view that the eastern wolf is a separate species. However, some of the **difficulties experienced by the other inseminated coyotes tend to temper that finding and suggest that more experimentation is needed, including determining the behavioral and physical compatibility of western gray wolves copulating with western coyotes.** Thus although our study adds new information to the controversy, it does not settle it. Further study is needed to determine whether the putative *Canis lycaon* is indeed a unique species.

So while it is possible that interbreeding does occur in the western U.S. it is apparent it does not occur frequently enough to support numerous morphological hybrids. The eastern situation may be different with respect to eastern wolves, but again there is no evidence of co-occurring gray wolves and coyotes in the southeastern U.S. prior to 1930 that would support that the red wolf originated through hybridization either in the Pleistocene or Holocene to the modern day.

Literature cited upon request (most can be found in Nowak 2002, Chambers et al. 2012, and/or vonHoldt et al. 2016)

Supplemental materials

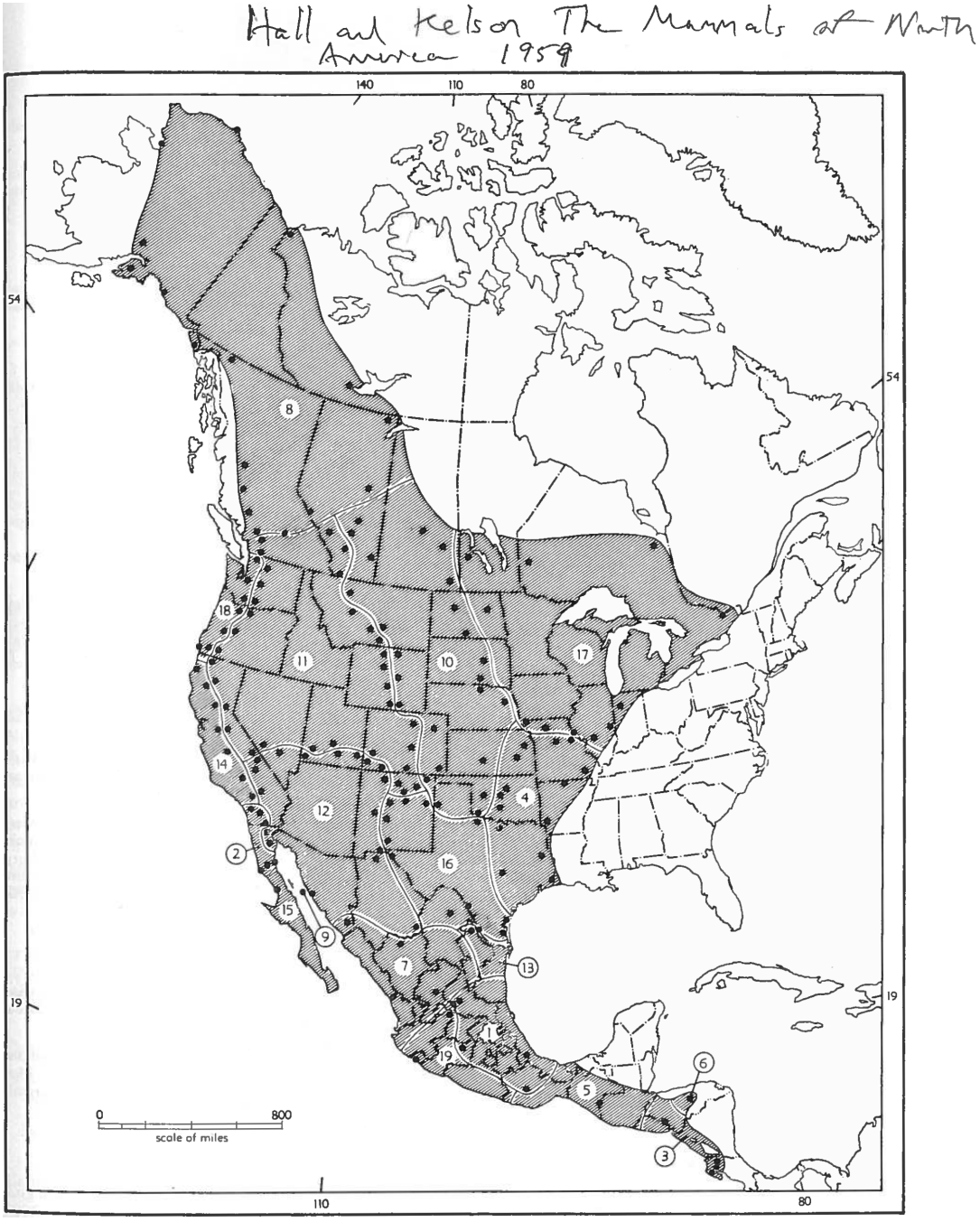
The following wikipedia schematic follows Nowak (2002) closely (https://en.wikipedia.org/wiki/**Evolution_of_the_wolf)**



Proposed evolution and branching of genus *Canis* towards the wolf.[6]:p240

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Coyote (*Canis latrans*) Distribution as of 1959



Map 443.
Canis
latrans.

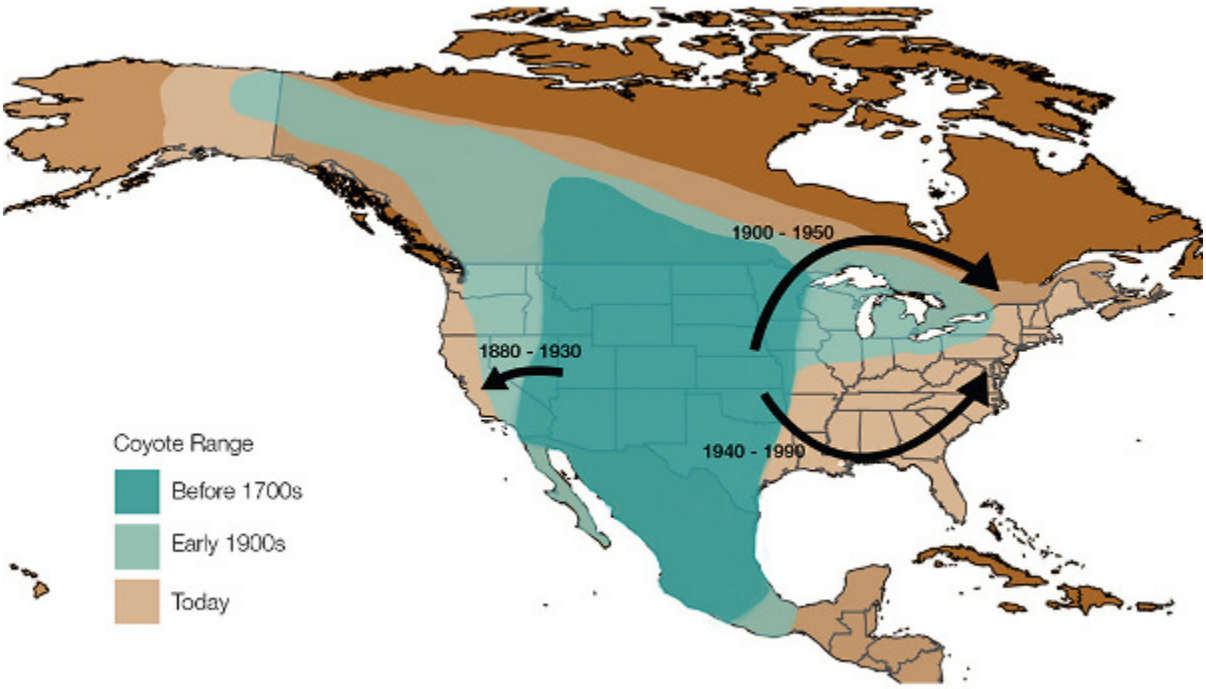
Guide to subspecies
1. C. *l. cagottis*

2. C. *l. clepticus*
3. C. *Z. dickeyi*
4. C. *l. frustror*

5. C. *l. goldmani*
6. C. *l. hondurensis*
7. C. *l. impavidus*
8. C. *l. incolatus*
9. C. *l. ;amesi*

10. C. *Z. latrans*
11. C. *l. lestes*
12. C. *Z. mearnsi*
13. C. *l. microdon*
14. C. *Z. ochropus*

15. C. *Z. peninsulae*
16. C. *l. texensis*
17. C. *Z. thamnos*
18. . C. *Z. umpquensis*
19. C. *Z. vigilis*



This map shows the expansion of coyote range over the past three centuries. Aggressive predator control programs and hunting contributed to the eradication of larger predators like wolves, allowing coyotes to spread rapidly into nearly every area of North America.

Kays, R. et al. (2009) Rapid adaptive evolution of northeastern coyotes via hybridization with wolves. Biology Letters, advance online.

The dramatic expansion of the geographical range of coyotes over the last 90 years is partly explained by changes to the landscape and local extinctions of wolves, but hybridization may also have facilitated their movement. We present mtDNA sequence data from 686 eastern coyotes and measurements of 196 skulls related to their two-front colonization pattern. We find evidence for hybridization with Great Lakes wolves only along the northern front, which is correlated with larger skull size, increased sexual dimorphism and a five times faster colonization rate than the southern front. Northeastern haplotype diversity is low, suggesting that this population was founded by very few females moving across the Saint Lawrence River. This northern front then spread south and west, eventually coming in contact with an expanding front of non-hybrid coyotes in western New York and Pennsylvania. **We suggest that hybridization with wolves in Canada introduced adaptive variation that contributed to larger size, which in turn allowed eastern coyotes to better hunt deer, allowing a more rapid colonization of new areas than coyotes without introgressed wolf genes. Thus, hybridization is a conduit by which genetic variation from an extirpated species has been reintroduced into northeastern USA, enabling northeastern coyotes to occupy a portion of the niche left vacant by wolves.**

Quote:

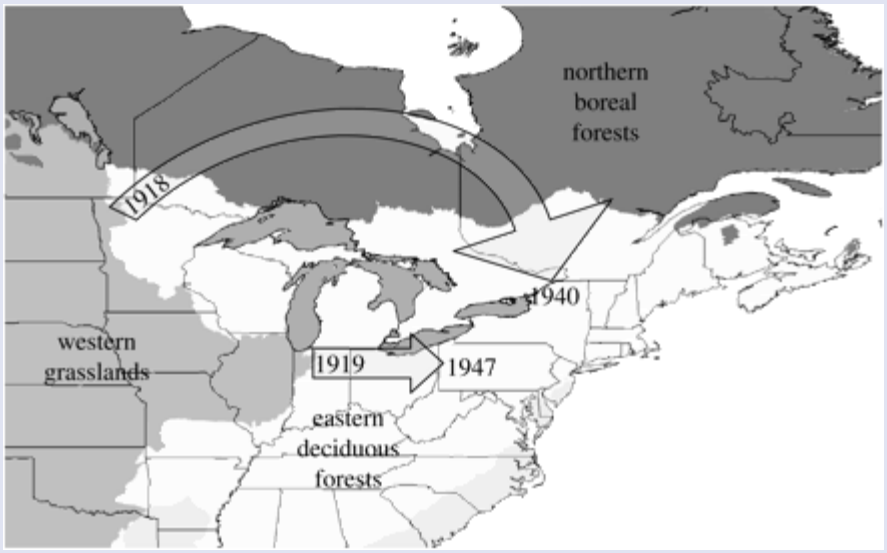


Figure 1.

Colonization routes of coyotes moving from their historic range in the grasslands of western states into eastern deciduous forests (shading shows biomes). Dates are for the first coyote records from Ontario (Young & Jackson 1951), New York (Fener et al. 2005), Ohio (Weeks et al. 1990) and western Pennsylvania (Williams et al. 1985).

the intro:

Quote:

Dramatic expansions in the distribution of a species without being introduced by humans are rare, and are typically explained by habitat change or release from competitors (Sakai et al. 2001). The coyote (Canis latrans) evolved as hunter of small prey in the Great

Plains, but has rapidly colonized all of eastern North America in the last 90 years. The spread of agriculture and the extinction of wolves (C. lupus sensu lato) in parts of the region are thought to have facilitated coyote expansion, but genetic interchange with remnant wolf populations may have played a roll. Coyote colonization was fivefold faster via the northern route through Ontario, which exposed them to wolf populations, compared with the southern route through Ohio, where wolves were extirpated prior to coyote expansion (figure 1).

The hybridization of colonizing coyotes with wolves (C. lupus lycaon) in Ontario has been demonstrated by recent studies (Leonard & Wayne 2008; Koblmuller et al. 2009; Schwartz & Vucetich 2009; Wheeldon & White 2009; Wilson et al. 2009). Mitochondrial phylogenies reveal three main lineages within Ontario wolves (grey wolf, Great Lakes wolf (GLW) and coyote), suggesting high rates of hybridization in the region. Nuclear loci reveal similar patterns, but suggest that the GLW remains a discrete ecotype despite hybridization.

Less attention has been paid to the effect of this hybridization on eastern coyotes, which are now the largest predator in the region, are abundant in many areas, and are thus thought to play important ecological roles. Although northeastern coyotes are clearly smaller than wolves, they are larger than western coyotes, and have a unique ecology (Lawrence & Bossert 1969; Parker 1995; Kays et al. 2008). Here we examine both genetics and morphology from a large sample of coyotes to evaluate the potential introgression of adaptive variation through hybridization with wolves

Non-genetic Data Supporting Genetic Evidence for the Eastern Wolf

L. David Mech
Northeastern Naturalist
Vol. 18, No. 4 (2011), pp. 521-526

Abstract

Two schools of thought dominate the molecular-genetics literature on Canis spp. (wolves) in the western Great Lakes region of the US and Canada: (1) they are hybrids between Canis lupus (Gray Wolf) and Canis latrans (Coyote), or (2) they are hybrids between the Gray Wolf and Canis lycaon (Eastern Wolf). This article presents 3 types of non-genetic evidence that bears on the controversy and concludes that all 3 support the second interpretation.

[there needs to be an update to the following results, but while it does represent the potential of “western” Gray Wolves and Coyotes to hybridize in captivity, there is no evidence that they actually have in the wild, at least not in a way that mirrors what Wayne et al. project could have happened in the east where hybrid swarms emerged as “gray” wolves were extirpated and phenotypic coyotes somehow escaped any detection at the time of European arrival in North America

only to “re-emerge” east of the prairies some 50 years or more later after “southern” wolf-like canids had become exceedingly rare.]

Production of Hybrids between Western Gray Wolves and Western Coyotes

- L. David Mech, Bruce W. Christensen, Cheryl S. Asa, Margaret Callahan, and Julie K. Young

PLOS One February 2014 | Volume 9 | Issue 2 | e88861

Abstract

Using artificial insemination we attempted to produce hybrids between captive, male, western, gray wolves (*Canis lupus*) and female, western coyotes (*Canis latrans*) to determine whether their gametes would be compatible and the coyotes could produce and nurture offspring. The results contribute new information to an ongoing controversy over whether the eastern wolf (*Canis lycaon*) is a valid unique species that could be subject to the U. S. Endangered Species Act. Attempts with transcervically deposited wolf semen into nine coyotes over two breeding seasons yielded three coyote pregnancies. One coyote ate her pups, another produced a resorbed fetus and a dead fetus by C-section, and the third produced seven hybrids, six of which survived. **These results show that, although it might be unlikely for male western wolves to successfully produce offspring with female western coyotes under natural conditions, western-gray-wolf sperm are compatible with western-coyote ova and that at least one coyote could produce and nurture hybrid offspring.** This finding in turn **demonstrates that gamete incompatibility would not have prevented western, gray wolves from inseminating western coyotes and thus producing hybrids with coyote mtDNA**, a claim that counters the view that the eastern wolf is a separate species. However, some of the **difficulties experienced by the other inseminated coyotes tend to temper that finding and suggest that more experimentation is needed, including determining the behavioral and physical compatibility of western gray wolves copulating with western coyotes.** Thus although our study adds new information to the controversy, it does not settle it. Further study is needed to determine whether the putative *Canis lycaon* is indeed a unique species.

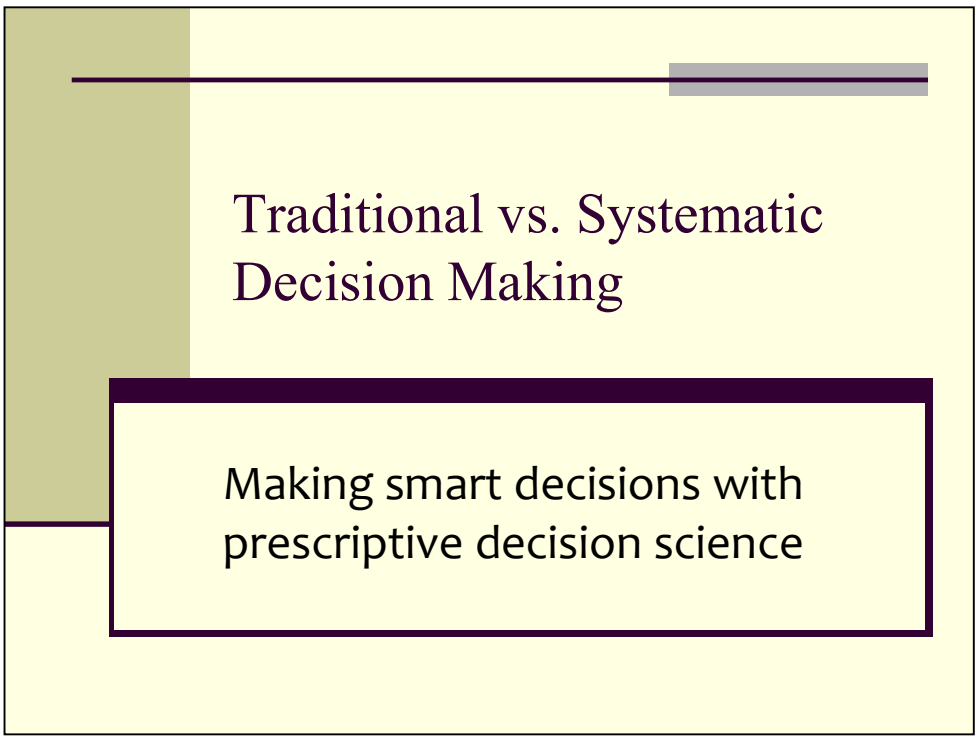
Xxxxxxxxxxxxxxxxxxxxxxxxxx

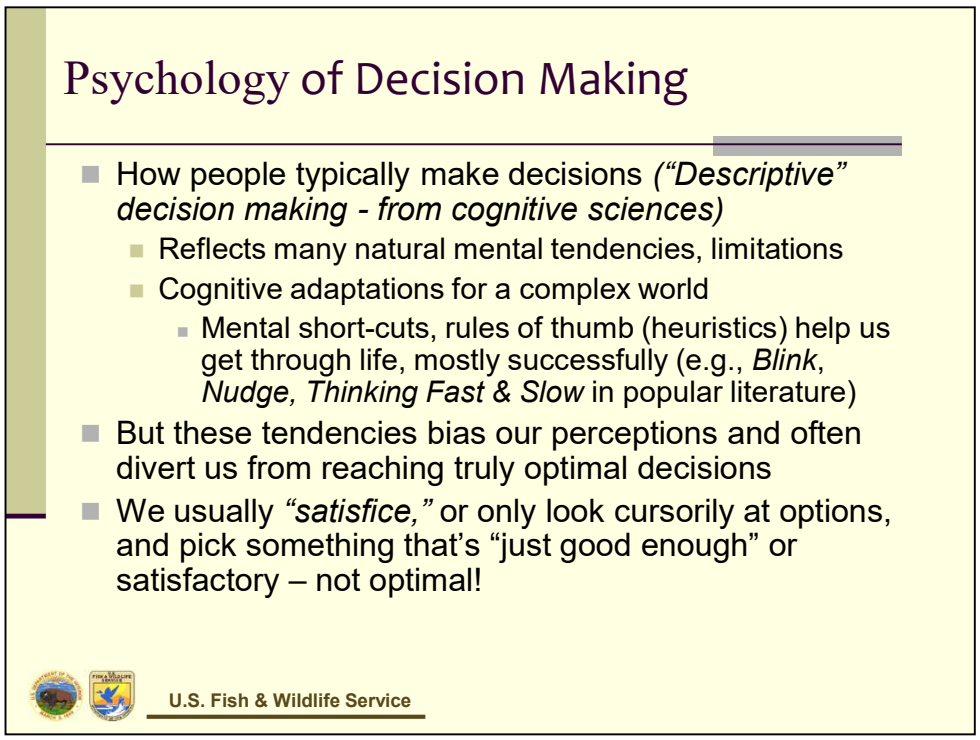
An Overview of Structured Decision Making



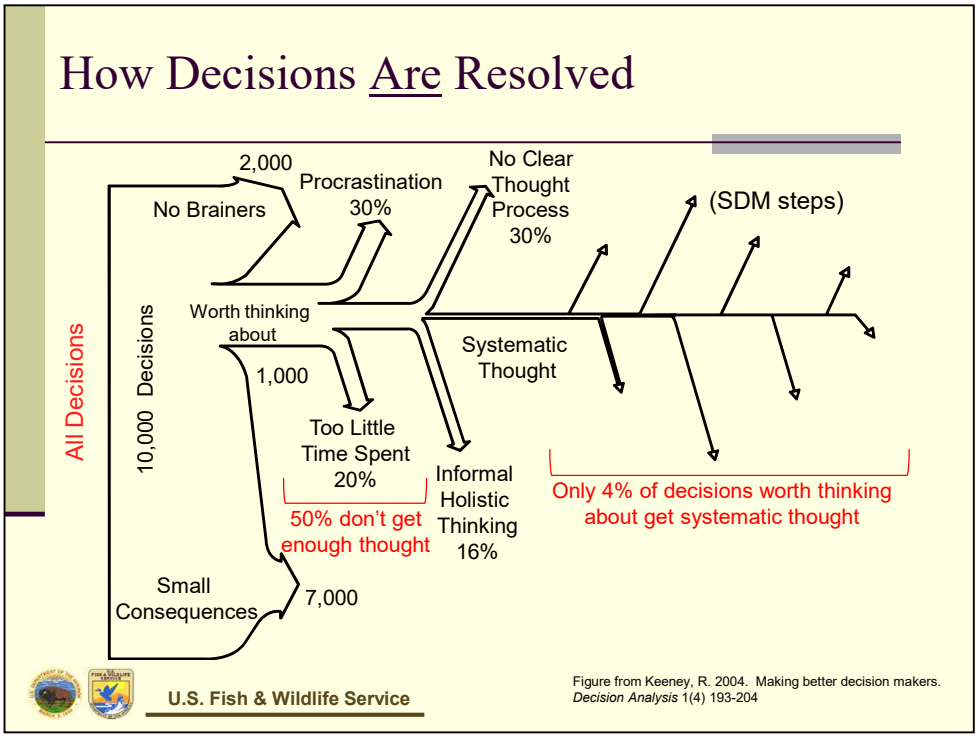
Red wolf Taxonomic Workshop
August 30, 2017
Atlanta, Ga

U.S. Fish & Wildlife Service

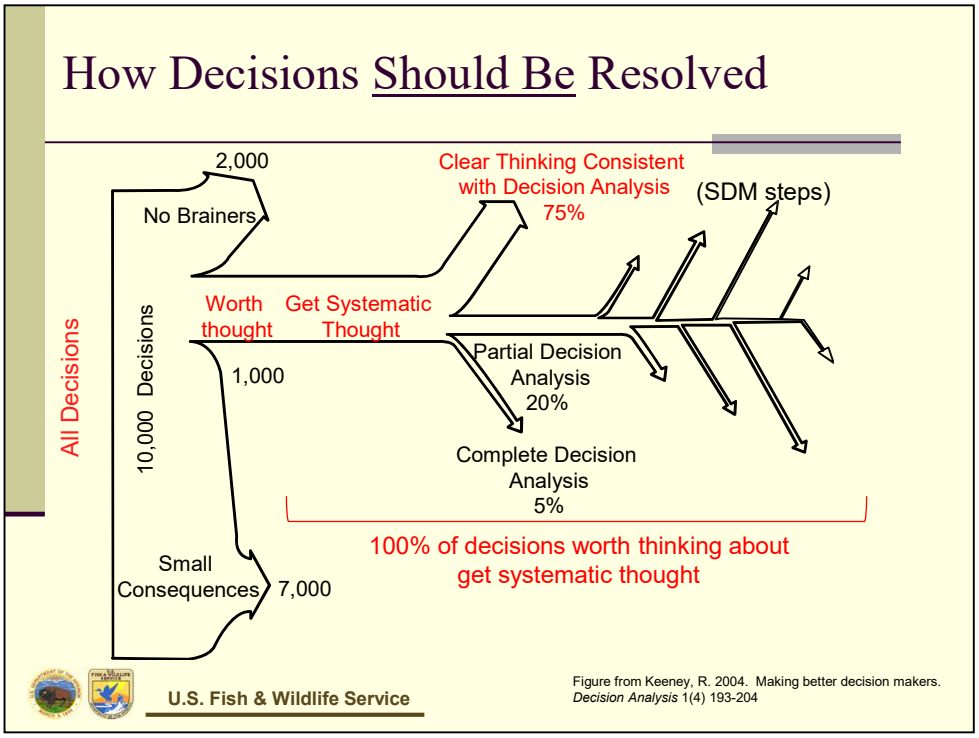

Traditional vs. Systematic Decision Making
Making smart decisions with prescriptive decision science



Blink is a book about how we think without thinking, about choices that seem to be made in an instant-in the blink of an eye-that actually aren't as simple as they seem.



Keeney (well known analyst and author) sees the world this way – half of the decisions that we make don't get enough thought, and of those that do, only 4% get any systematic thought



What Keeney would like to see (and the impetus for the Hammond et al book and this course):

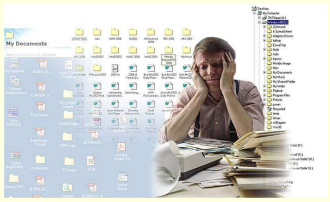
- All decisions that require thought get it
- Most decisions receive at least 'clear thinking that is consistent with decision analysis' or even some partial analysis
- THIS is what we teach in this course
- Note: only 5% need the 'hotshot' team of SDM analysts that this audience will be familiar with

Natural Resource Decisions are Hard



- Because…
  - Objectives complex & often competing
  - Management alternatives not realized
  - System dynamics poorly understood
  - Difficult trade-offs

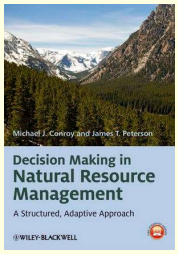
- Unaided, decision-makers have limited information processing capacity
  - Too much information to handle simultaneously!



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Decision Science can Help

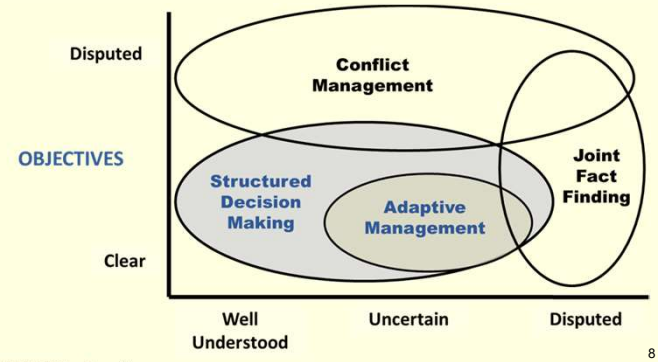
- Research focused on the science of making 'smart' decisions
  - Prescriptive Decision Theory, SDM
- Process for dividing a complex problem into small parts to allow focus on each part separately
  - Allows for a better understanding of the problem than if taking a holistic view
- Provides a wide array of tools for dealing with specific impediments
- Tools have been tailored to meet needs of natural resource managers



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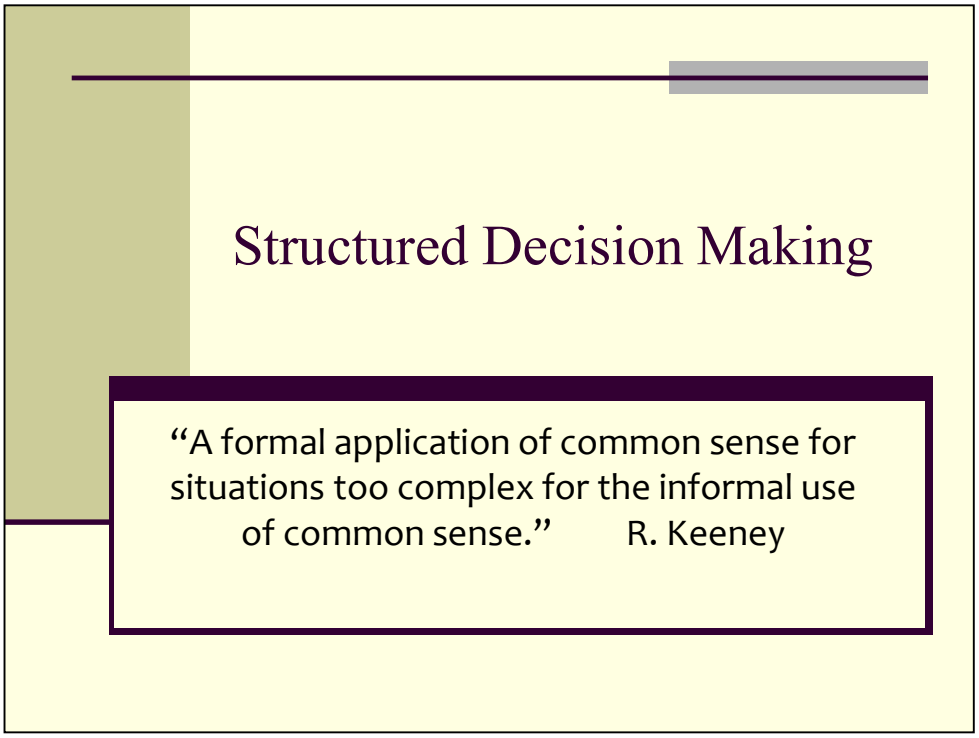
But not always…

- Best in absence of dispute in values or knowledge. However, a structured decision process can work to reduce & clarify important uncertainties to arrive at a recommendation.



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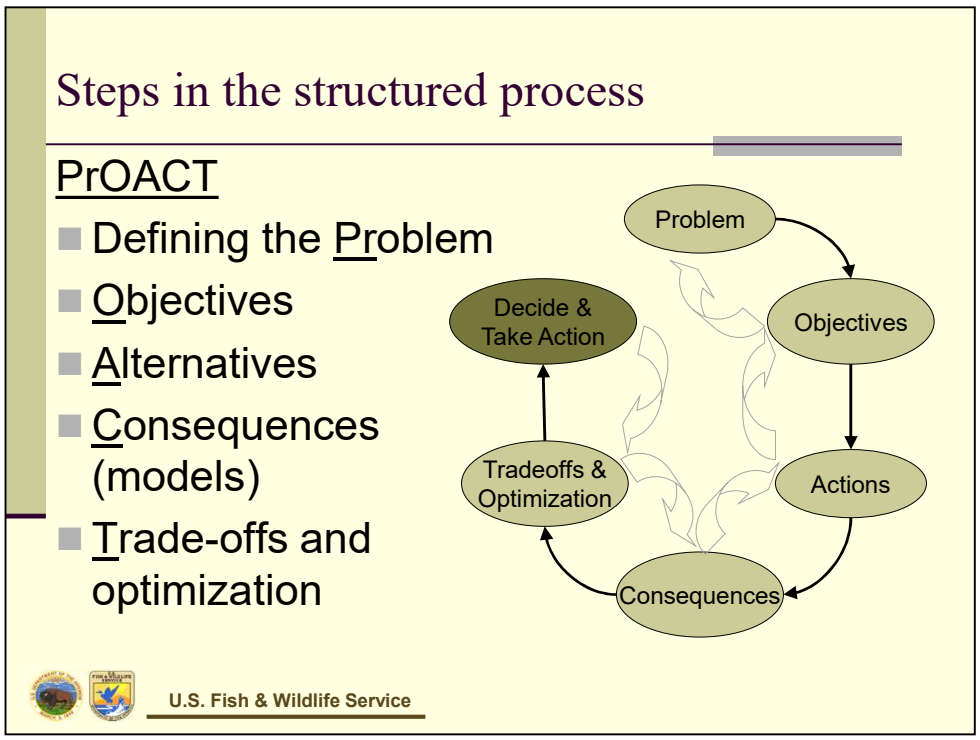

Structured Decision Making
"A formal application of common sense for situations too complex for the informal use of common sense." R. Keeney

Two Key Elements

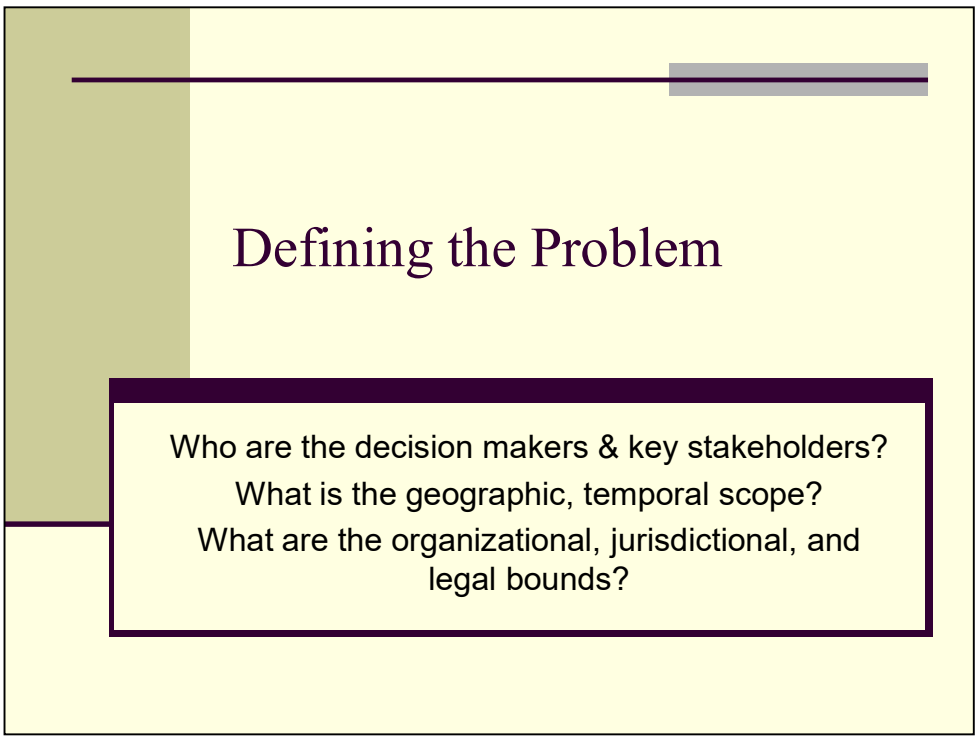
- Problem decomposition
  - Break the problem into components, separating policy from science
  - Complete relevant analyses
  - Recompose the parts to make a decision
- Value-focused thinking
  - The objectives (values) are discussed first, and drive the rest of the analysis
  - This is in contrast to our intuitive decision-making, which usually jumps straight to the alternatives

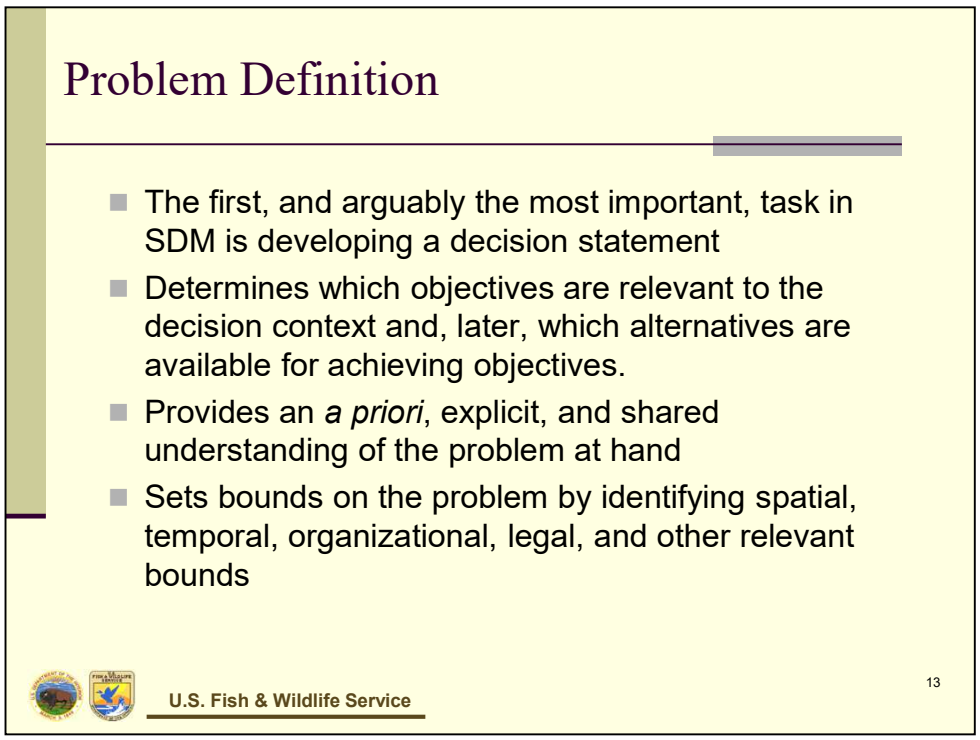


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Basically the steps of walking through complex problems that are too complex for simple logic


Defining the Problem
Who are the decision makers & key stakeholders?
What is the geographic, temporal scope?
What are the organizational, jurisdictional, and legal bounds?



Why is a “Problem Statement” useful? It clearly identifies the specific decision to be made, the decision maker, the scale of the decision and other essential components needed for management decisions. Lays the foundation for the remaining steps of the SDM process. In this module, we will talk about the components of a problem statement & why each is helpful in setting up a SDM framework.

Elements of Problem Framing

1. Identify the decision maker(s)
2. Identify other key players
   - Decision implementers & stakeholders
   - Technical experts, facilitators
3. Consider legal and regulatory contexts
4. Consider the decision structure
   - Timing, frequency, temporal and spatial scale, objectives, constraints, and actions
5. Consider the type of analysis required
6. Revise as needed



Construct Your Statement by…

Using the following template:

"Decision Maker (**D**) is trying to do **X** to achieve **Y** over time **Z** and in place **W** considering **B**."

where,

D = the Decision maker(s)
X = the type(s) of action that needs to be taken
Y = the ultimate goal(s) to be achieved by "X"
Z = the temporal extent of the decision problem.
W = the spatial extent of the decision problem
B = potential constraints (legal, financial, and political) and important uncertainties (scientific or other)

Classes of Decision Problems

- Certain decision structures appear again and again
- Being able to recognize these classes of decision problems helps structure the problem and identify the tools for resolving them

6 Classes of Decisions

1) **Prediction Problems**: impediment is ability to predict achievement of objective
2) **Multiple Objective problems**: impediment is how to trade-off competing objectives
3) **Portfolio Problems:** impediment is having to search among a very large selection of alternatives



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1) **Prediction Problems** – impediment is ability to predict achievement of objective

2) **Multiple Objective problems** – impediment is how to trade-off competing objectives

3) **Portfolio Problems** – impediment is having to search among a very large selection of alternatives

4) **Risk Problems** – must make decisions in the face of uncertainty

5) **Information Problems** – impediment is determining value of reducing uncertainty before decision making

6) **Dynamic Problems** – impediment is balancing short-term costs with long-term benefits

Classes of Decision Problems

6 Classes of Decisions

4) **Risk Problems:** must make decisions in the face of uncertainty
5) **Information Problems:** impediment is determining value of reducing uncertainty before decision making
6) **Dynamic Problems:** impediment is balancing short-term costs with long-term benefits



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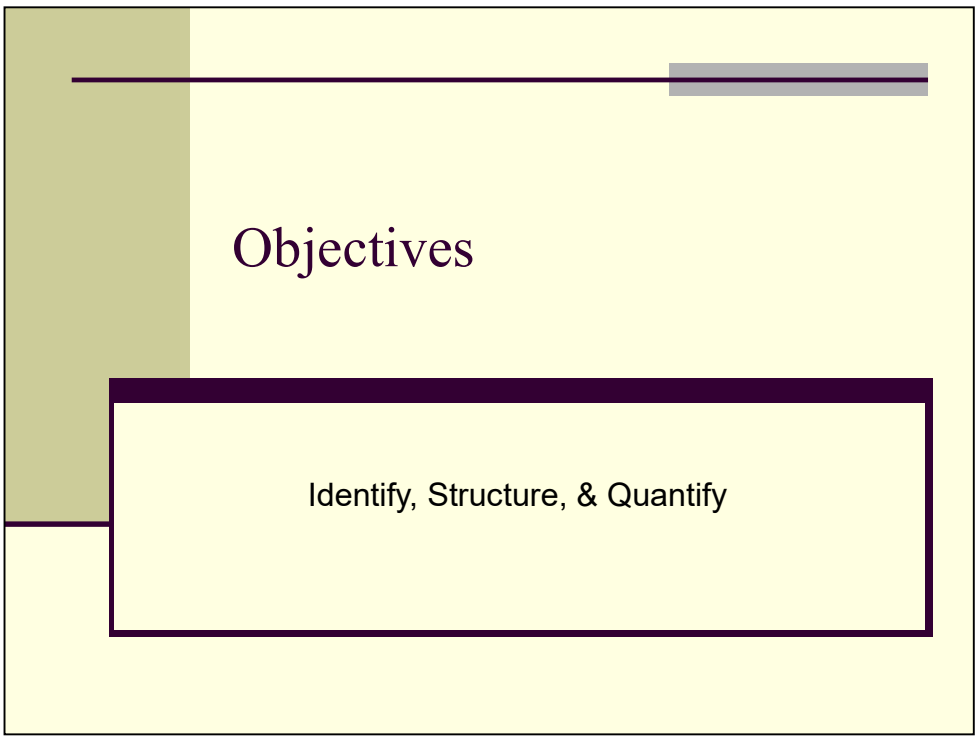
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1) **Prediction Problems** – impediment is ability to predict achievement of objective
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Objectives
Identify, Structure, & Quantify



The real message here goes back to the quote we talked about on my first slide. **If you don’t know where you are going (what you want the decision problem to achieve), you are going to solve the wrong problem.** This is among the very top reasons why decision are not acted upon or otherwise go wrong.

Sarah always reminds me, “its all about objectives.”

Objectives aren’t easily drawn out of people. It usually takes a lot of feedback between decision participants, to establish good objectives.

And you’ll see there will often need to be some feedback between different objectives and the problem itself to assure a good match.

Thus, objectives sometimes evolve.

And, there’s a contextual piece to stay aware of. Who’s objectives matter?

Realistically, you may never be able to draw out the most tightly help objectives…and that can have consequences. The best you can do is be up front about this with decision participants when you are trying to elicit objectives.

Steps for Creating Good Objectives

1) Articulate concerns and wishes
2) Convert concerns to objectives
3) Structure objectives
   - Classify objectives
   - Distinguish fundamental and means objectives
   - Create objectives hierarchy
4) Create measurable attributes for each objective
5) Review for completeness



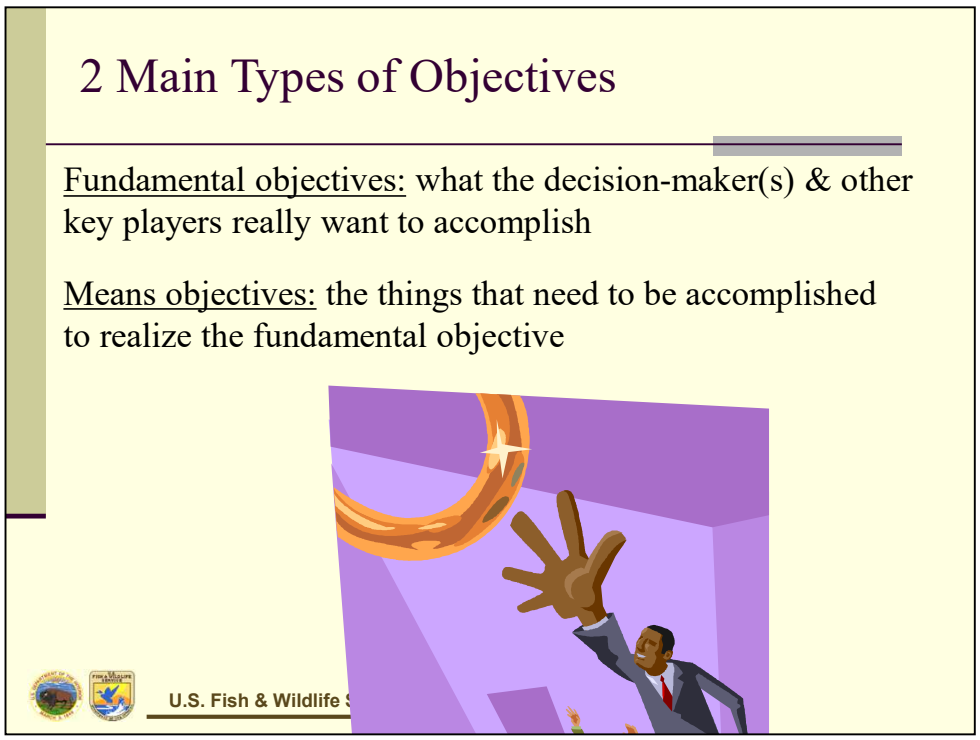
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We're going to get some experience with this recipe during the rest of this module.

All except for the repeat 'til well done part. Sarah mentioned the prototyping concept. **You'll want to get very comfortable with the idea that feedback and revisiting objectives until they are good enough is going to be a big part of solving many decision problems.**

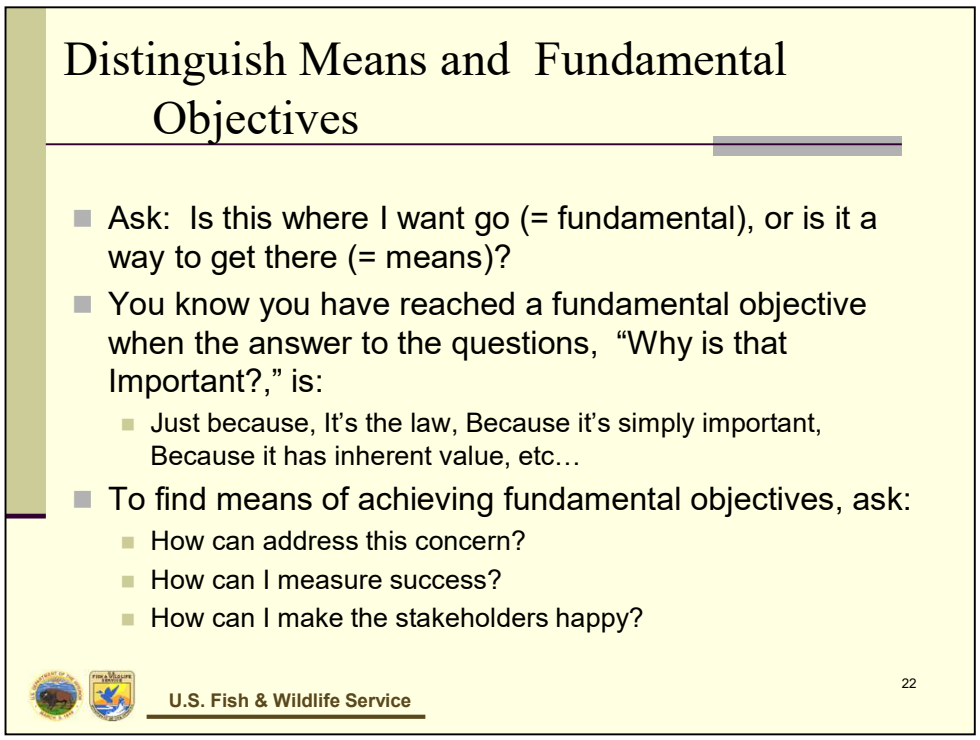
We will now look the steps in this recipe for building objectives.



There are two basic types of objectives:

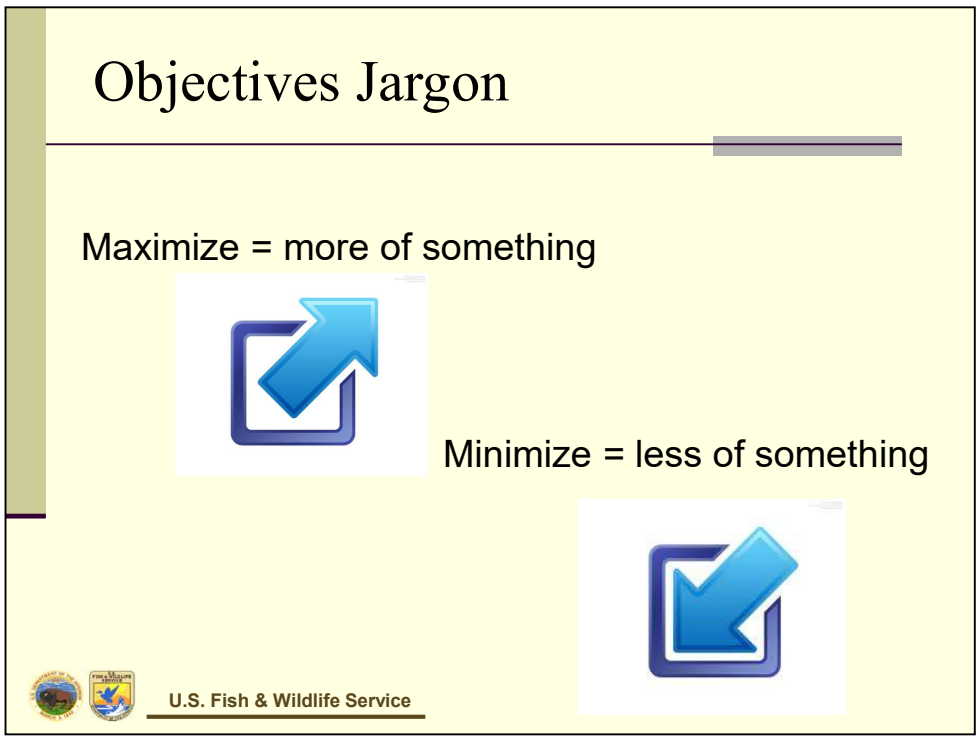
Fundamental objectives: what the decision-maker really wants to accomplish.

Means objectives the things that need to be accomplished to realize the fundamental objective

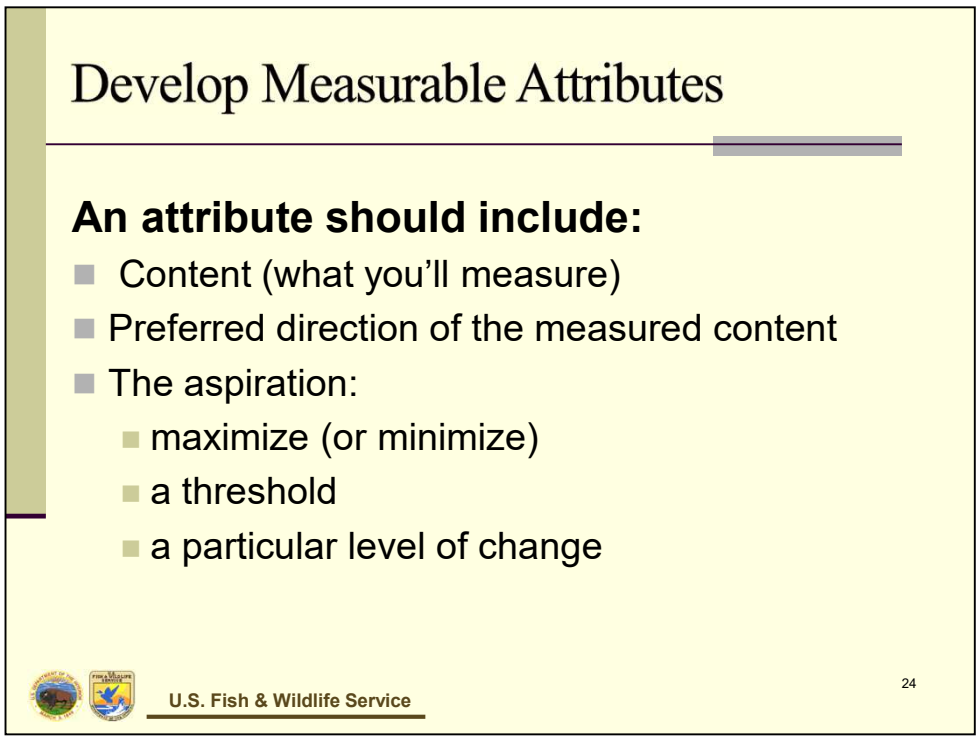


Tips for getting to fundamental objectives.

The best tip, if you have any doubt, is to ask, why is that important?



Notice that we use terms such as “maximizing native diversity.” Taken literally, this would mean that we will select decisions that in fact produce maximum diversity. Leaving aside for the moment the question of whether (or how) diversity can (or even should) be “maximized”, it follows that 1) that we have unlimited resources to achieve this objective, and 2) we would be equally satisfied by objective values, irrespective of the costs or other tradeoffs required to achieve that stated result. When we use the term maximize we mean more of something is the objective and minimize means that less of something is the objective. We also make this point because-- in our experience-- conservationists are much more adept at envisaging grand conservation goals than they are at taking into account costs and other tradeoffs. A “bottom-line” (i.e., costs) perspective is needed if for no other reason that poor choices waste resources and will ultimately detract from future decision making opportunities and so should be avoided if at all possible.



Note – max and min are often used to represent preferred direction, knowing you will be trading off (e.g., don't mean you have a specific target of the absolute max or min possible, just that you want to get the most/least given other competing objectives!)

Develop Measurable Attributes

An attribute is used to:

1) Predict (in advance of the decision) how a given decision will lead to measurable objective outcomes
2) Compare realized objective outcomes to predicted outcomes after decision implementation

Examples:

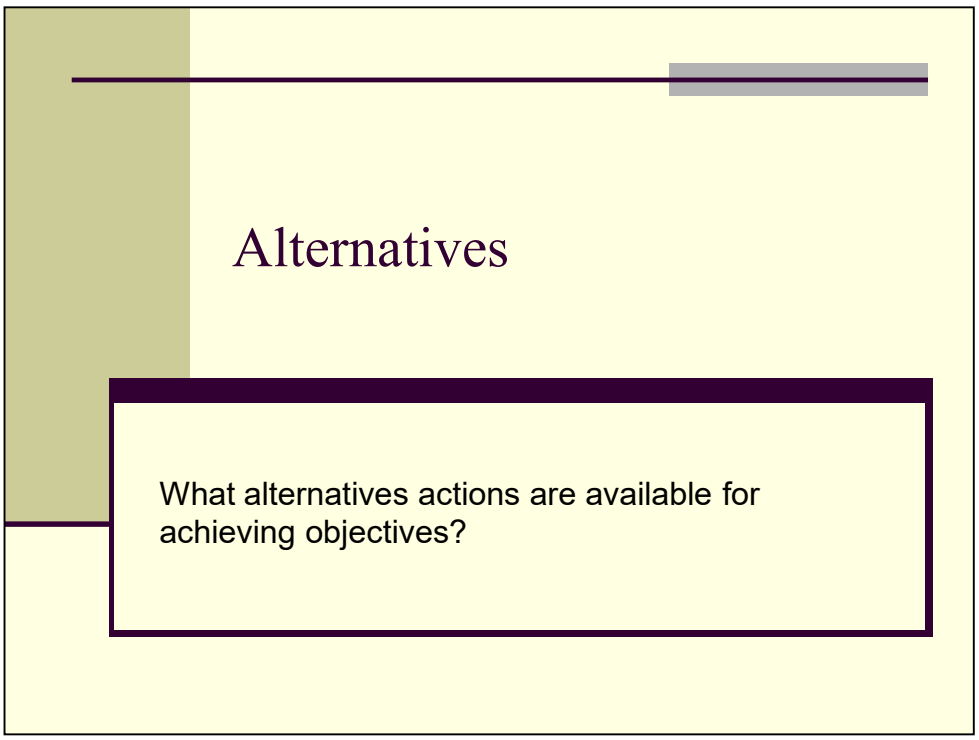
Objective	Direction	Aspiration	Attribute
Minimize costs	↓	Minimize	M$/yr
Maximize occupancy rate	↑	Maximize	Probability (0-1)
Minimize extinction probability	↓	Minimize	Probability (0-1)
Maximize harvest user satisfaction	↑	Maximize	Harvest Success Rate (# harvested/#permits)

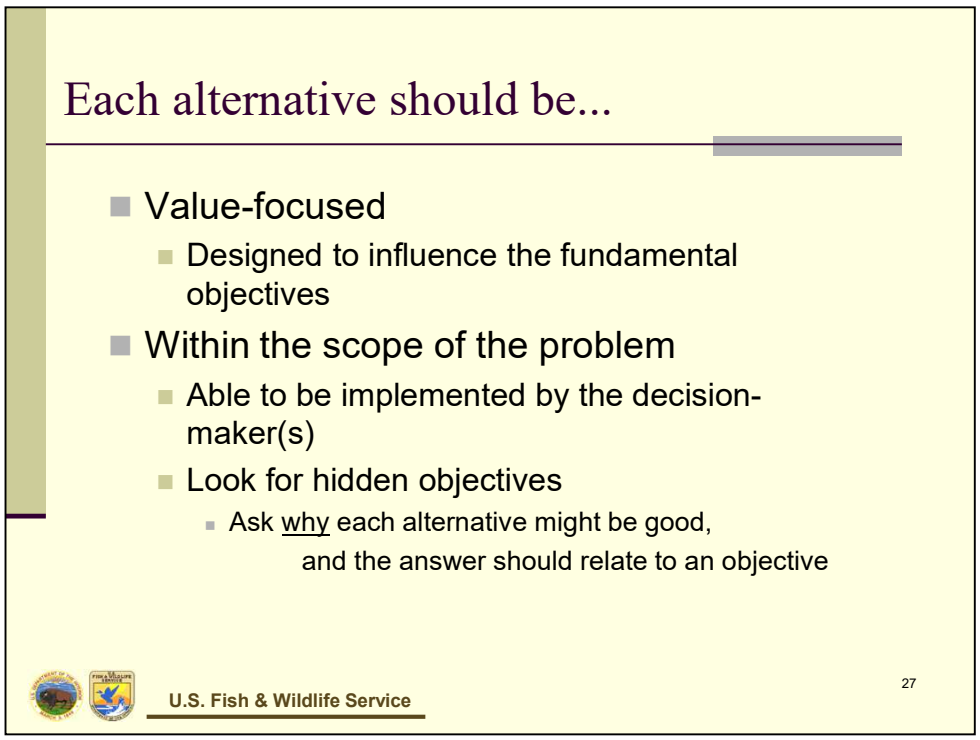


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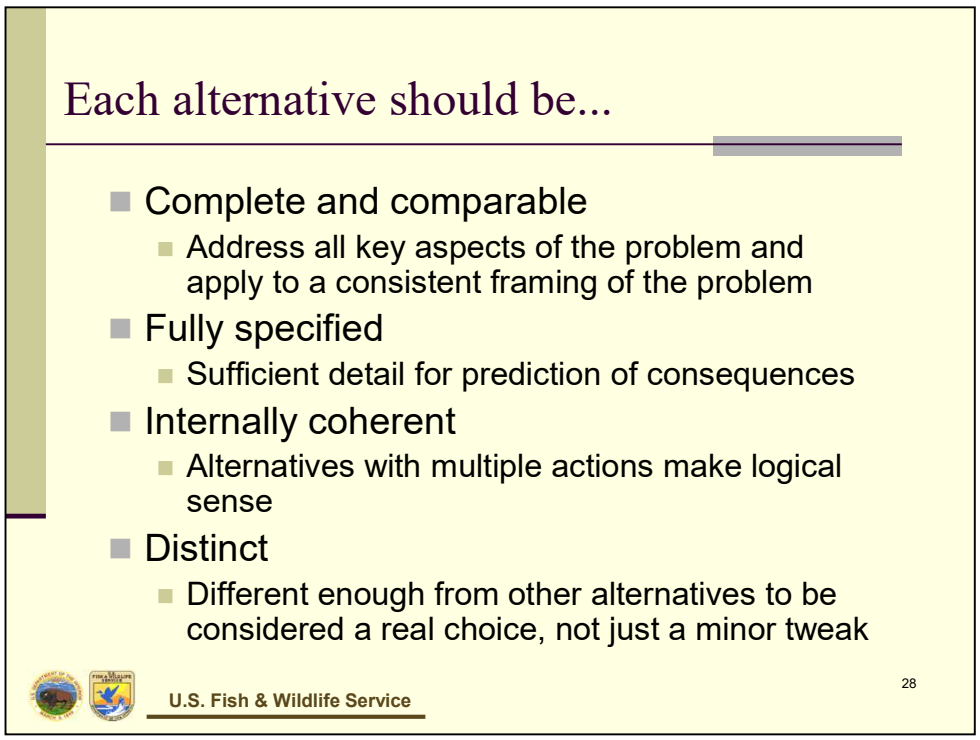
Note – max and min are often used to represent preferred direction, knowing you will be trading off (e.g., don't mean you have a specific target of the absolute max or min possible, just that you want to get the most/least given other competing objectives!)


Alternatives
What alternatives actions are available for achieving objectives?



2nd part of desired properties in notebook

The notebook mentions applying these criteria less strictly during the 1st prototype, but it's okay to not mention this exception during the presentation. If you do mention it, however, note that the prototyping concept was introduced in Module 1, so you do not need to go into detail, unless a student asks.



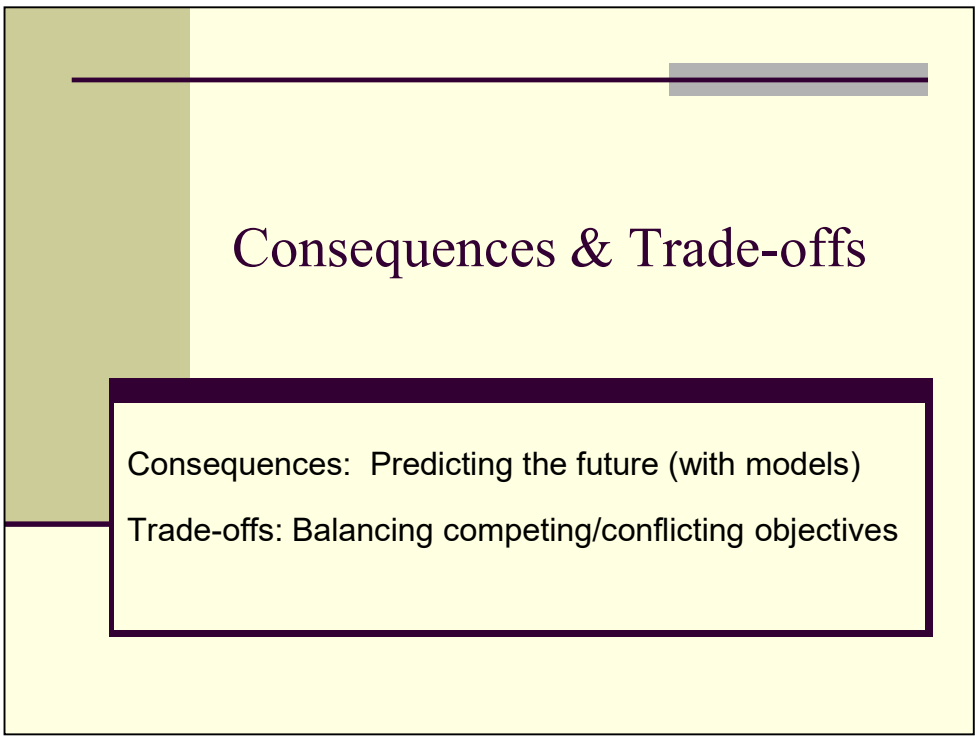
Example for “complete & comparable”: Glen Canyon Dam – an alternative that addressed trout only and not chubs or flow regimes, etc.

You may be asked for examples of alternatives that either do or do not meet these criteria. The students have blank space in their notebooks to list examples.

Alternatives should…

- **Not** be evaluated until the Consequences step of PrOACT
  - Do not want to stifle creativity or brainstorming that could lead to a break-through idea




Consequences & Trade-offs
Consequences: Predicting the future (with models)
Trade-offs: Balancing competing/conflicting objectives

Need for prediction

- How should we select the best alternative?
  - Want the best outcomes
  - Need to predict what we think would happen in the future if we implemented each of our alternatives
- What are the outcomes of interest?
  - What we care about = fundamental objectives (and associated measurable attributes)

Science and policy

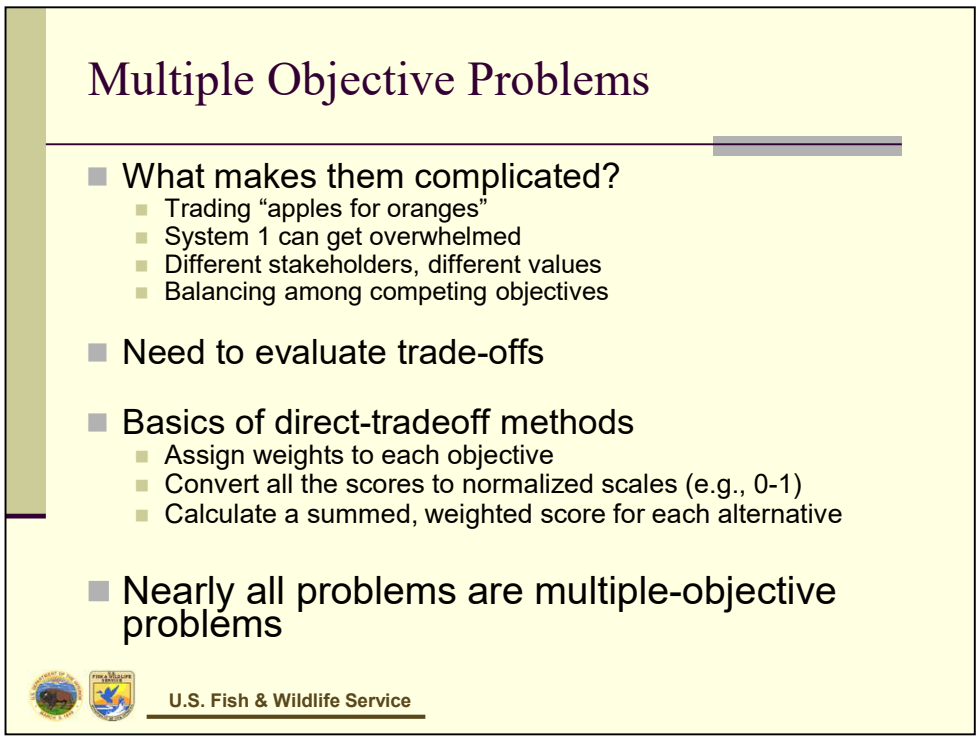
- Consequence analysis is a scientific endeavor
  - Predictions should represent the most reliable, unbiased understanding of how the world actually works
- Consequence analysis, however, is embedded in a value-laden decision context
- Therefore...
  - scientists need much information from the decision maker(s)
    - Framing of the decision
    - Design of the model
    - Attributes that will be used to evaluate the alternatives
  - decision-makers need to understand the scientific predictions
    - and how they relate to the other decision components

The Role of Modeling

- Models link actions to outcomes that are relevant to the objectives
  - Models make predictions
- The decision context provides guidance about how to construct the model
  - **We have a multiple-objective + risk problem**
- We will be using a SMART Table to resolve the multiple objective problem & a decision tree to evaluate risk



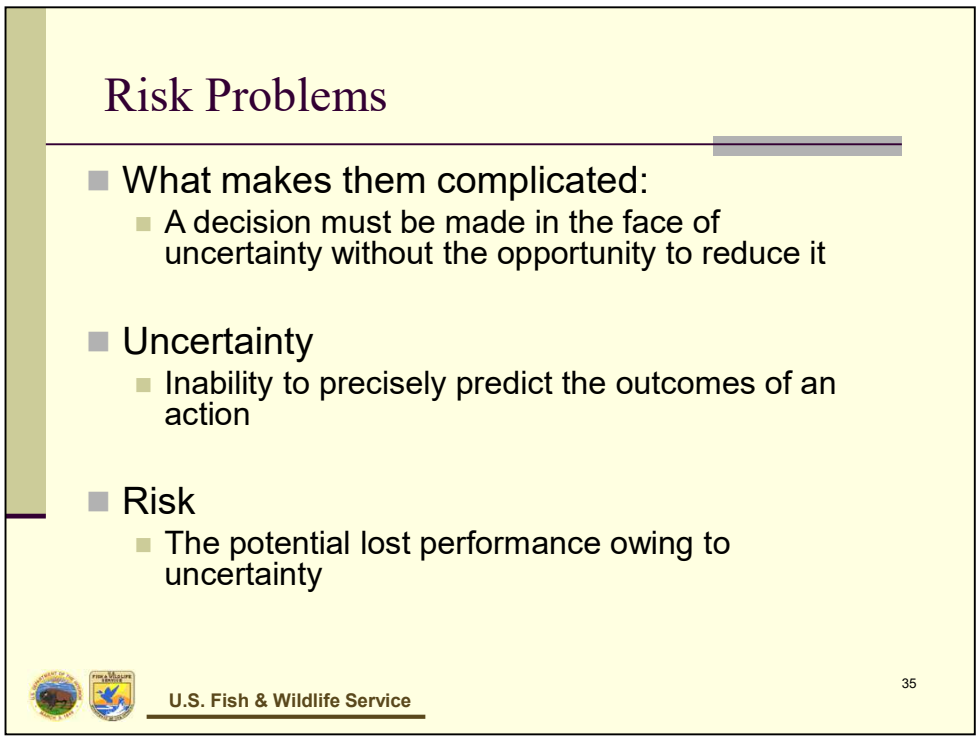
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Trading apples for oranges – Each objective has its own basis of comparison.

For one objective, compare alternatives using percentages, another may be on relational judgments – high, medium, low; another may be descriptive.

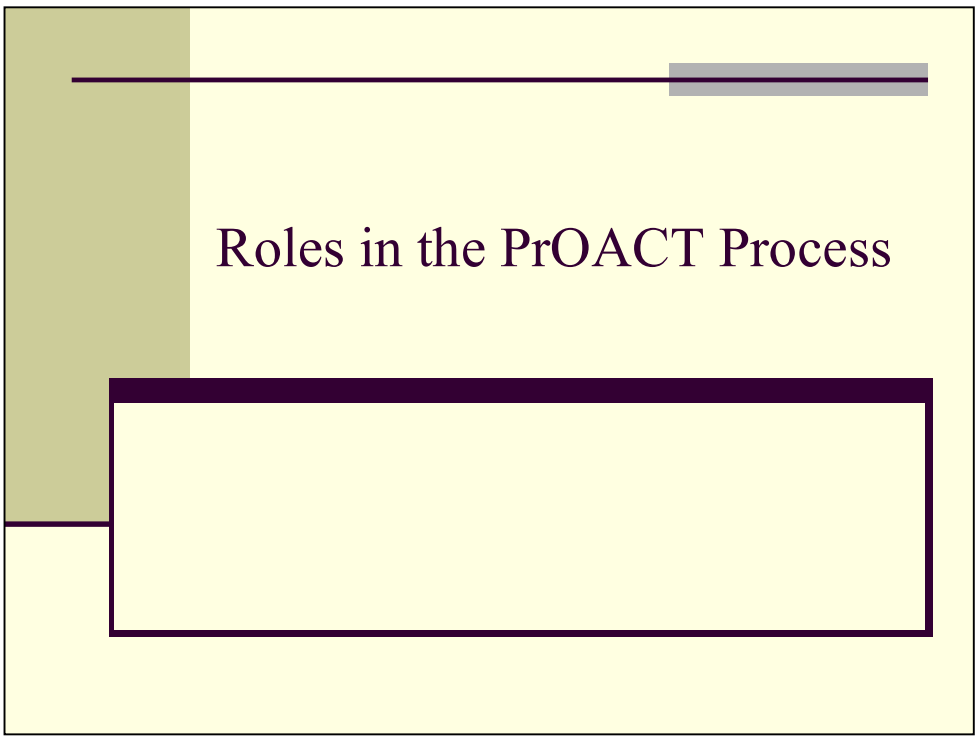
It’s not just trading apples for oranges, it’s trading off apples and oranges and trees and zebras.



This PrOACT process is set up to help us get rid of or reduce as much uncertainty as we can. That includes linguistic uncertainty and the uncertainty around how to frame a problem and set objectives. It's really the reason that we have this iterative process and why we encourage going back to previous steps, because every time we do that we're reducing some uncertainty and making the decision process stronger.

But, even Mike Runge can't predict chance events, or magically provide you with all the data you need to make your decision. But he did develop this module, so there's that.

So let's assume that we are dealing with a problem that depends on some factor that we can't know– either because we're dealing with chance events that we can't predict, OR because we're making a decision that involves something that we just don't know a whole lot about.


Roles in the PrOACT Process

Roles in the PrOACT Process

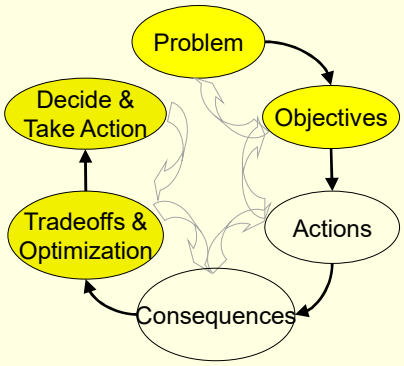
- Information providers, decision coaches, and facilitators are neutral players throughout the process
- Technical experts need to agree to wear their “expert” (=objective) hat



- Decision-makers are ultimately held accountable for the decision (or recommendation), so they have the only vested role in the process

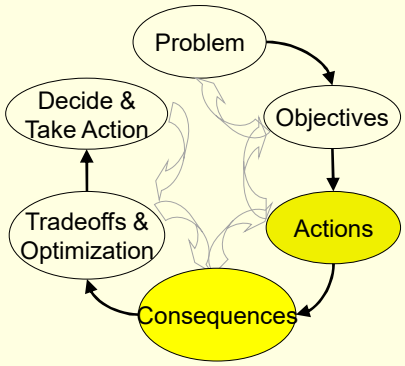
Roles in the PrOACT Process

- Decision-maker input is important in the early and late phases of PrOACT
  - Problem framing, ID and structuring of objectives, trade-offs, and the ultimate recommendation



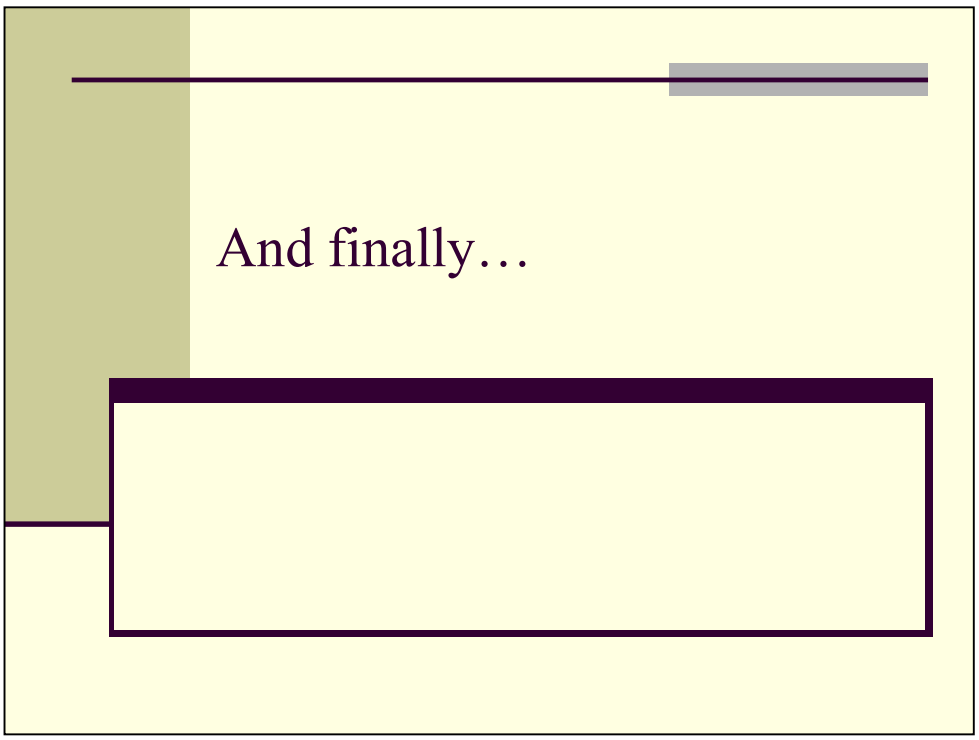
Roles in the PrOACT Process

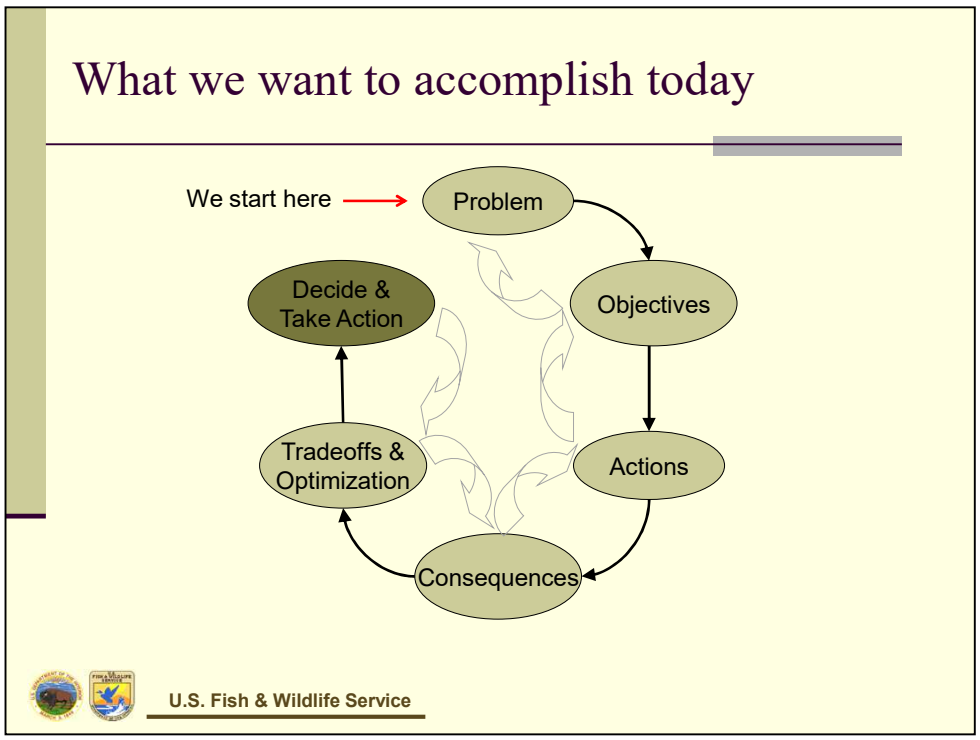
- Technical expert role is more important in the middle stages of the PrOACT process
  - Identification of creative alternatives
  - Evaluation of how well alternatives perform relative to objectives



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And finally…


What we want to accomplish today
We start here
Problem
Objectives
Actions
Consequences
Tradeoffs & Optimization
Decide & Take Action
U.S. Fish & Wildlife Service

UNIVERSITY OF CINCINNATI

Date: June 30, 2009

I, Teri Jacobs,

hereby submit this original work as part of the requirements for the degree of:

Master of Arts

in Geography

It is entitled:

Putting the Wild Back into Wilderness: GIS Analysis of the Daniel Boone National Forest for Potential Red Wolf Reintroduction

Student Signature: Teri Jacobs

This work and its defense approved by:

Committee Chair: Susanna Tong

Stephen Matter

Changjoo Kim

Approval of the electronic document:

I have reviewed the Thesis/Dissertation in its final electronic format and certify that it is an accurate copy of the document reviewed and approved by the committee.

Committee Chair signature: Susanna Tong

Putting the Wild Back into Wilderness: GIS Analysis of the Daniel Boone National Forest for Potential Red Wolf Restoration

A thesis submitted to the
Graduate School
of the University of Cincinnati
in partial fulfillment of the
requirements for the degree of

Master of Arts

in the Department of Geography
of the College of Arts and Sciences

by

Teri A. Jacobs
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June 1992

Committee:
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Stephen Matter, Ph.D., University of Cincinnati

Abstract

The red wolf (*Canis rufus*) is a keystone species because of its important ecological role as a top predator. Its restoration to historic ranges may help to promote ecosystem integrity, balance, diversity and health. However, as already outlined in the 2007 United States Fish and Wildlife Service Red Wolf Recovery Progress Report, at least two additional reintroduction sites within the species' historic ranges are still required to support viable populations of red wolves. This thesis research aimed to contribute to the Red Wolf Species Survival Plan by identifying and evaluating potential sites within the Daniel Boone National Forest in eastern Kentucky for the reestablishment of red wolves.

In previous wolf habitat prediction models, road density served as the criteria for suitability. Researchers calculated simple road densities; however, the logistic regression models thus derived did not accurately predict wolf occupation. Roads with higher traffic volumes and areas with greater road densities should, in theory, pose greater risks to wolf mortality, and simple road density may not be an adequate measure to such purpose. This research, therefore, ranked roads by mortality risk and utilized kernel density estimation in Geographic Information Systems as a means to weight the road density and to predict suitable wolf habitat. This method may provide a better picture of the spatial reality of road influence. By using the red wolf habitat suitability model based on the rank class and kernel density estimation, nine potential restoration sites were predicted; whereas the suitability model based only on the simple density function failed to predict any sites.

However, the results of this research are not final. The human and coyote factors remain unknown, and validation of the model is impractical due to the lack of data and time constraints. Yet, efforts such as field verification have been made in an attempt to validate the model. If data are available, follow-up studies in North Carolina may be a feasible measure to further test the model.

Keywords: red wolf (*Canis rufus*); keystone species; habitat suitability model; kernel density estimation; geographic information systems (GIS); Daniel Boone National Forest

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First of all, I would like to thank the Department of Geography for the Graduate Assistant Award and the University Graduate Scholarship, without which none of this would have come to fruition. In particular, I would like to thank Dr. Susanna Tong for her superb guidance and support, Dr. Nicholas Dunning for permitting me to take so many courses outside of the department (and for teaching Soils—one of my favorite classes), Dr. Changjoo Kim for acting as my GIS soundboard and for his expert advice, Dr. Stephen Matter for his suggestion to rank the roads, Bill Luhn for the Daniel Boone National Forest GIS data, Dr. John Cox for sharing his coyote data, Dr. David Mladenoff for sending me their latest chapter on the revised logistic regression model, and my fellow graduate students, Chris Carr for the contact information, Kevin Magee for scoring the Landsat imagery, and Peter Kimosop, Thushara Ranatunga, Benjamin Thomas, Yu Sun, Eric Weaver and others whom I have forgotten to mention for help with any of my GIS questions.

My family has tolerated all my long hours devoted to my education and thesis research, and I appreciate their patience and understanding.

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Chapter One

Introduction

1.1 Challenges of Carnivore Conservation

> Carnivores and wildlands are two sides of the same coin.
> The loss of one heralds the loss of the other.
> (Rasker and Hackman 1996: 992)

Aldo Leopold, the "father" of environmental ethics and wildlife management, considered carnivores "the ultimate test of a society's commitment to conservation" (Noss et al. 1996). For an endangered flower, a small, sequestered woodlot will suffice. Large carnivores like the wolf, however, require large home ranges across a broad spectrum of landscapes, and, in a world of shrinking wildlands and expanding human landscapes, conservation proves challenging politically, economically, culturally and ecologically.

Habitat destruction, hunting, persecution, disease, and commercial trade of body parts have imperiled predators worldwide. As human population, resource demands and human-predator conflicts escalate, the outlook for mega-carnivores appears grim. Our historical relationship with predators exemplifies our predisposition to destroy rather than preserve. Carnivore conservation, therefore, involves cooperation and compromise on every scale—individual, local, regional, national and global—and on every level—biological, ecological, geographical, political, legal and social. Confounding the issue, every species has unique requirements for survival.

This thesis research was undertaken with the intent to contribute to the science of red wolf (*Canis rufus*) conservation and its reintroduction to the wild.

1.2 Research Objective

In Kentucky, the loss of keystone species in combination with the loss of the dominant forest canopy species, the American chestnut (*Castanea dentata*), has resulted in impoverished biotic communities (Maehr, Grimes and Larkin1999). Insect infestations and disease indicate environmental stress within the Daniel Boone National Forest (DBNF).

Ecosystems are holistic—if one aspect is degraded, the other components will be affected as well. In DBNF, drought, insect defoliation, soil compaction, changes in soil depth, and trunk and root injury weaken oak species. Trees weakened or suppressed by other factors such as fire and heavy browsing by wild ungulates become susceptible to the twolined chestnut borer (USDA 2008). In the northern portion of the DBNF, the black beetle has impacted the oak-hickory stands, an important ecosystem in the forest (USDA 2008). The Forest Service expects the arrival of the gypsy moth to the DBNF by 2010; undoubtedly, the overcrowded, maturing oak-hickory forests will face magnified losses due to gypsy moth defoliation (USDA 2008).

In 1997, the first DBNF sighting of the hemlock woolly adelgid occurred (USDA 2008). The hemlock woolly adelgid interferes with tree growth and causes needle discoloration and needles to drop prematurely, which affects tree health. Hemlock stands are dying from the hemlock woolly adelgid in neighboring states of Virginia and Tennessee (USDA 2008).

More than 100,000 acres of pine forests in the DBNF have already been lost to the southern pine beetle, “the most devastating insect assault ever documented on the Daniel Boone National Forest in Kentucky” (USDA 2008). Stress from tornado, ice, fire,

drought and overcrowding primed the stage for the southern pine beetle (USDA 2008). With nearly 80% of pine habitats devastated, cascading effects, directly and indirectly, have affected 1/4th of the plant and animal species (USDA 2008). Biologists had to remove the remaining 15 endangered red-cockaded woodpeckers (*Picoides borealis*) from the DBNF, and the notable absence of pine warbler and its song raises concerns (USDA 2008). Climatic change may enhance drought and fire-prone conditions in the forest, further stressing the tree communities and increasing risks for infestation.

With the absence of the wolf, a top predator, herbivore and mesopredator populations have exploded and contributed to the degraded ecosystem (Ripple and Beschta 2004).

Intense herbivory reduces the vegetation community, structure, diversity, and health (Ripple and Beschta 2004), and the recent reintroduction of elk into the DBNF will further escalate herbivory intensity. White-tail deer, the main prey for the red wolf, has dominated the Kentucky landscape. Prior to European settlement and predator elimination, the estimated average density of deer in North America was 3.1-4.2 deer/km² (Rooney 2001). Thomas Barnes, a wildlife specialist at the University of Kentucky, stated in a news report that the deer population in Kentucky had risen to approximately 1 million (Pratt 2007)—an estimated deer density of 9.6 deer/km². Moreover, deer densities greater than 7.9 deer/km² negatively affect the regeneration process of the overstory. Browsing by overabundant deer eliminate species, create monocultures and reduce tree heights below the required 0-7.6m height interval for songbird nesting and foraging (DeCalesta 1997). Songbird populations, therefore, diminish due to the habitat degradation by ungulate herbivory (DeCalesta 1997).

Predation by the small to mid-sized predator such as the coyote (*Canis latrans*), skunk (*Mephitis mephitis*) and raccoon (*Procyon lotor*) reduces the populations of smaller vertebrates such as song birds, rodents and lagomorphs (Estes, Crooks and Holt 2001; Ripple and Beschta 2004; Côté et al. 2004). As mesopredators and herbivores increase in numbers, the biodiversity of smaller fauna and flora decrease.

Wolves in their "pivotal" ecological role may help to maintain biodiversity and habitat quality if the predator succeeds in controlling prey populations (Ripple and Beschta 2004). As one of North America's most critically imperiled vertebrates (NatureServe 2007) and one of the world's most critically endangered canids (IUCN 2006), the red wolf should be considered a conservation priority. Protection of the endangered red wolf, an umbrella species, would thereby encompass and protect its habitats and all the plant and animal species within its home-ranges, benefiting the forest community. Through reintroduction of the red wolf, a native species, the DBNF may recover the integrity of its ecosystems and preserve biodiversity.

In 1980, red wolves were removed from the wild and placed in a recovery program that entailed captive breeding and reintroduction into the wild. Currently, the red wolf population has risen to 208 in captivity and 130 in the wild (USFWS report 2007). Approximately 20 packs of an adult pair and their pups are distributed in North Carolina (Phillips, Henry and Kelly 2003). Despite the progress, analysis suggests a population of 550 (330 in captivity, 220 in the wild) to be a stable population for genetic diversity (Phillips, Henry and Kelly 2003; DeBelieu 1991). With this goal in mind, the United States Fish and Wildlife Service (USFWS) calls for additional establishment sites for the rare and endangered *Canis rufus* (USFWS report 2003). This thesis research aims

to contribute to the Red Wolf Species Survival Plan (RWSSP) by identifying and evaluating potential sites within the DBNF for the reestablishment of red wolves.

1.3 Problem Statement

Restoration of the red wolf (*Canis rufus*) to historic ranges in eastern Kentucky will enable the reestablishment of a keystone species. Its top predator role may help to maintain ecosystem integrity, balance, diversity, and health. Thus far, however, researchers have not determined if the Daniel Boone National Forest (DBNF) in eastern Kentucky has the capacity to support viable populations of red wolves. Habitat analysis of the DBNF, therefore, rectifies this gap as it can provide relevant knowledge about the potentiality for red wolf restoration to the DBNF. It will be helpful to the United States Fish and Wildlife Service and red wolf recovery teams.

As indexes for wolf suitability, researchers on wildlife reintroduction focus mainly on density of prey, roads and humans. Mech (1995) denoted road density as the "yardstick" by which agencies and recovery teams measured wolf habitat suitability; however, previous researchers only used simple road densities without assigning a weighing factor. Roads with higher traffic volumes and areas with greater road densities should, in theory, pose greater risks to wolf mortality. To address this inadequacy, this research, therefore, ranked roads by mortality risk and utilized kernel density estimation in Geographic Information Systems (GIS) as a means to weight the road density and to predict suitable wolf habitat. This will provide a better picture of the spatial reality of road influence.

Chapter Two

Literature Review

2.1 Introduction

2.1.1 Historical and Current Status of the Red Wolf

Early European settlers brought not only their religious and political beliefs to the New World, but also their negative views of the wolf (Fritts et al. 1997), a "nearly fanatical hatred of wolves" (DeBlieu 1991). Myth and folklore have portrayed them as "savage and demonic" (DeBlieu 1991). People, thereby, associated the wolf with evil, darkness, sorcery, malicious and cunning, and they feared superstitions of werewolves. By the eighteenth century, the wolf symbolized "the untamed land that had to be subdued in the name of civilization" (Fritts et al. 1997), and, at the time, taming the wildlands represented humankind's manifest destiny (Phillips, Henry and Kelly 2003).

In Eurasia, persecution had eliminated wolves except in the central Appenine Mountains of Italy, the Cantabrian Mountains of northern Spain, the Carpathians of Eastern Europe, the northern parts of the former Soviet Union, and the central plains and mountainous regions of Asia (Mech 1995). In America, man defeated the wolf in the two-hundred year long war against the predator (Phillips, Henry and Kelly 2003), with wolf populations surviving only in Canada, Alaska, and in the wildlands of northern Minnesota and nearby Isle Royale National Park in Lake Superior (Mech 1995).

The advent of firearms, steel traps, poisons and aerial hunting facilitated the slaughter of wolves (Mech 1995, Musiani and Paquet 2004, DeBlieu 1991). "Wolfers" killed wolves for furs and money (Phillips, Henry and Kelly 2003, Musiani and Paquet 2004); others for protection of livestock (Mech 1995, Musiani and Paquet 2004), for

disease control, for recreation, and for fear (Musiani and Paquet 2004). However, the majority of wolf-human conflicts stemmed from agricultural and pastoral practices, whereby wolf depredation of domesticated livestock instigated eradication measures (Musiani and Paquet 2004, Mech 1995, DeBlieu 1991).

Red wolves (*Canis rufus)*, in particular, exemplify the fervor of persecution in the United States. As human populations expanded into the wildlands, the wildlands and the red wolf disappeared. DeBlieu (1991) outlined the systematic extermination of the red wolf from the southeastern seaboard and from Alabama, Mississippi, Tennessee, Kentucky, Missouri, Oklahoma, and Arkansas. Two subspecies, *Canis rufus floridanus* and *Canis rufus gregoryi*, became extinct. The remaining subspecies, *Canis rufus rufus*, found refuge in the swamps of Texas and Louisiana, where parasitic infestation and hybridization with coyotes further compromised the population of the species (Philips, Henry and Kelly 2003).

By 1967, the United States listed *Canis rufus* as an endangered species, and the USFWS determined recovery for the red wolf would only occur in a captive breeding program (Phillips, Henry and Kelly 2003, DeBlieu 1991, USFWS 2007 report). The USFWS removed 400 red wolves and declared the species extinct in the wild. Of the 400, only 43 were believed to be red wolves, and only 14 were considered pure enough to enter into the breeding stock for the recovery program (Phillips, Henry and Kelly 2003, Brownlow 1996).

The red wolf recovery program has proved successful. At present 208 red wolves exist in captivity and nearly 130 red wolves, distributed in 20 packs (Phillips, Henry and Kelly 2003), exist in North Carolina (USFWS report 2007).

2.1.2 Red Wolf Biology and Behavior

Red wolves, intermediate in size between the gray wolf (*Canis lupus)* and the coyote (*Canis latrans)*, weigh on average between 45-80 pounds (USFWS), or 20-36 kg in metric scale (Roth, Murray and Steury 2008), with a body height of 66 cm and length of 1.2 m (USFWS). Disproportionately large ears and long legs distinguish the red wolf from the gray wolf and coyote (Phillips, Henry and Kelly 2003, Phillips and Henry 1992). Despite the characteristic red color (USFWS 2008), the red wolf (Fig.1) displays a range of fur colors: red, brown, even a black phase, but most often a mixture of gray, black and cinnamon-buff (Phillips, Henry and Kelly 2003).



Figure 1: Red Wolf.
Photo taken from the National Audubon Society Field Guide to North American Mammals

Like the gray wolf, the red wolf lives as a family pack consisting of an alpha breeding pair and their offspring (Phillips, Henry and Kelly 2003, Phillips and Henry 1992), typically with five to eight animals (USFWS 2008). A hierarchal social structure

exists within the pack: the alpha pair leaders followed by the second-ranked beta wolf, young subordinates, juveniles and pups, and the omega wolf, the scapegoat (Greeley 1996). A wolf's place in the echelon dictates its behavior. Upon greeting, for instance, a subordinate wolf shows submission, respect and affection to the dominate wolf by lowering its body and licking or nuzzling the other's muzzle. Wolves communicate through these non-verbal displays and others as well as a range of vocalizations, including howls, barks, snarls, growls, and whimpers. Success of the pack depends on their communication and cooperation.

For wolves, cooperative strategies during hunts enable the smaller predator to take down the larger prey such as the white-tailed deer. Scat analysis from the Alligator River National Wildlife Refuge (ARNWR) revealed white-tailed deer, raccoon, and marsh rabbits constituted 88.7% of the biomass consumed by the red wolf (Phillips 1995). Rodent consumption, preferred by juveniles, decreased with age (Phillips, Henry and Kelly 2003). In ARNWR, food habits differed among the packs. For example, the Milltail pack (pack names coincided with their habitat) relied on small prey (rodents and rabbits), and the Gator pack relied on larger prey (deer and raccoons) (Phillips, Henry and Kelly 2003). Variances stemmed from prey abundance and distribution. In the agricultural fields used by the Milltail pack, rodents and rabbits occurred in higher densities than within the wooded and gum swamp habitats used by the Gator pack (Phillips, Henry and Kelly 2003). Phillips, Henry and Kelly (2003) suggest the "differential use of prey may have played a role in determining their home range sizes." For the red wolf, home range sizes spanned 25 km² to 130 km², averaging 88.5 ± 18.3 SD km² for individuals and 123.4 ± 53.5 SD km² for packs (Phillips, Henry and Kelly 2003).

Wolves in the pack may disperse at the age of sexual maturity between the months of September and March, with 72% occurring between November and February (Phillips, Henry and Kelly 2003). Only the alpha pair in the pack breeds, annually producing one litter of 1-5 pups after a 63-day gestation period. From mid-April to mid-July, red wolves utilize dens, whether underground burrows, hollow logs, ditches or windrow nests in agricultural fields (Phillips, Henry and Kelly 2003). Phillips (1995) documented the 1994 survivorship of wild-born red wolf pups. Of the 66 pups, 54% were free-ranging, 8% were returned to captivity, 23% have fates unknown and 15% died. Researchers discovered wild-born pups survived for longer periods than the released adults and captive-born pups.

2.1.3 Ecological Benefits of Red Wolf

The extirpation wolves allowed the expansion of coyotes east of the Rocky Mountains. As an apex predator, the organism at the highest trophic level, the wolf theoretically exerts top-down control on the ecosystem, creating trophic cascades, chain reactions across multiple trophic levels (Estes, Crooks and Holt 2001). Removal of the apex predator results in a proliferation of the mesopredator, the small to mid-sized predator such as the coyote, skunk (*Mephitis mephitis*) and raccoon (*Procyon lotor*), which, as a cascading result, reduces the populations of smaller vertebrate species such as rodents, birds and lagomorphs (Estes, Crooks and Holt 2001; Ripple and Beschta 2004; Côté et al. 2004). Moreover, "the absence of highly interactive carnivore species such as wolves can thus lead to simplified or degraded ecosystems" (Ripple and Beschta 2004:755).

Research evinces an association between apex predators and higher biodiversity (Sergio et al. 2006; Ripple and Beschta 2004). Biodiversity describes the quantity and quality of species richness within geographic regions and the variability between species and ecosystems. The loss of species results in the loss of biodiversity. With decreased biodiversity, the ecosystem that functions on the interdependence of all its components may suffer.

Wolves prey upon ungulates, herbivores that influence plant communities. Ungulate herbivory can affect vegetation structure, composition, diversity, productivity and succession, and can alter the habitat quality for other animals (Ripple and Beschta 2004). Without predation pressures, ungulates, such as the white-tailed deer (*Odocoileus virginianus*), may experience population explosions, sometimes beyond the carrying capacity of a habitat's available forage (Côté et al. 2004) and, through their intense browsing, reduce the species abundance and diversity of seedlings and saplings, and shift herbaceous and shrub community structures to grasses and ferns (DeCalesta 1997). Biodiversity declines in three communities—tree, herb and shrub, and songbirds—due to the overabundance of deer (DeCalesta 1997).

In Isle Royale, balsam firs flourished with an increase in wolves and a decrease in moose (Smith et al 2003). In Yellowstone, Ripple at al (2001) found taller aspens in the high wolf-use riparian zones and wet meadows and more "vigorous" regeneration along wolf trails and other heavy use areas than in low wolf-use areas. They hypothesized that the elk changed its foraging behavior by adopting an "anti-predator strategy," staying in open country for vigilance and safety. The presence of wolves instigated modifications

in the elk's diet, temporal feeding patterns and spatial use, and selection of habitat patches and foraging sites. In the absence of elk, aspen regenerated.

Top predators influence lower trophic levels by direct effects on mortality and indirect effects on behavior modifications (Lima 1998; Estes, Crooks and Holt 2001; Ripple et al. 2001; Ripple and Beschta 2004). Ripple and Beschta (2004) elaborated on the concepts behind behavioral changes in response to predation: optimal foraging theory, "ecology of fear" concept, "predation sensitive food" hypothesis, prey and plant refugia and "terrain fear factor." Optimal foraging theory describes the foraging strategy organisms adopt to maximize returns in the minimum amount of time and to balance the need for food and safety. In any given habitat, herbivores' selection and use of space manifests from their fear of predation, the foundation for the "ecology of fear" concept. Despite fears, prey take greater risks to forage as food availability dwindles and occupy riskier sites as defined by the "predation sensitive food" hypothesis. As predation risk increases, the rate of mortality increases, thereby limiting prey population size. Prey refugia, on the other hand, are sites of prey occupation where the risk of predation is minimized. Ungulate migration outside the core wolf areas increases survival potential, but within the high wolf density areas, herbivory decreases, creating plant refugia for plants that escaped browsing. In areas with high wolf density and predation risk, prey may avoid these altogether or forage less intensely. Wolves have a higher kill rate if they can approach prey without detection or with an element of surprise, and, in response, prey develop strategies to either hide from predators by seeking forest cover or to spot predators from afar by seeking open terrain. This strategy model of space-use and forage-patterns based on features of the landscape refers to the "terrain fear factor."

Environmental variables such as terrain, elevation, habitat structure, snowpack, weather or wildfires influence predator and prey behaviors, predation risks and survival rates (Ripple and Beschta 2004). In response to the dynamics in the environment and changing predation risks, prey possess adaptive flexibility in behavior, which in turn changes the foraging patterns and environmental effects (Lima 1998).

> The science of ecology has undergone a succession of paradigms on the nature and importance of species interactions, including those between predators and their prey. (Estes, Crooks and Holt 2001: 858)

Ecologists recognize important species interactions follow the three successive pathways, often simultaneously and interactively: bottom-up forces where primary production regulates populations; competitionism where lateral forces within trophic levels regulate populations; and top-down forces where apex predators regulate populations (Côté et al. 2004). Like a complex machine with various interconnected parts working simultaneously with and against the other, the ecosystem hypothetically functions best with all parts present.

2.1.4 Economic Benefits of Red Wolf

Urban development, agriculture and resource extraction threaten to erase the natural face of the planet, and, within remaining pockets, fragmentation may cut the flow of animal and genetic movement. If habitat destruction does not cease, large carnivores will cease to exist, except in zoos (Clark *et al* 1996). Unfortunately, economy drives human expansion, and people assume a strict dichotomy exists between people and carnivores, between the economy and environment, and that conservation favors carnivores and the environment over people and their economies (Rasker and Hackman

1996). Communities, therefore, resist conservation efforts and predator persecution persists. It took 25 years to reintroduce the grey wolf into Yellowstone National Park (Weber and Rabinowitz 1996), for citizens believed wolves would harm not only the livestock industry but the states' economies overall (Rasker and Hackman 1996).

In order to convince the public predators do not adversely affect economy, Weber and Rabinowitz (1996) and Rasker and Hackman (1996) compared the economies of wilderness and resource management counties. The research teams found wilderness counties experienced greater income and economic growth than the counties dependent on resource extraction. As shown by Rasker and Hackman (1996), between the years 1969-1992, employment and personal income increased by 93% (34,500 new jobs) and 89% ($987 million), respectively, in the wilderness counties of northwest Montana, while the resource-extractive counties in northwest Montana only increased 15% in employment (2152 new jobs) and 19% in personal income ($70 million). Furthermore, the resource-extractive counties lost more than 1300 jobs in construction, transportation and public utilities sectors, and, therefore, had higher unemployment rates than the wilderness counties (Rasker and Hackman 1996).

Yellowstone National Park serves as a prime case study for the economic impacts of carnivore, in particular wolf, conservation. Prior to wolf reintroduction, opponents expressed concern about wolves having a negative impact on big game populations and, in turn, on the local and regional economies driven by hunting revenues (Duffield, Neher and Patterson 2008). Proponents countered with a prediction that the attraction of wolves would boost park visitation and regional economies (Duffield, Neher and Patterson 2008). Investigating the economic impacts of wolf recovery, Duffield, Neher and

Patterson (2008) estimated 94,000 visitors from outside the three-state region came to Yellowstone specifically for the gray wolf and spent on average $375 per person, or a total of $35.5 million (a total, adjusted for inflation, less than the predicted revenue). Ranchers, on the other hand, experienced annual depredation losses averaging $63,818, twice the high-end of Environmental Impact Statement (EIS) predicted estimates, in 2004 and 2005. However, the EIS based their assumptions on wolf populations numbering 100, not the actual 300. The EIS had in addition projected losses of $342,000 to $890,000 in hunter expenditures; yet, no reductions for permits, numbers of harvested animals or hunter success for mule deer or moose occurred because of wolf restoration. While populations of mule deer, bison and moose had not declined because of wolf predation, herd sizes of elk had diminished as numbers of wolves increased. The number of elk permits dropped "substantially" because of wolf presence, aggressive culling policies and drought. Overall, Duffield, Neher and Patterson (2008) concluded wolf recovery netted an estimated $58 million in positive gains for the region in 2005.

In 2005, livestock predation by wolves accounted for 0.11% of cattle losses, whereas coyotes killed 22 times more cattle than wolves, dogs killed 5 times more cattle than wolves and vultures killed twice as many cattle as wolves (Defenders of Wildlife 2009). Cattle losses by theft were 5 times higher than cattle losses by wolves (Defenders of Wildlife 2009). Disease ranked highest for cause of cattle loss.

Deer, especially in high population densities, transmit diseases such as bovine-virus-diarrhea to livestock and Lyme disease to humans (Côté et al. 2004). Disease prevalence increases with high density of host species because of increased transmission rates (Stronen et al. 2006). Wolves could reduce risks of transmissions, if diseases

increase prey vulnerability (Barber-Meyer, White and Mech 2007), by reducing average group sizes of herd species (Stronen et al. 2006). After wolf restoration in Yellowstone, bovine-virus-diarrhea in elk decreased "substantially" as compared to prior values (Barber-Meyer, White and Mech 2007). Wolves therefore may play a positive role in agricultural landscapes. Wolf regulation of wild ungulate density may reduce disease prevalence and indirectly lower transmissions to livestock, a cost-value few ranchers and farmers recognize but from which they may benefit (Stronen et al. 2006).

The commercial losses from nursery, crop and ornamental garden damage by deer browsing and deer-vehicular collisions surpass the commercial losses incurred by wolves (Côté et al. 2004). Côté et al. (2004) reported in 1991 deer caused $351 million in damages to agriculture and households and $1 billion in accident-costs. By controlling deer populations, wolves may mitigate commercial as well ecological damages.

Defenders of Wildlife issued a report on wolf ecotourism in 2005. In Yellowstone, 200 visitors paid $1700 weekly for Safari Yellowstone and the opportunity for gray wolf watching. A study on red wolves in North Carolina's ARNWR indicated a possible 19% increase in the region's tourism, which may bring in 25,000 visitors and $37.5 million to Eastern North Carolina. In 2005, 900 visitors participated in the red wolf howling safaris.

In 2006, the Defenders of Wildlife hosted a stakeholders' meeting to discuss strategies for developing and managing red wolf ecotourism in North Carolina. Plans included construction of a wolf education center and express hotel, providing other recreational opportunities and revenue from canoe, kayak and bike rentals, and generating income from the merchandise and the howling tours. At present howling

tours, which on average attract 1,000 participants annually, charge a nominal fee of $5 per person. Approximately 10,000 visitors toured the Red Wolf Coalition-sponsored 2007 exhibit in Colombia, North Carolina (Red Wolf Coalition 2008). The potential economic value of red wolves has yet to come to fruition, but, with appropriate planning, individuals, local communities and regional organizations may benefit along with the red wolf.

2.2 Red Wolf Recovery Program

2.2.1 The Alligator River Wildlife Refuge (ARNWR)

As outlined in the Red Wolf Species Survival Plan (RWSSP), the goals include increasing the number of genetically pure red wolves in captivity, maintaining a viable gene pool and reestablishing the captive species in the wild. Genetic viability, as surmised by biologists, requires an estimated 330 red wolves in captivity and restoring at least 220 wolves in the wild at three or more sites (Phillips, Henry and Kelly 2003).

In 1987, the USFWS released the first wolves and by 1995 reintroduced 63 captive-born wolves into the 18,218ha ARNWR in the North Carolina outer banks (Phillips 1995). The second reintroduction site in the Great Smoky Mountains National Park (GSMNP), however, failed because of the high pup mortality (USFWS 2007). Biologists identified parvovirus in one litter of pups and evidence of coyote predation on another, as well as heavy intestinal infestation and malnutrition (USFWS 2007).

ARNWR proved ideal for red wolf reintroduction with 48,562 ha of coastal plains, abundant prey, lack of coyotes, few livestock, few human settlements, adjacency to 20,639 ha of undeveloped land held by the Department of Defense and water barriers

as a natural enclosure to facilitate management of the wild populations (Phillips, Henry and Kelly 2003). An additional ideal restoration site, Pocosin Lakes, contained 45515 ha, abundant prey, only small populations of coyotes and livestock (Phillips, Henry and Kelly 2003). DeBlieu (1991) and Phillips' field journal described the first wolf releases, replete with every nuance of the process, atmosphere and mood. As a general rule, biologists released the wolves in family groups or adult pairs between August and October (71%) (Phillips1995). Slow-releases, where the captive-bred wolves stayed in pens and relied on biologists for food for a period of time, helped the red wolf acclimate to its new wild surroundings.

Statistics showed successful releases as only 21% (Phillips, Henry and Kelly 2003). In general, 70% of the unsuccessfully released wolves that travelled far from the release area either died or were returned to captivity (Phillips, Henry and Kelly 2003). Altogether 36 captive-born red wolves died within a year from release (Phillips, Henry and Kelly 2003). The main causes of wolf mortality in North Carolina arose from vehicular accidents (30%), malnutrition and parasitism (27%) and intraspecific aggression (12%). Since 1999, the loss of red wolves from human factors included gunshot (22%), vehicle (14%), poison (3%), traps (2%) and management (13%) (USFWS 2007). Disappearance (22%) counts as another high percentage for loss, in addition to the natural causes mentioned previously.

Field data from ARNWR, though, revealed upward trends in the populations of red wolves, the number of breeding pairs and number of pups born (USFWS 2007). Preliminary USFWS (2007) analysis estimates red wolf survival rates in the wild as 78.2% overall, with adults at 80.6%, yearlings at 79.3%, and pups at 67.8%.

However, the objectives of the RWSSP, according to the 2007 Five-Year Progress Report (USFWS), remain incomplete. The USFWS still requires at least two additional reintroduction sites within the species' historic ranges to support viable populations of red wolves. This thesis research aims to contribute to the objective of the RWSSP by identifying and evaluating potential sites within the Daniel Boone National Forest for the reestablishment of red wolves.

2.2.2 Current Challenges of Red Wolf Conservation

Red wolf recovery hinges upon the mitigation or elimination of deterministic and stochastic threats. In the five-year report, the USFWS (2007) through five-factor analysis determined that habitat fragmentation and modification, disease, interspecific aggression, hybridization with coyotes, and human-induced mortalities continue to threaten the recovery efforts.

2.2.3 Impacts of Humans on Red Wolf Recovery

During hunting season, according to the USFWS 2007 report, the red wolf in ARNWR faces a 7.2 times greater risk of dying from gunshot. Since 2004, gunshot mortality (whether illegal or accidental) has impeded the upward population trends. Indirect effects from gunshot mortality exacerbate problems of red wolf recovery by reducing the wolf population, which reduces their ability to defend territory against coyotes and increases the chance of interbreeding. Gunshots, along with vehicular strikes and disappearance, constitute the leading causes of red wolf loss. In general, human activity accounts for more than half (58%) of the losses.

Lynn (2002) explained two features of man's attitude toward the wolf that hinders its recovery and threatens its survival: wolves and humans should not share the same space; wolves do not belong in the "humanized" landscapes. Fear of the wolf drives the antagonism between man and wolf. In rural communities, people fear wolves will prey upon livestock and pets, and prevent logging, mining and hunting opportunities by excluding human presence in the forest, putting lives and livelihoods at risk (Musiani and Paquet 2004; Ratti et al. 1999; Mech 1995; Stronen et al. 2006).

Age, occupation, and education influence values. Surveys found older, less educated citizens perceive predators as dangerous or damaging to economic welfare (Ratti et al. 1999). In rural agricultural areas, wolf survival is "disproportionately dependent on actions of people who depend on the productivity of the landscape for their livelihood" (Stronen et al. 2006: 2). Anti-wolf sentiment threatens to push wolves into remote areas devoid of all human activity (Mech 1995).

Phillips (1995) concluded red wolf recovery depends, not on partitioning undisturbed wildlands, but "overcoming the political, emotional and logistical obstacles to human coexistence with wild wolves." History as precedent proves humans handle wolf conflicts by eradication. Resolving the conflict then depends on our values, not facts alone, and our tolerance of wolves and acceptance of coexistence with wolves, not merely a science of wildlife management (Lynn, 2002). According to Saunders (2003), the caring relationship with nature relates to the "formation of an environmental ethic." Attitudes reflect the positive, negative, or neutral tendencies to think, feel, or act toward a particular object, place, event or person, and, in regards to an environmental ethic, attitudes dictate "how humans behave in nature and how humans care about/value nature"

(Saunders, 2003). Beliefs and perceptions predetermine tolerance to wolves (Stronen et al. 2006). Public education on wolf ecology and management is vital to wolf recovery (Musiani and Paquet 2004; Fritts et al. 1997; Mech 1995). Moreover, teaching empathy, rather than focusing solely on the predator's prominent role in the ecosystem, may be more effective in changing attitudes and, thus, environmental behavior (Prokop and Krubiatko 2008).

Lack of community support undermined the initial red wolf recovery efforts in the Land Between the Lakes, a region between Kentucky and Tennessee, because officials failed to address local concerns about red wolf conflicts (Ratti et al. 1999). Whereas flexible, non-restrictive regulations enabled greater support in North Carolina, for landowners and hunters felt the government prioritized their needs (Phillips et al. 2003; Phillips 1995). Prior discussions with locals about wolf management and regulations will work to alleviate concerns. Where pressure exists to manage wolf populations, non-lethal and non-traditional methods, if cost effective, may diminish livestock depredation and benefit people and wolves in agricultural environments (Musiani and Paquet 2004); however, wolf control may call for lethal measures, despite protest from preservationists (Mech 1995).

The human factor plays an important aspect in wildlife reintroductions and should be part of the plan, not an after-thought.

2.2.4 Impacts of Coyotes on Red Wolf Recovery

The stochastic process of hybridization with the coyote (*Canis latrans)*, whereby a unidirectional introgression of coyote genetic material into the red wolf genome occurs,

poses a serious threat: the possible extinction of the *Canis rufus* species (Brownlow 1996; Ratti et al. 1999). In areas with high wolf density, wolves and coyotes may coexist without hybridization (Ratti et al. 1999). In simulations performed by Roth, Murray and Steury (2008), higher numbers of coyotes, on the other hand, led to higher extinction rates for small founding red wolf populations. At present, coyotes occupy historic red wolf ranges (van Manen, Crawford and Clark 2000; Phillips et al. 2003), and the likelihood of hybridization is high, especially considering the low populations of red wolves in the wild. Murray and Waits (2007) noted the expanding coyote and the declining red wolf populations create a "disequilibrium and hybrid zone expansion."

Controversy surrounds this issue. Some researchers believe in preserving the genetic "purity" of the red wolf, while others would rather conserve the evolutionary process of speciation, whereby hybridization produces a canid more suited to survival amongst humans and their "anthropogenically modified landscapes" (Kyle et al. 2008). Biologists even argue the genetic purity and taxonomic status of the red wolf (Wayne and Jenks 1991; Nowak 1992; Phillips and Henry 1992; Brownlow 1996; Phillips et al. 2003; Murray and Waits 2007; Kyle et al. 2008). Nowak (1992:594) described the red wolf as "an intermediate stage in the course of wolf evolution from a small coyote-like ancestor to the modern gray wolf." Researchers hypothesized the red wolf derived from gray wolf (*Canis lupus*) and coyote interbreeding. Yet, hybridizations between gray wolves and coyotes in the northern United States and Canada do not produce red wolves (Phillips and Henry 1992). Other authorities believe the red wolf may be a subspecies of the gray wolf; however, Kyle et al. (2008) contended the red wolf was endemic to North America before gray wolf colonization. Interestingly, Kyle et al. (2008) proposed conspecificity

between the red wolf and the eastern wolf (*Canis lycaon*), adding yet another dimension to the taxonomic debate. Regardless of the red wolf's status, the Endangered Species Act (ESA) extends protection to species, subspecies and even species with "limited genetic introgression from another species" (Nowak 1992).

Minimizing coyote hybridization currently involves removing coyotes from red wolf habitat and sterilizing or euthanizing coyotes and/or hybrids (Phillips et al. 2003; Murray and Waits 2007; Kyle et al. 2008; Roth, Murray and Steury 2008). With sufficient decrease in coyote reproductive rates, red wolf extinction rates decreased to zero in simulations (Roth, Murray and Steury 2008). Red wolves establish home range territories more quickly with absent or low-density coyote populations (van Manen, Crawford and Clark 2000). In addition, releasing red wolves as family packs may provide the stable social structure to withstand possible coyote introgressions (van Manen, Crawford and Clark 2000). If red wolf populations recover despite the threat of hybridization, the recovery program will act as a model for other wildlife restorations because "invasive species will continue to shape ecological communities and conservation biology efforts" (Murray and Waits 2007).

Interspecific competition shapes ecological communities as well. Roth, Murray and Steury (2008) examined the sympatry between red wolves and coyotes, how the two competitors share space and resources. Wolves and coyotes form family groups with territorial home ranges with exclusive core areas and overlapping edges. Home ranges for the red wolf in North Carolina average 111 km², whereas the coyote's home range average between 2 and 20 km². In southeastern Kentucky, telemetry data suggests an average coyote home range of 18.3 km² for a male-female dyad/pair plus pups (per

personal communication with Dr. John J. Cox, UK Dept. of Forestry). With one breeding pair per wolf and coyote pack, dispersal rates of sexually-mature young adults tends to be high, especially in low-density populations. Coyotes, though, have a higher reproductive rate than red wolves. Eighty-percent of female coyotes produced an average litter of six pups, whereas fifty-three percent of female red wolves produced an average litter between three and four pups. With a smaller body mass, 2/3 the size of a red wolf, the coyote faces higher mortality rates from interspecific aggression, which influences the space-use patterns of the smaller canid.

Wolves dominate coyotes and force coyotes from certain areas (Arjo and Peltscher 2004). In response, coyotes may shift habitats to lower quality sites, such as closer to roads and to human habitations, which wolves tend to avoid (Arjo and Peltscher 2004). Roth, Murray and Steury (2008) suggested the impact of coyotes on red wolf recovery will lessen if red wolves can exclude coyotes from higher quality habitats. However, red wolves reintroduced into coyote-colonized landscapes may have difficulty establishing home ranges (Roth, Murray and Steury 2008).

Abundance of prey and intra-and interspecific aggression affect habitat selection for canids (Arjo and Peltscher 2004). Prey tends to congregate in lowlands during the winter and thus leads to wolf and coyote sympatry (Arjo and Peltscher 2004). Riparian environments provide thermal cover and security for deer and further habitat overlap (Arjo and Peltscher 2004). Coyote use riparian habitats for microtines (voles and lemmings) and for scavenging wolf kills, which tend to occur along rivers (Arjo and Peltscher 2004). In North Carolina, red wolves mainly consume deer, raccoon and rabbits. With no diet estimations for North Carolina coyote, biologists assume the canid

behaves as opportunistic, generalist predator, consuming a wider variety of foods, including rodents, lagomorphs, fruits, and carrion (Roth, Murray and Steury 2008). Red wolves may even supplement their competitors' diet by providing carrion (Roth, Murray and Steury 2008). Therefore, the coyote probably exploits resources to a greater degree than the red wolf. Roth, Murray and Steury (2008) assume exploitative competition or territorial exclusion fuels interference behaviors, which in turn depends on the pack size and the quality of the habitat. The ability of the larger red wolf to exclude the coyote might enable coexistence; otherwise, higher coyote populations have a higher chance to hinder red wolf re-colonization (Roth, Murray and Steury 2008).

It appears critical to red wolf recovery to improve the understanding of interspecific relationships—canid sympatry, competition, interference and coexistence.

2.2.5 Principles of Carnivore Conservation

One of the primary goals of conservation biology is to preserve ecosystem dynamics and biodiversity, and conservation biologists spotlighted the top predators to achieve this aim rather than explain the complexities and benefits of thriving ecosystems. Sergio *et al* (2006) discussed several reasons why top predators promoted higher diversity: predators choose sites based on productivity, prey density, high topographic and habitat variety, and provide spatial refugia for some species, whether by deterring other predators or interguild competitors of that species. Moreover, apex predators signal disturbance and dysfunction in an environment. Carroll *et al* (2001) attributed large mammalian carnivores' sensitivity to landscape changes because of their low population

densities, low fecundity rates, limited dispersal ability across open or developed habitat and "other traits that lower ecological resilience."

Early conservation scientists centered on carnivores for reserve design based on the belief that carnivores made good indicator species for ecosystem health (Noss *et al* 1996). The ideal reserve consisted of an expansive, undisturbed core with surrounding, limited-use buffer zones. Yet, biologists know little about the viability of reserves (especially in the context of global climate change), whether 1,000-10,000 km² will work for decades or if 100,000 km² will work for the long-term (Noss *et al* 1996). The notion of a single reserve has since evolved into a vision of a network of reserves, allowing for the dynamic movement and natural migration of prey and predators. In developed regions, small highly managed reserves with unfixed corridors might prove more effective and economically feasible.

In time, biologists decided localized species of flora and fauna indicated ecosystem status better than long-ranging habitat generalists such as large carnivores. Conservationists needed a reason to conserve carnivores though, and, hence, directed attentions to their role as a keystone species. Keystone, as the term suggests, refers to the key stone, the central wedge of an arch for example, that holds the structure together. In ecology, a keystone species helps to support and balance the community of life , and if removed, it may lead to dramatic cascading effects across trophic levels. The impact of the keystone species is much greater than expected as compared to its relative abundance or total biomass, whereby a small change in the population densities of keystone species may cause major disruptions within the ecosystem. Paine (1969) defined a keystone predator as one that feeds preferentially on the dominant competitor prey species, and by

this, predation prevents the dominant prey from excluding other species. Therefore, a higher diversity of life is maintained in a system where the keystone predator exists than when it is absent.

Habitat modification and predator persecution have removed the keystones. Without the mega-carnivore, the "top-down" control, the community structure changes. For example, the opportunistic coyote increased after the extirpation of the wolf and, consequently, the kit foxes experienced 75-90% mortality from coyote predation (Linnell and Strand 2000). Songbirds have suffered from the loss of large carnivores as well (Noss *et al* 1996). The songbird profits from the presence of the apex predator, which limits the presence of the mesopredator that preys upon the songbird. In addition, large carnivores may reduce the abundance of large dominant herbivores, which allows the plant communities and smaller herbivores to diversify.

Conservation of keystone predators, in effect, creates an umbrella effect, whereby protections for the predator encompass all species sharing the same space. Therefore, the predator with the largest habitat assumes the role of the umbrella species (Carroll *et al* 2001), but whether a carnivore functions as an umbrella species depends on the biogeographical characteristics of a region (Noss *et al* 1996). Not all rare or endangered habitats fall under an umbrella's range. Caro (2003) analyzed the use of umbrella species in East Africa and concluded the need to predict which background species populations would receive long-term protection from the umbrella species. As expected, background species have higher populations within East African reserves than outside the reserves, indicative of the success of umbrella species concept in conservation.

In addition, research shows a direct link between the manipulation of flagship species and efficacy of conservation based on top predators (Sergio *et al* 2006). Flagship species, unlike indicator, keystone and umbrella species, do not represent ecological roles or benefits. Conservation endeavors rely on fascination and sympathy for support. Organizations rally, "Save the wolves. Save the polar bear. Save the cheetah." Instead of graphs and charts, breathtaking photographs of power and beauty win hearts, and the countless brutal images of mutilation, skins and bones portray the direness of the situation. Non-governmental organizations (NGOs) such as World Wildlife Fund or Cheetah Conservation Fund have championed conservation for these charismatic species. Although procured on glamour, NGOs allocate donations for habitat protection, restoration, local education, and research.

Regardless of nomenclature, carnivores have represented focal species in conservation. As Noss *et al* (1996) poignantly noted, "Carnivores inspire people more than fungi can." Current trends, though, suggest a shift from species-oriented conservation to ecosystem focus (Linnell and Strand 2000).

Carroll *et al* (2001) advocated ecosystem-level regional planning along with analysis of species-habitat association and interactions among predators, which manifest as either exploitation or interference. Exploitation refers to one species consuming more resources than another, and interference refers to the direct death of a contender as a result of the interaction. In Africa, negative relationships exist between the densities of African spotted dogs and cheetahs with the densities of lions and hyenas (Linnell and Strand 2000). Wild dogs cannot keep hyenas and other large scavengers away from kills, which has slowed their recovery. Lion predation accounts for 73% of cheetah cub

mortality. In Namibian farmlands, cheetahs survive best outside the protected areas where predator control has removed lions and hyenas. Smaller species avoid habitats of dominant carnivores, keeping spatial distance, and can succeed in areas with lower prey abundance. Therefore, intraguild predation has certain implications for carnivore conservation, such as including the coyote factor into kit fox conservation plans (Linnell and Strand 2000).

Policy and laws have neglected interactive species and have relied more on "social and economic concerns than on biological information." However, to maintain ecological integrity, wildlife reserve planners should subsume interspecific interactions into conservation goals (Soulé *et al* 2003). Despite fears in Yellowstone National Park, the reintroduction of the grey wolf has also restored the ecosystem. The elk herds avoid wolf territory, areas associated with high vulnerability and risk for the elk but with recovery for the aspen trees.

In the end, our success of rehabilitating an ecologically degraded world will be judged more on the persistence of interspecies interactions than on the geographically limited persistence of populations based only on causing the least economic burden and ensuring only symbolic survival. (Soulé *et al* 2003).

2.3. Potential Release Sites

2.3.1 Criteria for Red Wolf Habitat

Biologists consider wolves habitat generalists, for they are "able to live in areas where prey and shelter are sufficient, so long as habitat fragmentation, disturbance or harassment by humans are minimal or do not occur" (USFWS 2007). Gray wolves in

Northwestern Montana preferred mesic forests (Arjo and Peltscher 2004). In North Carolina, restored red wolves have occupied a mosaic of landscapes—wetlands, pine forests, upland shrubs, crop land, and pocosins (wetland forests with pine tree overstory and evergreen shrub understory) and have utilized edge interfaces for travel and prey access (USFWS 2007). Fuller (1995) suggested a clustering of 2-3 packs in an area of 322 km² for viable gray wolf populations.

Researchers have described various variables affecting suitable wolf habitat. In general, wolf density correlates with prey density (Oakleaf et al. 2006). Jędrzejewski et al. (2004) reported forest cover, fragmentation, road length and distance to border as the four major factors for wolf suitability in Poland. Shaffer (2007) specified seven criteria for suitable red wolf habitat: road density less than 0.25km/km²; 1.0 km from highways; 2.0 km from towns; land cover classes comprised of deciduous, evergreen or mixed forests, shrub/scrub, grassland, woody wetland and herbaceous wetland; deer density at least 5.0 deer/km²; slopes no greater than 20º; and patch areas at least 45.6 km².

As indexes for wolf suitability, researchers focus mainly on density of prey, roads, and humans. Mech (1995) denoted road density as the "yardstick" by which agencies and recovery teams measured wolf habitat suitability. Wolves do not have an aversion to roads and travel roadways with lower traffic volumes (Wydeven at al. 2001; Mladenoff et al. 2009). Only roads with moderate to heavy traffic pose problems for wolves due to increased risk for wolf mortality from vehicular accidents (Mladenoff and Sickley 1998). In North Carolina, during the years 1987-1994, motor vehicles caused 30% of the red wolf deaths (Phillips et al. 2003). Highways and major roads with frequent traffic, not only heighten risks, but form significant barriers to wildlife

movement within the forest, and subsequent fragmentation creates potentially small patchy habitats (Heilman et al. 2002).

Wydeven at al. (2001) traced the early development of road density as a landscape feature to predict suitable habitat. In 1952, Thompson, a graduate student of Aldo Leopold, warned that road development would cause the extirpation of wolves from northern Wisconsin, and, by 1960, his prediction proved true. Thiel (1985) calculated the road density of northern Wisconsin and discovered wolves disappeared when road densities exceeded 0.68 km/km². Researchers since consider the value of 0.6 km/km² the standard threshold for maintaining wolf populations. In 1995, Mladenoff et al. utilized GIS to analyze road densities within 14 wolf-pack territories in Wisconsin, finding highly suitable habitat with road densities less than 0.45 km/km² (mean 0.23 km/km²). Fuller et al. (1992) determined road densities less than 0.7 km/km² in wolf pack areas in Minnesota. Other researchers (Shelley and Anderson 1995; Harrison and Chapin 1998; Mladenoff and Sickley 1998; Mladenoff et al. 1999; Ratti et al. 1999; Corsi et al. 1999; Unger 1999; Frair 1999; Houts 1999; Kohn et al. 2000) incorporated road density in habitat studies and determined it the best predictor for suitable wolf habitat.

Mladenoff et al. (1999) tested road density within wolf habitats by defining six probability classes. In an area with road density values between 0.37 and 0.45 km/km² (50% probability class), the habitat has a 50-75% chance of supporting wolves. With this probability class index, Mladenoff and Sickley (1998) estimated 52,804 km² of potential habitat in western and eastern Maine and northern New Hampshire for eastern wolf recovery (Harrison and Chapin 1998).

Road density approximates human activity and the potential for human-caused mortality (Harrison and Chapin 1998; Mladenoff et al. 2009). Highest natural mortality for wolves occurred in habitats with road density values between 0.63 and 0.84 km/km² and highest human-induced mortality occurred in habitats with road densities between 0.84 and 1.14 km/km² (Wydeven at al. 2001). Some researchers combine road and human densities into the wolf habitat analysis. Wydeven et al. (2001) reported sustainable thresholds as road densities less than 0.7 km/km² and human densities less than 4 humans/km². In Wisconsin, human densities within wolf habitats averaged 1.52 humans/km² and within nonpack areas averaged 5.16 humans/km² (Harrison and Chapin 1998).

In mountainous terrain, Wydeven at al. (2001) suggested road density may not provide as useful an index because of "very patchy" ungulate distribution. Forested areas managed for wolves should maintain sustainable road densities (0.45km/km² at core wolf habitat and overall 0.6 km/km²) by closing logging roads after operations, avoiding increasing road density or changing traffic levels, and keeping land 100 m within den sites undeveloped (Wydeven at al. 2001). Wydeven at al. (2001) believed as human attitudes toward the wolf improve road densities may not factor as much into wolf habitat selection. Until then, researchers will continue to apply the "yardstick" measure of road densities to wolf habitat suitability studies.

2.3.2 Daniel Boone National Forest

Road analysis completed by the Daniel Boone Forest Office shows the Forest Development Road System consists of 2147.67 km of roads—717.768 km of arterial and

collector roads and 1429.10 km of local roads, 965.6 km of which the Forest Service maintains annually. Forest arterial roads serve as major access routes to and through large areas, and Forest Collector roads serve as connecting roads to smaller areas of land. Forest Local roads, generally of short length, dead-end at a terminating facility. Traffic on Forest Arterial and Forest Collector roads do not differ from types of traffic expected on public roads, whereas traffic on Forest Local roads is limited to specific users or activity. At present, however, traffic volumes need to be accessed and mapped.

DBNF has one inventoried roadless area within the 1,133 ha Wolfpen area adjacent to the 5044 ha Clifty Wilderness.

With 2.1 million proclamation acres, of which the National Forest Service (NFS) manages 27,479 ha, the DBNF (Fig. 2) in the Appalachian foothills in eastern Kentucky appears promising as a restoration site for red wolves.

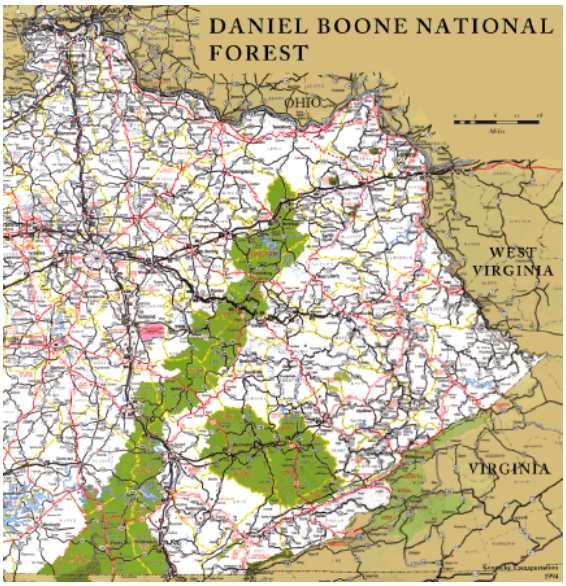


Figure 2: Map of the Daniel Boone National Forest
(courtesy of http://www.littlewolf.org/preserve/daniel-boone-national-forest/)

The loss of keystone species in combination with the loss of the dominant forest canopy species, the American chestnut (*Castanea dentata*), resulted in impoverished

biotic communities in Kentucky (Maehr, Grimes and Larkin1999). By 1850, people had extirpated red wolf, timber wolf, black bear (*Ursus americanus*), mountain lion (*Puma concolor*), bison (*Bison bison*) and elk (*Cervus elaphus*), all large mammals save the white-tailed deer, leaving Kentucky with the fewest large mammals than any other state in the southern Appalachians (Maehr, Grimes and Larkin 1999). Maehr, Grimes and Larkin (1999) viewed restoration of the large mammals to historic ranges as a conservation priority. Kentucky, through reintroduction of native species, especially large mammals and particularly large carnivores, may recover the integrity of its ecosystems.

After an absence of 150 years, elk returned to southeastern Kentucky in 1997 (Maehr, Grimes and Larkin 1999) and the initial herds have grown upwards to 7,500, the project's goal. Wildlife biologists selected the restoration zones based on the low human population and distance from row crops and major urban centers (Larkin et al. 2004) and the suitable habitat of forest, grasslands and shrublands for elk (Maehr, Grimes and Larkin 1999).

Larkin et al.(2004) provided a detailed description of the 14-county restoration zone for elk that covers 1.04 million ha of in the Cumberland Plateau. In eastern Kentucky, mountain-top coal removal has transformed the rugged topography of winding ridges, steep slopes and narrow valleys into "gently sloping grasslands." Herbaceous vegetation in the strip-mined reclamation areas includes Kentucky 31-tall fescue (*Festuca arundinacea*), bush clover (*Lespedeza* spp.), perennial ryegrass (*Lolium perenne*) and orchard grass (*Dactylis glomerata*), which supply 573 kg of forage with the capacity to support 0.28-.083 domestic calf-cow units/ha. Secondary and tertiary growth forests

represent a mixed-mesophytic forest, which occur on moist, well-drained sites. American beech (*Fagus grandifolia*), yellow-poplar (*Liriodendron tulipifera)*, basswood (*Tilia* spp.), sugar maple (*Acer saccharum*), northern red oak (*Quercus rubra*), white oak *(Quercus alba*), eastern hemlock *(Tsuga Canadensis*) and yellow buckeye *(Aesculus octandra)* exemplify several of the 30 overstory species contained within the restoration zone forests. On ridge tops, southwestern facing slopes and sites with shallow soils, Oak-Hickory (*Quercus-Carya*) and Oak-Pine (*Quercus-Pinus*) dominate. Common understory species include eastern redbud (*Cercis Canadensis*), flowering dogwood (*Cornus florida*), spicebush (*Lindera benzoin*) and pawpaw (*Asimina triloba*). The three release sites in the Cyprus-Amax Wildlife Management Area (Cyprus) in Perry County, the Orr mining property (Orr) in Harlan County and the Redbird Wildlife Management Area (Redbird) in Leslie County represent a landscape dominated by active and reclaimed-surface mines, the DBNF and private forests. Cyprus, a 7,400 ha coal mine, contains 1,000 ha of active mining, 2,000 ha of reclaimed grasslands and the remainder in deciduous forests. Closed to the public, Orr experiences little human activity except for mining of an active coal mine (3% of the property) and contains a mosaic of secondary and third growth forests (89%) and reclaimed grasslands (7%). Redbird comprises 9,200 ha of the DBNF with approximately 95% forest cover and less than 2.5 ha of open habitats and experiences the least impact from human activity and settlement of the two other release sites.

Situated in the eastern portion of the Cumberland Plateau, Redbird lies southeast of DBNF, the narrow 225.3 km strip of forest oriented north-south along the western edge of the Cumberland Plateau (Daniel Boone Forest Office). The Cumberland Plateau,

a tableland with relatively low relief, ranges in elevation from 200 m in the Ohio River floodplains to 1,200 m in the Black Mountains. Sandstone cliffs, bluffs, ridges, hills, natural bridges, waterfalls and winding narrow-valley streams "deeply" dissect the terrain, and the forest composition varies.

As topography varies, soil types vary. Soil scientists have classified 90 soils within the DBNF (USDA 2008); although, most of the soils are Udults, Ultisols characterized by strongly leached acidic soils with a uric moisture regime and by high forest productivity. The USDA generalizes the soil textures within the DBNF as deep, fine-loamy and fine-silty on alluvial terraces (4%), moderately deep to deep fine-silty and fine-clay on ridge tops and crests (23%), and moderately deep to deep fine-loamy, coarse-loamy and loamy-skeletal on gently sloping to steep sloping sites and on coves (73%). On shallow loamy-skeletal soils, tree growth averages 0.2832 m^3/ 0.4049 ha/ yr, whilst on deep well-drained soils found on flood plains, terraces, benches, toe slopes and coves, tree growth ranges up to 3.77 m^3/0.4049 ha/yr. Upland hardwood species such as white oak, chestnut oak, northern red oak, black oak, scarlet oak, hickory and pine constitute 49% of the DBNF (USDA 2008). Cove hardwoods (24%) such as northern red oak, white oak, basswood, yellow poplar, hemlock, sugar maple, beech and occasional black walnut and black cherry, pine (15%) and mixed hardwood-pine (12%) constitute the remainder of the mixed mesophytic forest (USDA 2008). In addition to the woody understory described in the elk restoration zones, rhododendron or fern-ephemerals occupy moist sites and mountain laurel or blueberry-huckleberry occupies dry sites within the DBNF (USDA 2008).

According to the 30-year climate record, the humid-temperate DBNF region has an average annual temperature of 13ºC (mean winter temperature of 4ºC and mean summer temperature of 24ºC) with evenly distributed precipitation throughout the year averaging 117 cm annually (mean annual snowfall of 51 cm) (Larkin et al. 2004). Evaporation from ponds and lakes averages about 88.9 cm, 27.9 cm less than the annual precipitation (USDA 2008). The DBNF contains four Army Corp of Engineer reservoirs, Cave Run Lake, Buckhorn Lake, Lake Cumberland and Laurel River Lake, with 258 km² of water at normal pool level and 347 km² at maximum pool level (Daniel Boone Forest Office 2003). Intense rainfall activates the flows of many small ephemeral streams and cause flooding in areas with shallow soils and steep slopes (Daniel Boone Forest Office 2003). With 1931.2 km of branches and streams (USDA 2008), a dendritic drainage pattern forms from the combination of flat-topped ridges and rolling hills, and the DBNF crosses the drainage basins of three large rivers, the Cumberland River, Kentucky River, and Licking Rivers (Daniel Boone Forest Office 2003).

Brine disposal from oil and gas drilling and acid mind discharges reduce water quality in the streams (Daniel Boone Forest Office 2003). Riparian ecosystems provide quality aquatic and terrestrial habitats for a myriad of species, flood control, removal of sediments from surface run-off, ground water recharge, retardation of erosion, nutrient cycling and other vegetation, soil and hydrologic functions. In the DBNF, the Forest Service in cooperation with other agencies have established restoration projects and improved maintenance within the watershed to protect the riparian zones and water quality (USDA 2008).

Boating, fishing and water sports attract visitors to the lakes, rivers and streams. On an annual basis, 5 million tourists visit the DBNF for the scenery and the recreational activities such as boating, fishing, water sports, hunting, hiking, camping, rockclimbing and wildlife viewing (USDA 2008). The DBNF provides habitat for 23 endangered and threatened species and manages 5 wildlife areas: the 3739.7 ha pioneer Weapons Wildlife Management Area, the 5486.7 ha Mill Creek Wildlife Management Area, the 7020.1 ha Beaver Creek Wildlife Management Area, the 2700.1 ha Crane Creek Wildlife Management Area, and the 10331.2 ha Redbird Wildlife Management Area (USDA 2008).

van Manen et al. (2000) created prediction models for red wolf release successes in historic ranges in the southeastern United States. Three categories of independent variables potentially related to red wolf success included the biological condition of the release sites, the human influences on the release sites and the characteristics of the release. Red wolf population size, coyote density and large and medium prey densities accounted for the biological conditions, while human, road and livestock densities as well as the amount of agricultural land characterized the human influences of the release sites. For the third variable, the characteristics of the release, the researchers considered the age and sex of the red wolf, its previous environment, time in captivity, period of acclimation, group size and release season. In general, they found negative correlations between road, coyote and human densities and longer captive and acclimations periods with red wolf success. Survival improved with low human density, large prey density and by using wild-reared wolves and shorter acclimation periods. For the eastern Kentucky-northern Tennessee region, the composite index of red wolf release success resulted in 0.667

(values greater than 0.8 indicated high success potential). If these models prove reliable, the release of red wolves in the DBNF (unknown whether included in or adjacent to study region) has the potential for greater than average success.

2.4 Methodological Approaches

2.4.1 Logistic Regression for Wolf Restoration

In order to predict the probability of wolf release success, van Manen et al. (2000) used a logistic regression model. Simply stated, logistic regression statistically analyzes the probability of an occurrence of an event, generally explaining the outcome of predictor variables (risk factors, for example) and a dichotomous dependent variable (success/failure or absence/presence).

Mladenoff et al. (1995) developed the logistic regression model for potential wolf habitat in the Northern Great Lakes region. The researchers applied five spatial landscape-scale variables: human population density, prey (deer) density, road density, land cover, and land ownership. Because of the intercorrelation of the variables associated with human land-use, Mladenoff et al. (1995) disregarded all but the road density variable. An additional variable, the fractal dimension, improved the logistic model's performance. The fractal dimension, denoted as *D,* represents an index of land cover patch boundary complexity, basically a rough or fragmented geometric shape. In the study, wolves inhabited simpler patch shapes than those within the nonpack areas, indicative perhaps of the wolf's preference for habitats with less fragmentation.. Radio-collared wolves provided information about movement through the landscape and enabled the researchers to verify habitat locations and types. In the Great Lakes region,

pack areas had greater proportions of mixed conifer-hardwood, forested wetlands and public lands and lower proportions of agricultural land, deciduous forests and large lakes. Mladenoff et al. (1995) incorporated the favorable habitat into the logistic model to predict and map wolf distribution into new territory using GIS and derived two model equations:

1. $\text{logit}(p) = -6.5988 + 14.6189R$

where road density is calculated by dividing the road length within an area by the cell area.

2. $\text{logit}(p) = -49.550 + 19.854R + 26.861D$

where p represents the probability of wolf occurrence, R the road density, D the fractal dimension index.

Researchers have since applied this approach for wolf-habitat predictions (Mladenoff et al. 1995; Mladenoff and Sickley 1998; Mladenoff, Sickley and Wydeven 1999; Brito, Crespo and Paulo 1999; Ratti et al. 1999; Glenz et al. 2001; Houts 2003; Keating and Cherry 2004).

While popular, the logistic regression for habitat modeling carries the risk of misapplication based on inadequate understanding concerning the model, its interpretations, and sampling design (Keating and Cherry 2004). Brito, Crespo and Paulo (1999) compared logistic regression to overlap analysis and determined logistic regression more "elucidative and precise," however, presence/absence data (generally based on telemetry data) present accuracy problems. Researchers may misinterpret non-use as unsuitable habitat for a particular species, whose actual presence may go undetected by deficient sampling techniques. Ratti et al. (1999) noted other limitations to

the logistic model. The model's small sample of wolf packs makes "comparisons to other areas and wolf packs tenuous." With wolf density below carrying capacity, recolonizing wolves select optimal habitats, whereby less-optimal but suitable habitat remains unoccupied and available. In addition, the relative homogeneity of the land cover types and ungulate density of the study area may render the model inappropriate for diverse areas. Moreover, logistic regression predictive models have failed to predict wolf re-colonization in Wisconsin "apparently because it failed to consider the adaptability of wolves" (Mech 2006).

Mladenoff et al. (2009) revisited their logistic model predictions for the Great Lakes region and found wolves, in reality, had begun to occupy the lowest quality habitats but at very low rates. In an attempt to better describe wolf occupancy, Mladenoff et al. (2009) created a new model, which incorporated landscape composition. They found that the presence of wolf negatively correlated with road density and agricultural lands and positively correlated with mixed forests. By introducing agricultural land use, the performance of the logistic regression model increased. This model is expressed as

$$\text{Logit}(p) = 5.0018 - 11.7095A - 2.5655R,$$

where p represents the probability of wolf presence, A the percentage of agricultural lands and R the road density (km/km²). In summary, Mladenoff et al. (2009) concluded their original 1995 model is "the best conservative indicator of preferred, most-critical habitat" and the new model should be seen as "more descriptive of wolf occupancy, and more dependent on complex population dynamics, than [the] simpler 1995 model."

Chapter Three

Methodology

3.1 Study Area

With 849, 841.3 proclamation hectares, of which the National Forest Service (NFS) manages 282, 310 ha, the DBNF (Fig.3) in the Appalachian foothills in eastern Kentucky appears promising as a restoration site for red wolves.



Figure 3: Map of the Daniel Boone National Forest
(courtesy of http://gorp.away.com/gorp/resource/us_national_forest/ky/map_db.htm)

Abundant prey, mainly contiguous mixed-mesophytic forest and successful elk reintroduction factored into site selection within historic red wolf range. The DBNF remains one of the few national forests remaining in the southeast region of the United States with sufficient wildlands area for wolf occupation (Fig. 4). Other sizable national forests in the southeastern region that warrant habitat analysis include the Ozark National

Forest in Arkansas, Shenandoah National Park in Virginia, and Nantahala National Forest in North Carolina, which lies south of the Great Smoky Mountains National Park where red wolf reintroduction failed. However, this analysis settled on the DBNF for its nearby location to the University of Cincinnati.

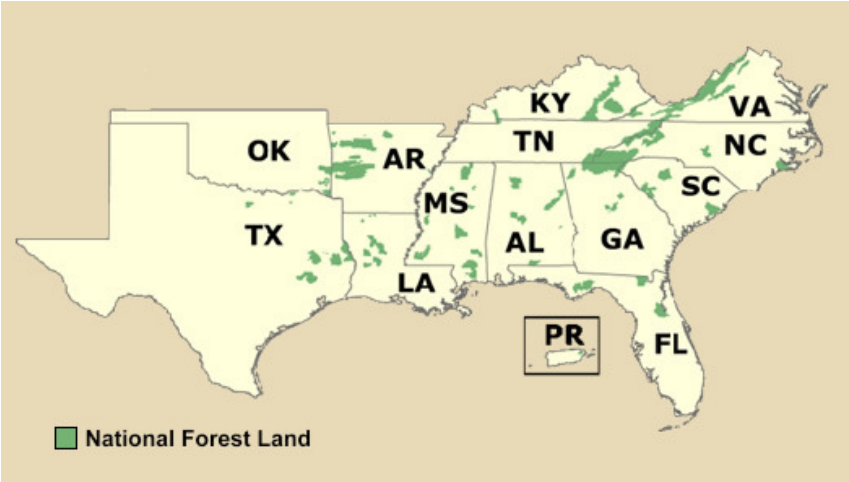


Figure 4: National Forest Land of the Southeast United States.
Map courtesy of the USDA Forest Service. (http://www.fs.fed.us/r8/sitemap.php)

White-tailed deer populations within the state number well over a million, and a gross estimated deer density, extrapolated from DBNF deer harvest data (Ratti et al. 1999), of 10 deer/km² exists within the DBNF. Requiring a minimum of 5 deer/km² (Shaffer 2007), red wolf populations would not be limited by prey density. The estimate, while regarded with caution, may underestimate the deer population and density. Hunting in Kentucky is regulated by zones, and, in the DBNF counties and state park, zone 3 and zone 4 regulations apply and place more restrictions on the amount of deer harvest.

Overpopulation, rather, has increased susceptibility to disease. In 2007, the lethal epizootic hemorrhagic disease, or "bluetongue," affected the deer in Kentucky, which the

USFWS called the "worst outbreak in 30 years" (USFWS report 2007). The USFWS cautioned hunters from consuming meat from emaciated or weak deer in case of secondary infections. The restoration of the red wolf may mitigate disease within the deer populations by reducing the number of deer more effectively than managed culling. With a reduction in deer population, the incidences of car-deer collisions (Fig. 5) and crop-ornamental garden damage may decrease as an additional benefit.

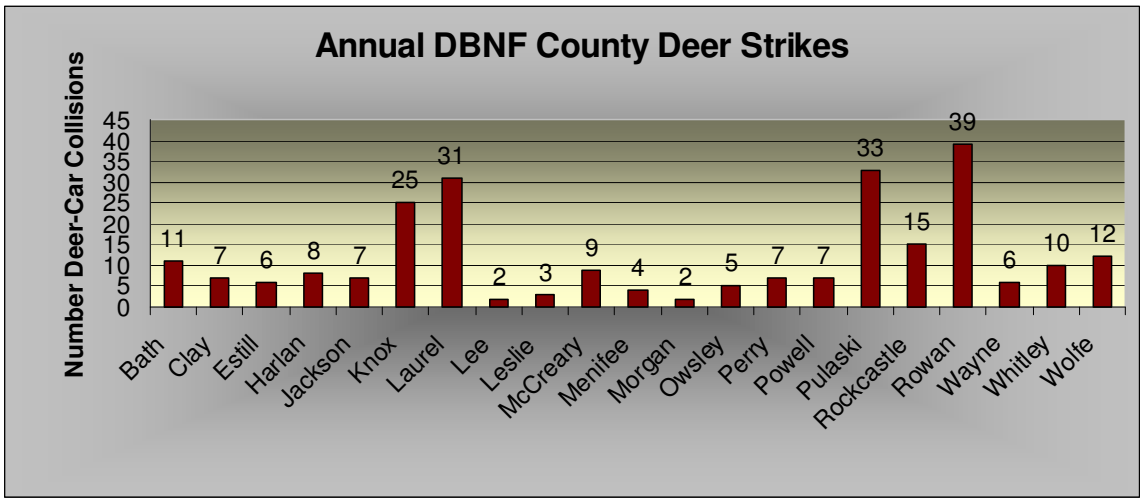


Figure 5: Annual Daniel Boone National Forest County Deer Strikes
Data source: http://www.kentuckystatepolice.ky.gov/deerauto.htm
Kentucky State Police

The 21 Kentucky counties containing portions of the DBNF include Bath, Clay, Estill, Harlan, Jackson, Knox, Laurel, Lee, Leslie, McCreary, Menifee, Morgan, Owsley, Perry, Powell, Pulaski, Rockcastle, Rowan, Wayne, Whitley and Wolfe (Fig. 6). Table 1 synthesizes the county information.

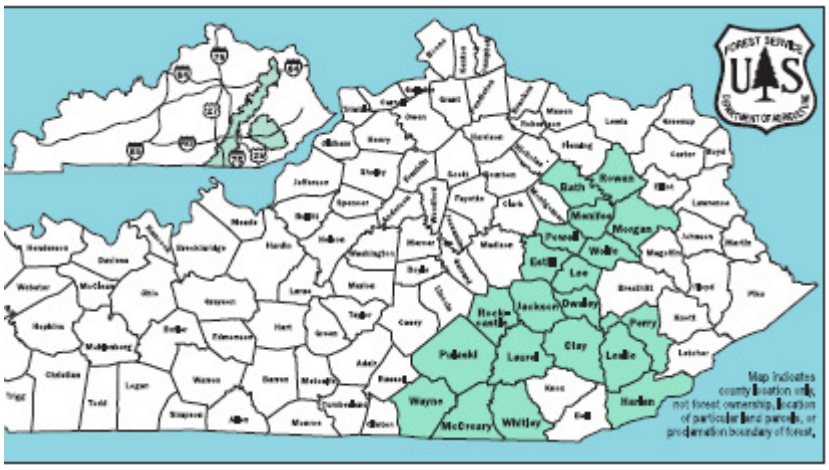


Figure 6: Daniel Boone National Forest County Map
(courtesy of **http://www.fs.fed.us/r8/boone/aboutus/map.shtml**)

County	Population	Size (acres)	Pop. Density (per km²)	2008 Deer Harvest	Forest Acres	% Total Acreage	2007 Farms (acres)	2008 Head of Cattle	Market % Livestock
Bath	11,750	178,854	16	522	19,300	10.8	129,057	24,700	58
Clay	23,930	301,440	20	585	77,946	25.9	51,194	3,000	43
Estill	14,948	162,560	23	586	5598	3.4	64,780	8,000	73
Harlan	30,783	298,880	25	347	803	0.3	3,034	155	45
Jackson	13,645	221,440	15	445	58,601	26.5	82,614	10,500	69
Knox	17,385	248,320	17	845	74	0.03	51,115	3,900	74
Laurel	57,586	279,040	51	846	64,255	23.0	102,489	22,000	68
Lee	7,414	134,400	14	484	8587	6.4	29,419	2,100	50
Leslie	11,639	258,560	11	282	52,142	20.2	5,642	0	0
McCreary	17,315	273,920	16	441	142,669	52.1	15,056	2,100	83
Menifee	6,744	130,560	13	415	46,857	35.9	43,110	3,800	65
Morgan	14,156	243,840	14	1104	13,089	5.4	136,303	12,225	53
Owsley	4,634	126,720	9	206	16,570	13.1	35,857	1,300	31
Perry	29,241	218,880	33	340	2151	0.98	10,661	980	94
Powell	13,859	115,200	30	445	15,972	13.9	32,763	2,400	35
Pulaski	60,851	423,680	35	986	38,381	9.1	231,781	65,000	74
Rockcastle	16,788	203,520	20	350	16,677	8.2	90,435	18,500	70
Rowan	22,733	179,840	31	695	62,648	34.8	49,963	5,400	62
Wayne	20,696	293,760	17	630	1174	0.4	142,827	26,00	91
Whitley	38,668	281,600	34	880	46,517	16.5	73,414	10,554	71
Wolfe	6,989	142,720	12	353	16,615	11.6	57,701	3,100	67

Table 1: Daniel Boone National Forest County Demographics

Data sources:

US Census Bureau http://quickfacts.census.gov/qfd/states/21000.html

Kentucky State Data Center http://ksdc.louisville.edu/kpr/popest/est.htm

USDA http://www.nass.usda.gov/QuickStats/PullData_US_CNTY.jsp

http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_2_County_Level/Kentucky/st21_2_008_008.pdf

NFS http://www.fs.fed.us/land/staff/lar/2008/TABLE_6.htm

3.2 Data

Bill Luhn, the GIS Coordinator for the DBNF, supplied the vector road and land classification data for the spatial analysis in GIS. The road layer was originally projected to North America 1983 Geographic Coordinate System (GCS). In order to make

coordinates compatible with the land classification layer, the road layer was transformed to NAD 1983 State Plane Kentucky FIPS 1600 feet coordinate system. Maps are displayed in Lambert conformal conic projections.

Deer harvest data were obtained from the Kentucky Department of Fish and Wildlife. Daniel Boone National Forest statistics were obtained from the National Forest Service, and county statistics were obtained from the United States Census Bureau, Kentucky State Data Center, and the United States Department of Agriculture. Landsat 7-TM remote sensing imagery of the DBNF was downloaded from the United States Geological Survey (USGS).

3.3 GIS Analysis

3.3.1 Use of GIS in Habitat Selection

The role of GIS in conservation biology and ecological modeling has expanded and enhanced conservation efforts for endangered species (Bishop et al. 2002, Akçakaya 1994). Bishop et al. (2002) listed several applications of conservation GIS: habitat conservation planning, land use management, environmental impact assessment, mapping of the spread of invasive species, species richness, or diversity, prediction of species distribution, and habitat selection for the reintroduction of rare species.

As noted by Bishop et al. (2002), GIS is a useful tool in habitat selection. It involves the combination of digital spatial map layers with abiotic and biotic data for habitat criteria. Habitat analysis considers many factors, such as habitat use and habitat availability, the location where species spend most of their time, the selection of required resources, and the amount of energy animals expend foraging or hunting. For instance,

modeling fish habitat requires hydraulic modeling with data on the stream flow conditions and biological sampling statistics on the conditions in which fish live (Merwade et al. 2004). For larger animals such as wolves, radio-collars and GPS monitoring can be used to track not only the geographic extent of distribution but also the frequency and intensity of habitat use. These data can then be incorporated into GIS for further analyses.

Wydeven et al. (2006) stated "Wolves lend themselves well to examining of their habitat selection using GIS. Wolf packs occupy fairly discrete areas that are maintained as territories, and represent the breeding potential of a wolf population." With clear boundaries and specific home range sizes, wolf territories can be transformed into distinct polygon vectors to determine areas. With the assumption that a larger area can support a larger wolf population and a higher breeding potential, GIS analysts will be able to calculate the carrying capacity for wolves and population growth.

Habitat selection studies often require many biophysical data, such as vegetation cover. With GIS, biologists may collect these empirical data more efficiently (Akçakaya 1994). Traditional vegetation mapping with aerial photographs interpretation accrues high costs in labor and time. However, with the integration of ecological, statistical and data models into GIS, vegetation mapping can be more accurate and realistic, and it can be acquired with reduced costs (Accad and Neil 2006). Whether studies focus on distribution patterns, densities or predictions, spatial statistics in GIS facilitate data collection and quantitative analyses.

3.3.2 GIS Models and Software for Habitat Selection

As GIS in conservation science becomes more prominent, computer engineers have designed software and extension tools specifically for ecological modeling. Akçakaya (1994) analyzed population viability and produced metapopulation models in GIS using RAMAS, a software package, which integrates "landscape data on habitat requirements with demographic data to analyze risks of extinction, evaluate management options, and assess human impact on wildlife populations." ESRI also provides several extension tools (such as XTools for ArcGIS) and GIS-linked software (such as Hawth's Analysis Tools, Patch Analyst 4.0, EcoSim, EM4), which are available for download.

In this research, traditional spatial analyst tools were chosen to identify suitable habitats for red wolf reintroduction because wolves are habitat generalists. The finer-scaled patch analysis is not necessary. With no wolves present in the DBNF, this research also lacked the data to predict animal distributions and population growth with the more sophisticated tools.

3.3.3 Kernel Density Estimation in Habitat Selection

In previous wolf habitat GIS analyses, road density served as proxy for human activities. It is used as a delimiting factor for wolves as high road densities equate to higher mortality risks. In North Carolina, vehicular and gunshot incidents account for more than half of the red wolf deaths. Road density is therefore an important predictor for suitable wolf habitat.

In this research, the vector road data included all roads, paved and unpaved, public and private, within the DBNF. In total, 3691 line segments existed, representing the highway, arterial, collector, and local roads. They were classified by road type:

undefined highway, free flowing mixed traffic, congested during heavy traffic, flow interrupted/limited use and slow flow or blocked. The latter two types of roads consisted of forestry, fire service and closed secondary roads and were removed from the analysis due to their assumed negligible risk to wolves. Roads extending beyond the forest boundary were clipped.

Earlier models, such as those by Mladenoff et al. (1995) and Shaffer (2007), only considered simple road density. Simple density is calculated by adding the lines that fall within an area and dividing the sum by the area size. Many of these models neglect to weight the risk factor associated with different road types. To enhance the performance of these models, this analysis attempted to capture the weighted risks by adopting the more sophisticated kernel density estimation. In this estimation, the road density was calculated as a weighted function based on the assumption that asphalt highways posed the greatest threat to wolf mortality and local gravel roads the least. A new field of "Rank" was added to the road layer's attribute table according to traffic volume and associated risk to wolves. Kernel density calculations then summed all the values of the kernel surfaces—the smoothed curved radius around a line, with density greatest on the line and diminishing outward—and produced smoother results than the simple density function. In GIS spatial analyst, the kernel density estimation is calculated with the Epanechnikov *K* estimator, an optimal smoothing function determined by $K(t) = \frac{3}{4}(1-t^2)$, where $|t| = d/h \leq 1$ (d = the distance between the cell and the line in the dataset). Kernel density estimations, unlike other interpolation techniques, such as kriging-cokriging, trend surface, and regressions, aim to produce *smooth* commutative density functions

(Amatulli et al. 2007), producing the "hot spots." This weighted function may produce a more realistic picture of road density within a space.

Worton (1989) used kernel density estimates for home-range studies. He described the kernel process as a probability density function (*k*) placed over a data point or line, and the addition of *n* components constructs the estimator. The kernel represents a density. Therefore, the estimation reflects a "true probability density function." The smoothing parameter controls the variation in each component, with direct correlation existing between size of the bandwidth *h* and the scope and scale of detail in the data observations. The probability function is expressed as

$$\widehat{f}_h(x) = \frac{1}{Nh} \sum_{i=1}^{N} K\left(\frac{x - x_i}{h}\right)$$

where *K* represents the kernel and *h* represents the bandwidth. The bandwidth defines the radius of the circle of each grid cell, and, in GIS, the default bandwidth measure is based on the geographic extent of the point or line patterns. While the selection of the bandwidth is important, the process of selection is more art than science.

With their smoothing parameters (*h*) and more efficient use of locational data, kernel density estimators outperform histograms. In fixed kernel methods, the smoothing parameters are *fixed* values. Adaptive kernel methods allow the smoothing parameter to vary, such that low concentration areas have higher *h* values than areas with high concentration of points as such they help to produce a smoother estimate. Using two data sets, Worton (1989) illustrated the application of the kernel density estimation for home-range analyses and compared the results between a least-squares cross-validation and an ad hoc approach for selecting *h* values. Worton defined the ad hoc method of choosing the value of *h* as the use of "the optimum *h* value obtained for some standard distribution,

such as the normal distribution." The least-squares cross-validation demonstrated greater clarity in the "utilization distribution" (UD) density than the ad hoc approach, which over-smoothed the estimate. The accuracy of the UD estimator, therefore, depends on the value of *h.* However, he iterated that the ad hoc fixed kernel density estimation, if accuracy does not matter as much, provided all the pertinent details to UD density, such as the location of the modes. Worton (1989) also reported that kernel density estimators successfully explained an animal's movement within home-range territories.

Seaman and Powell (1996) evaluated the accuracy of kernel density estimation for home-range analysis and found fixed kernel performed better than the adaptive kernel. In general, the density estimate will be high in areas with many observations and, conversely, low in areas with few observations (Seaman and Powell 1996).

Though viewed as the "most reliable contouring method in ecology" (Hemson et al. 2005), kernel density estimation has only been applied to home-range analysis, animal movements and resource use, and measurements of overlap areas of species distribution, and other properties of the location such as soil, temperature and photosynthetic rate (Seaman and Powell 2005) but not road density. Road analysis with kernel density estimation has been limited to networks in the urban environment, such as traffic monitoring, accidents, and bus stops. This research aims to demonstrate the effectiveness of the kernel density estimation for predicting habitat suitability based on the weighted road density risk-factor.

3.3.4 Kernel Density Output

As a general cartographic rule, maps for presentation purposes have 4 to 6 classes; therefore, the kernel density output values for road density were reclassified from 9 to 5 classes, which generated a better spatial pattern. Natural breaks classification was used rather than GIS's equal interval default because natural breaks bases itself on the frequency in the data and breaks the values into natural or intuitive classes. While this does not reflect wolf suitability, it allows the analyst to understand the intensity and frequency of road density calculated by the kernel density estimation, especially in comparison to the simple density method.

In order to set the range of wolf suitability according to previous studies (Mladenoff et al. 1995; Mladenoff et al. 1997; Wydeven 2001; Paquet et al. 2001), wolf suitability was then rated as highly suitable for core areas where den sites would occur (road densities less than 0.23 km/km^2), high (0.23-0.45 km/km^2), medium (0.45-0.6 km/km^2), low (0.6-0.84 km/km^2), and unsuitable (more than 0.84 km/km^2).

3.3.5 Criterion for Selecting Potential Sites

With a low probability of wolf persistence in areas with road density greater than 0.68 km/km^2 or 0.7 km/km^2 (Thiel 1985; Fuller et al. 1992; Wydeven et al. 2001), this threshold was used in the raster calculation as one of the main variables in the final wolf habitat suitability model. The second variable followed Mladenoff et al.'s (2009) adjustment of the original logistic regression model to exclude agricultural lands.

Color values were assigned for the land cover classification data to illustrate a more natural composite: green colors for forest, blues for water and wetlands, reds for human development and yellow-oranges for agriculture. The layer was then reclassified

according to wolf suitability. Areas with crop and pasture were reclassified as null for unsuitability, and the remaining classes were reclassified as positive for suitability. Human development need not have been reclassified for unsuitability as it was already factored into the road density calculations and thresholds.

With the use of the raster calculator, areas with low road density and forested, non-agricultural landscapes were determined and merged. The red wolf habitat suitability was then converted from raster to vector in order to highlight habitat patches with a minimum area of 50km² and potential restoration sites.

3.3.6 Assessment of Methodology

In general, non-parametric estimations of density distribution such as the kernel density estimation perform more robustly than parametric estimations, especially if the probability density function does not follow a normal distribution curve. Non-parametric estimations rely on fewer assumptions, which may result in fewer misinterpretations. Since this research ranks the roads by mortality risk, the use of the non-parametric kernel density estimation is more appropriate.

However, to assess the kernel methods, road density was recalculated with the simple density function. Three red wolf habitat suitability models were created. The first model based the simple road density off the shape lengths. Logarithmic and exponential transformations were then applied to the road lengths to normalize the skewness in the density probability and to generate "goodness-of-fit" models because non-parametric density estimations may perform "poorly" if the densities are too far from the Gaussian shape (Wand, Marron and Ruppert 1991). Instead of logistic regression and less rigorous

statistical assumptions, Corsi, Dupré and Boitani (1999) used the logarithmic transformation to normalize the density data on dump sites and ungulate species to obtain similar results.

An evaluation of the influence of the weighted roads within the model was determined by using the simple density function with the weighing factor and by using the kernel density estimation without the weighing factor. Outputs were compared to the weighted kernel density estimation model.

3.3.7 Field Verification

To ascertain the effectiveness and viability of the model and methodology, further investigation was conducted on a few selected potential restoration sites generated from the kernel density estimation. Field work, which involved personal observation, was used to verify whether the sites are actually suitable for reintroduction. Besides proximity to streams and roads were measured in GIS, slope analysis was performed on these sites using the Digital Elevation Model (DEM) layer of the DBNF. Since the literature indicated two different gradient thresholds (20º and 40º), the resultant values were reclassified into three ranges: 0-19.9, 19.900000001- 39.9, and > 39.900000001. Moreover, vegetation cover, serving as a surrogate for prey availability, was determined by first running a Tasseled Cap Transformation of a Landsat 7 image of the DBNF. The Tasseled Cap Transformation optimizes data viewing of vegetation by weighting the reflectance of the pixels to produce a composite index of brightness, greenness, and wetness. In GIS, the habitat patch layers were overlain with the Tasseled Cap

Transformed image, and the extent of greenness was measured. Deer density was then estimated using the equation

$$\text{Deer/km}^2 = 2.2789 + 0.0533 \text{ x greenness}$$

where greenness represented the vegetation cover (Carroll et al. 2001).

While efficient, modeling habitat selection in GIS is to be used as a guide and not meant as a replacement for fieldwork. GIS data might not portray the heterogeneity, richness, or quality of the environments that impact the fitness and survival of a species, and only through site verification can a more accurate assessment be made.

Chapter Four

Results

The amount and distribution of favorable red wolf habitat was mapped in a stepwise fashion.

4.1. Road Density

The spatial distribution of road density (Fig.7) shows the highest densities are associated with Interstate 75, major state byways, the Red River Gorge geological area, and the large lake recreation areas in the north (Cave Run Lake) and south (Cumberland Lake). Wolf habitat ranges from optimal to unsuitable (Fig.8) with the suitable wolf habitat patches with road densities less than 0.7 km/km² (Fig.9).

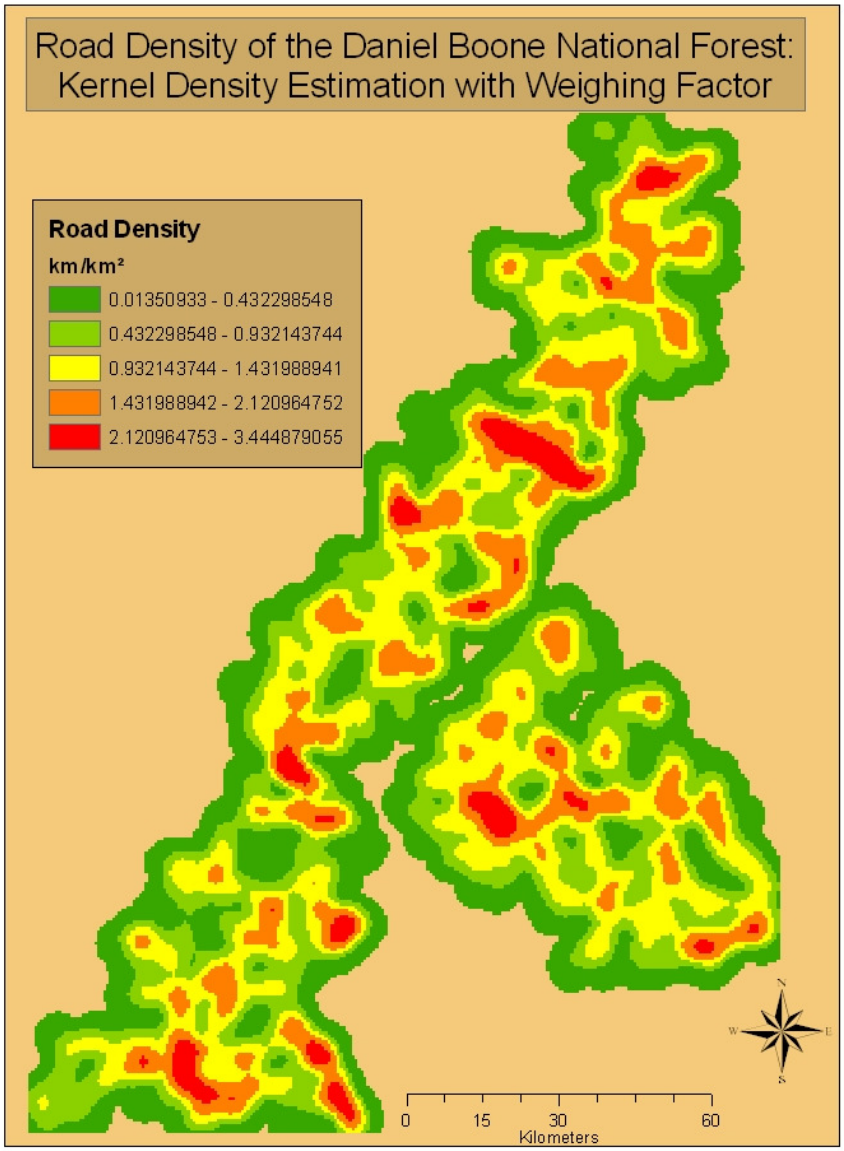


Figure 7: DBNF Road Density: Kernel Density Estimation with Weighing Factor. Road density as the predictor model in GIS. Dark green represents low road density areas and suitable wolf habitat.

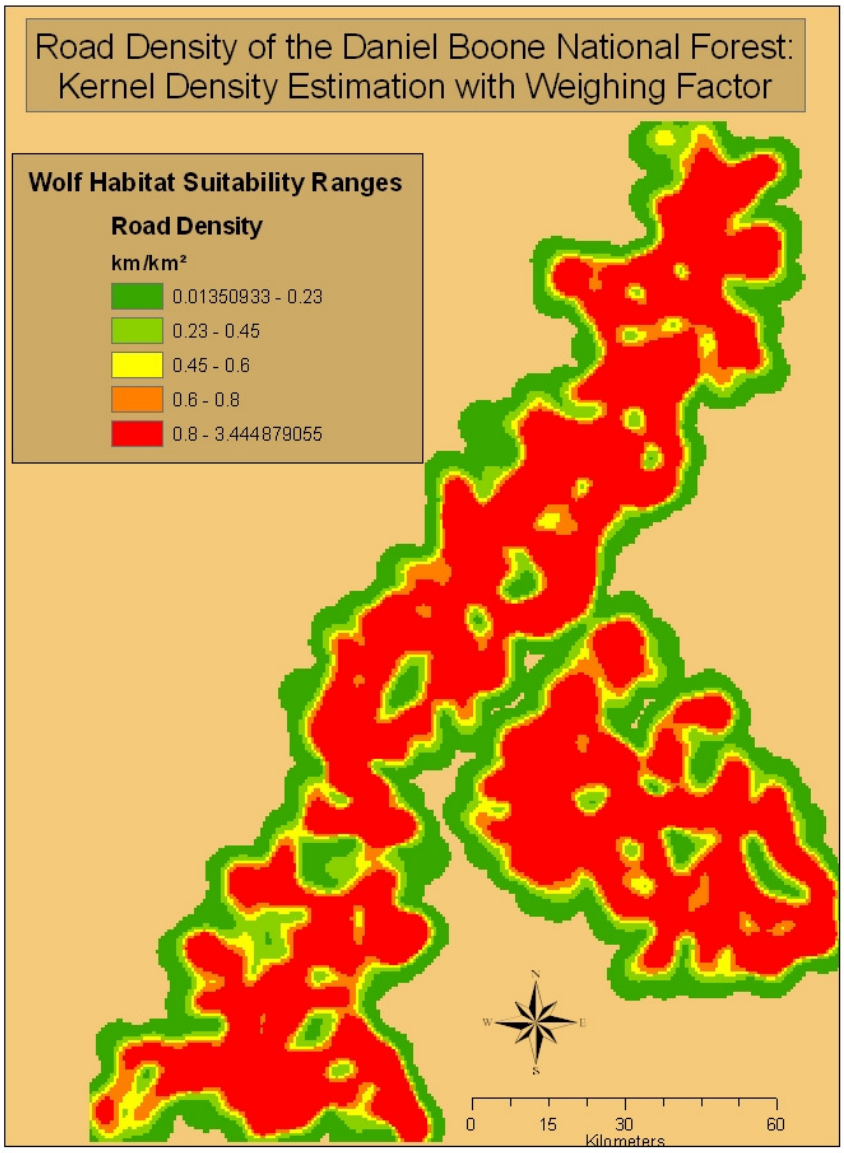


Figure 8: DBNF Road Density: Red Wolf Habitat Suitability Ranges
The wolf habitat suitability ranges indicate optimal core habitat in darker green, good habitat in bright green, fair habitat in yellow, poor habitat in orange and unsuitable habitat in red.

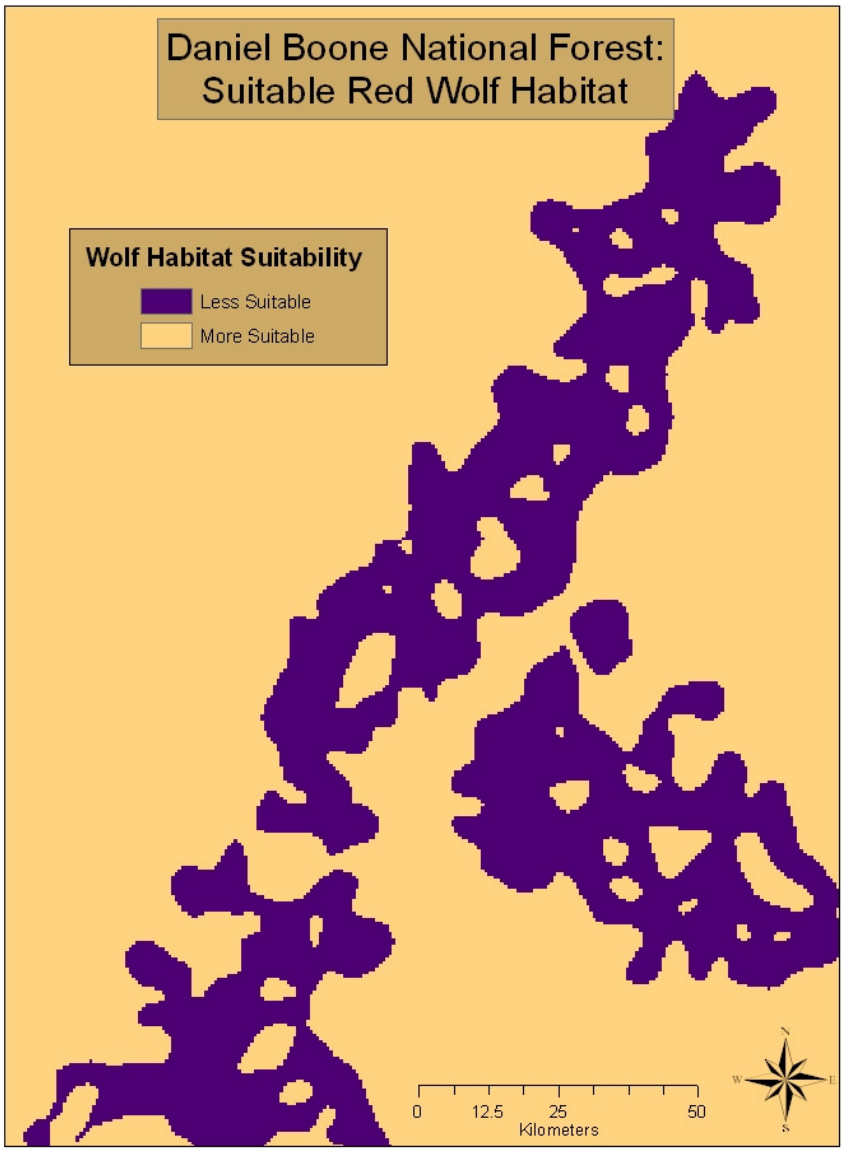


Figure 9: Road Density of the DBNF: Red Wolf Habitat Suitability
Map results of raster calculation for more suitable and less suitable habitat based on road density. Potential "optimal" patches have road densities between 0 and 0.7 km/km².

4.2 Forest Composition and Land Cover

Forest dominates the landscape composition of the DBNF (Fig.10). Within the forest, the extent of pasture and crop land (Fig.11) appears more concentrated along the

southeastern edge of Stearns District, the Morehead District and the western and northwestern region of the Red Bird District.

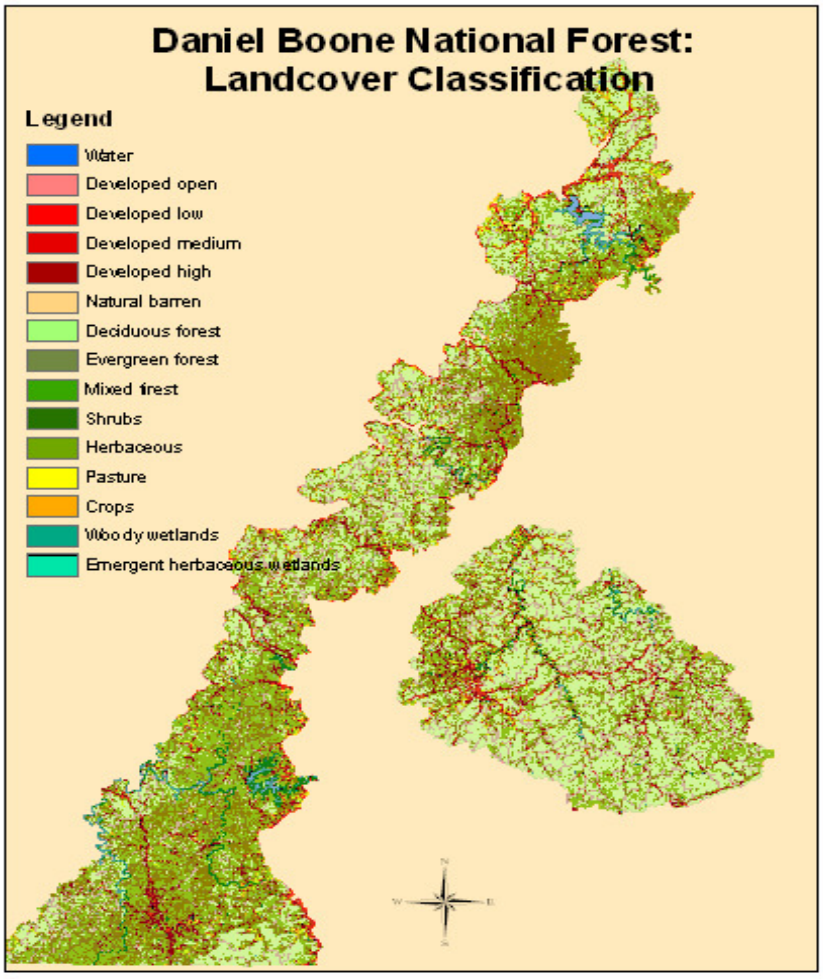


Figure 10: Daniel Boone National Forest: Landcover and Landuse Classification. Map shows natural color composite of the different landcover classes.

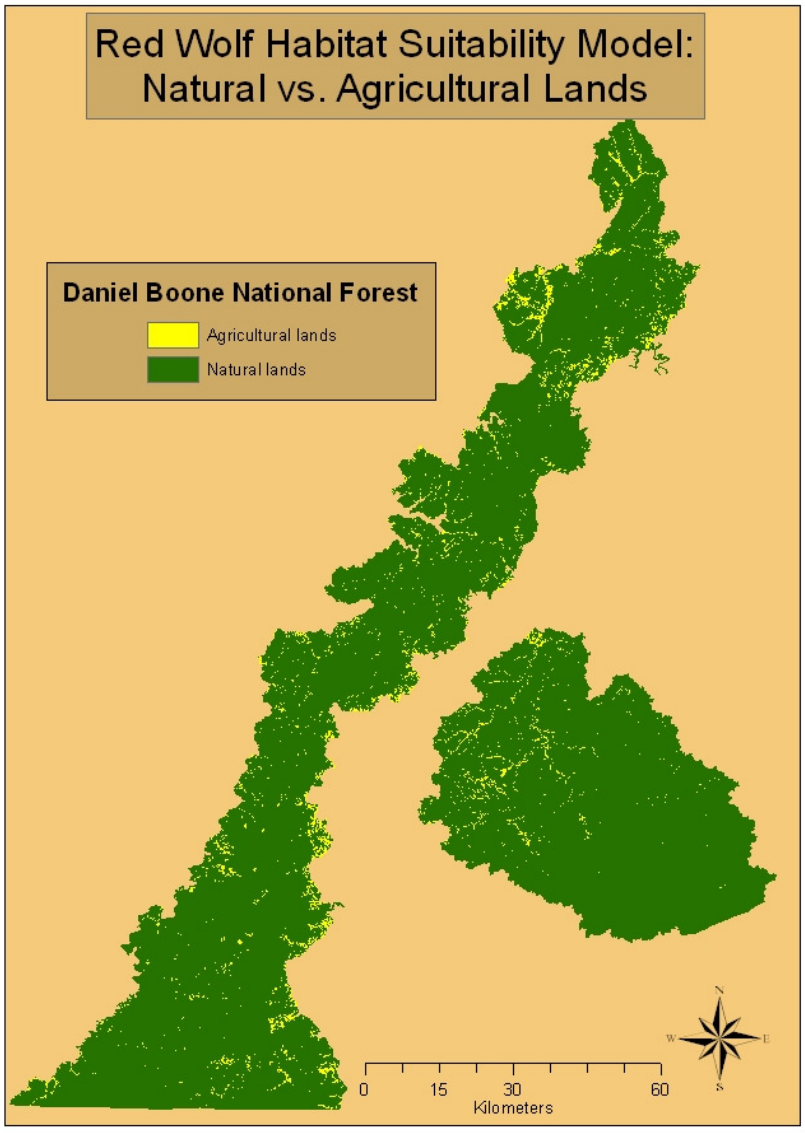


Figure 11: Red Wolf Habitat Suitability Model: Natural vs. Agricultural Lands. Results of raster calculation for the landcover/landuse classification.

4.3 Red Wolf Habitat Suitability Model: Kernel Density Estimation Methodology

The red wolf habitat suitability model based on road ranks and kernel density estimation (Fig.12) reflects patches with low road density and mainly natural landscapes,

while the map of potential restoration sites (Fig. 13) includes an additional requirement for suitability and delineates patches with areas greater than 50 km². As a result, this study identified nine patches as potential sites for red wolf reintroduction.

Differences between the kernel density estimation of road densities with and without the ranking system appear evident (Fig. 14). With higher density probabilities in areas where road type would have carried a lower mortality risk in the weighted kernel methods, the suitability model without the ranking system (Fig. 15) predicted very few, smaller habitat patches and only one potential restoration site for the red wolf.

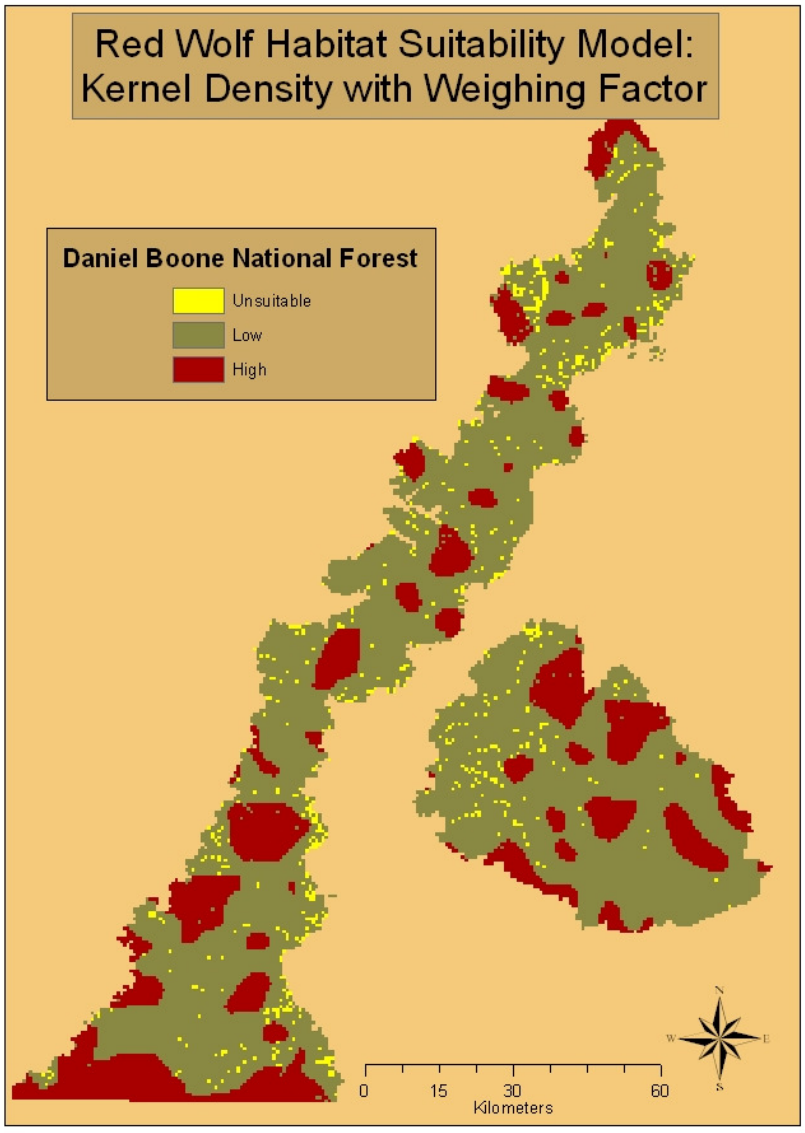


Figure 12: Red Wolf Habitat Suitability Model: Kernel Density with Weighing Factor. Road density based on road ranks and kernel density estimation and landcover rasters merged. Red designates potential habitat suitable for red wolves: areas of low road density and mainly natural landscapes.

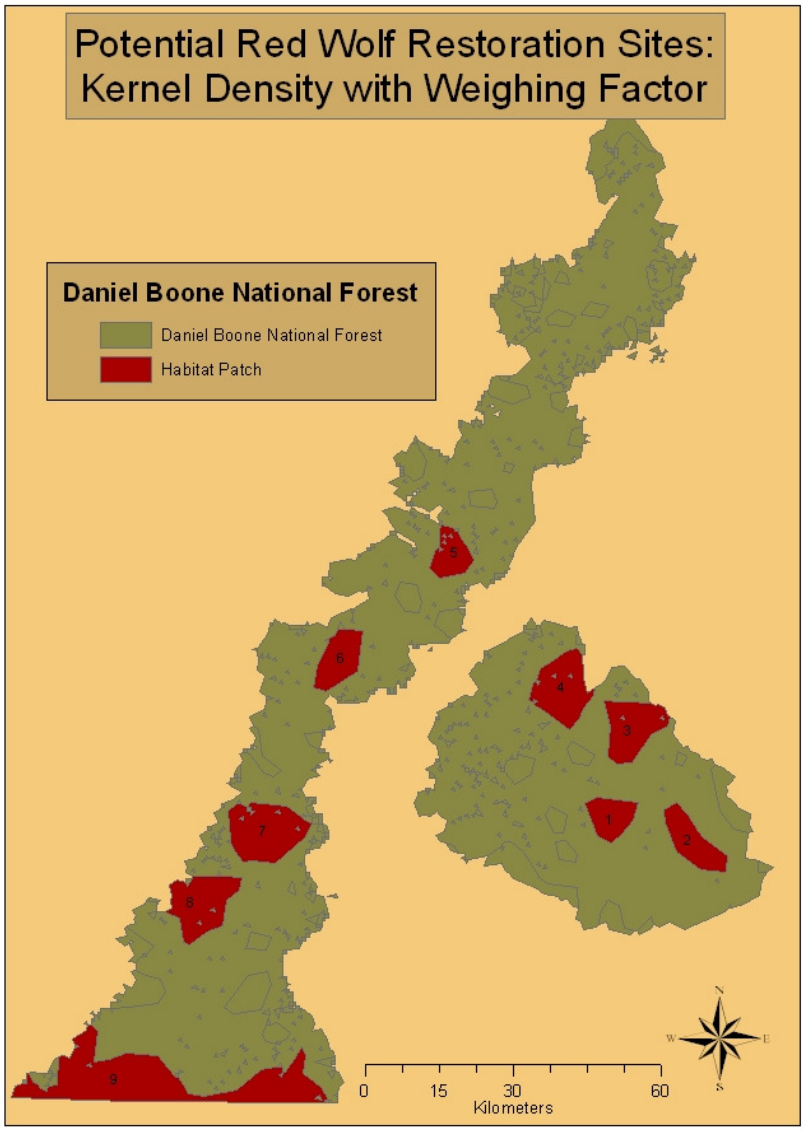


Figure 13: Potential Red Wolf Restoration Sites: Kernel Density with Weighing Factor. Map of the nine potential red wolf restoration sites. Patches have areas greater than 50 km², low road density and suitable habitat.

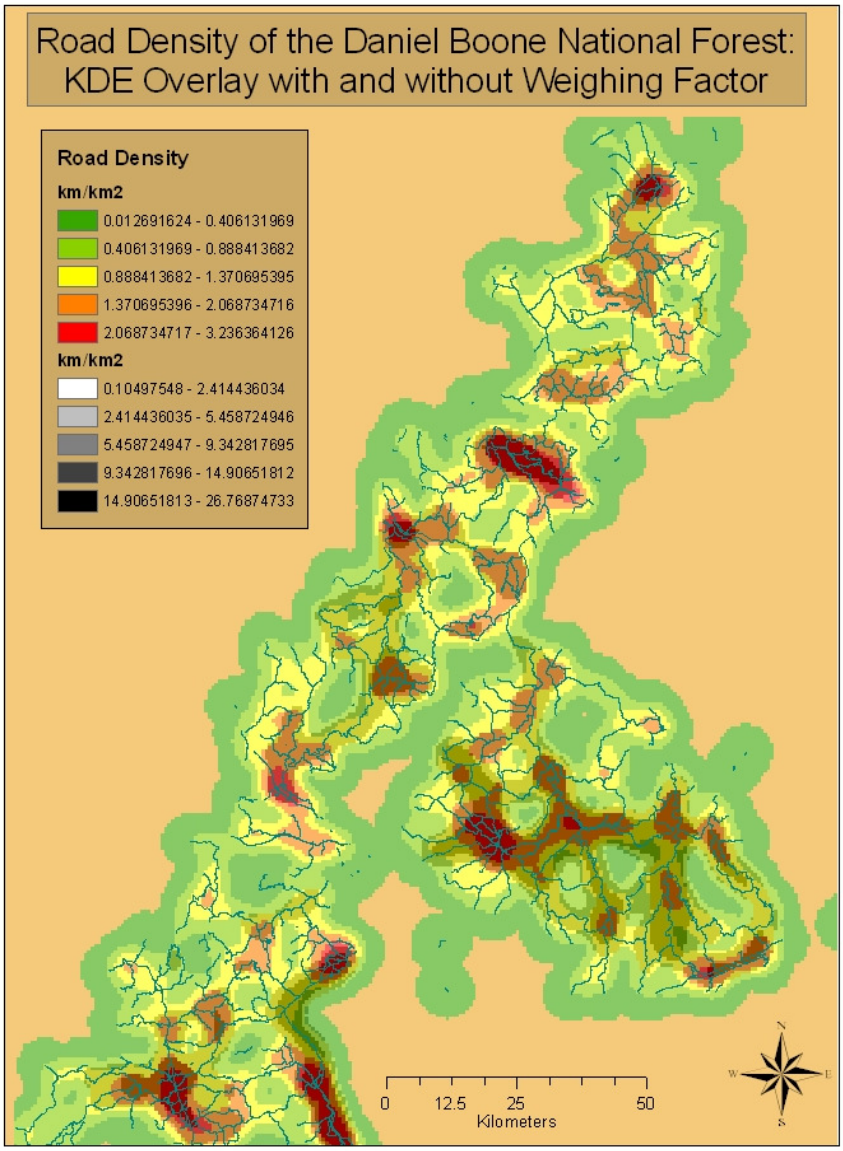


Figure 14: Road Density of the DBNF: KDE Overlay with and without Weighing Factor. Map of the overlay of the kernel methods with and without the weighing factor. Shadowed grey areas represent the road density without the ranking system.

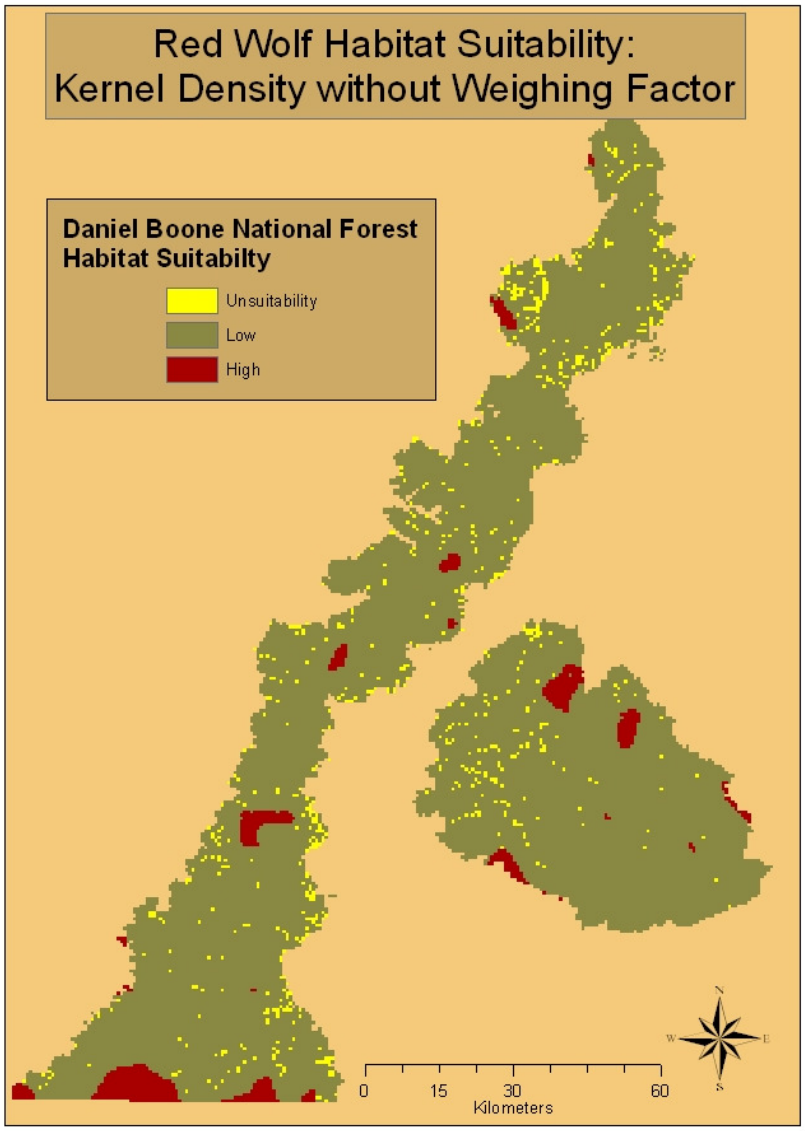


Figure 15: Red Wolf Habitat Suitability Model: Kernel Density without Weighing Factor. Map of suitability model based on kernel density without weighing factor. Fewer patches with much smaller areas resulted. This method produced one potential restoration site at the southern border.

4.4 Red Wolf Habitat Suitability Model: Simple Density Methodology

On the other hand, the red wolf suitability model based on the simple density function (Fig.16) returned a limited number of patches and none with areas greater than 50km². The simple density function performed more like the kernel density estimation when the weighted roads were incorporated into the calculations. The model based on the simple density and weighing factor (Fig. 17) produced fewer reintroductions sites with smaller areas as compared to this research methodology's model. Table 2 compares the areas of the potential restoration sites of both models.

KDE Habitat Patch	Area km²	SD Habitat Patch	Area km²	Difference
1	65	1	55	10
2	86	2	60	26
3	112	3	82	30
4	127	4	112	15
5	60	5	30	30
6	83	6	75	8
7	152	7	129	23
8	131	8	107	24
9	391	9	369	22

Table 2: Habitat Patch Comparison of the Different Model Results.

Potential restoration sites derived from the kernel density methods were larger. In total, the kernel density model predicted 1207 km² of suitable sites for red wolf reintroduction, whereas the simple density model only predicted a total of 1019 km². With home ranges of 25-130 km², the 188 km² difference between the models could support 1.45 to 7.52 red wolf packs, or approximately up to 37.6 individuals.

The Logarithmic Transformation (Fig. 18) produced more suitable habitat patches than the kernel density and simple density estimators; however, the suitability is questionable as suitable patches appeared in unsuitable high-road density areas such as in Red River Gorge, Cave Run Lake and Cumberland Lake. On the other hand, the Exponential Transformation (Fig.19) produced fewer suitable habitat patches than the kernel density methods but more than the simple density estimator. It still seems as if the kernel methods performed more robustly, and its use seems justified. However, the

question remained if the model based on the kernel density and weighing factor could facilitate information about the actual suitability of the habitat patches.

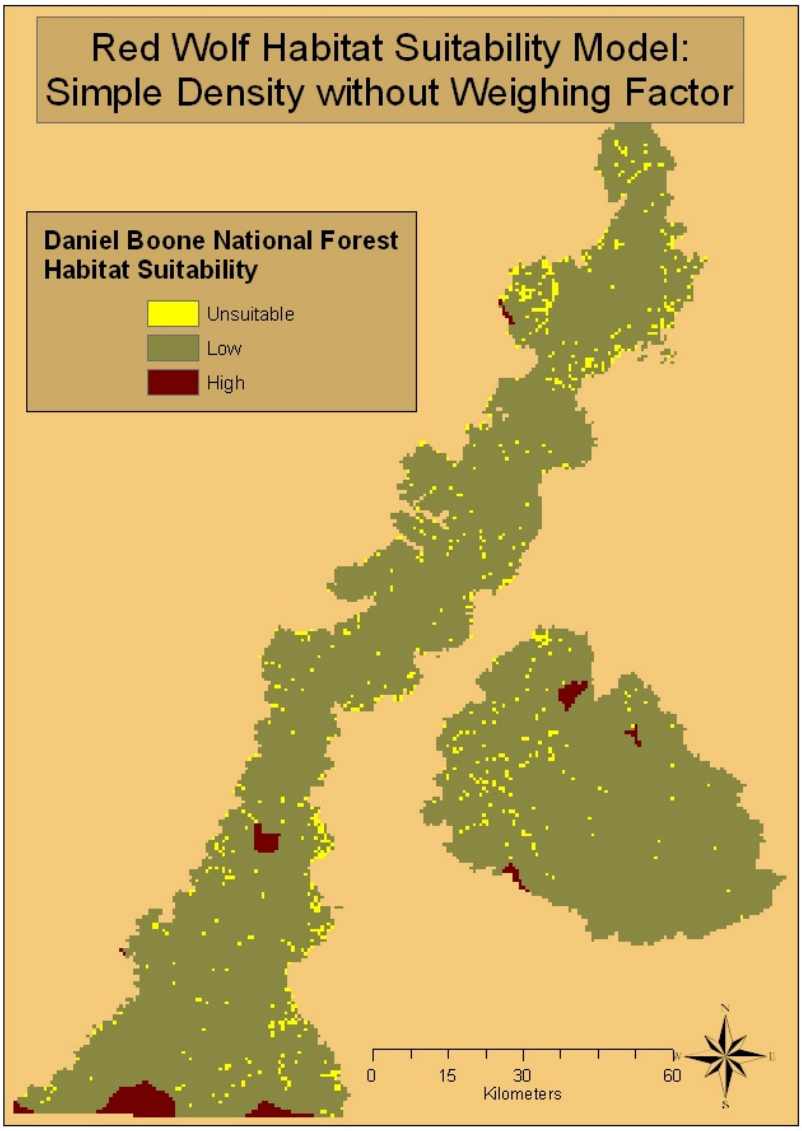


Figure 16: Red Wolf Habitat Suitability Model: Simple Density without Weighing Factor
Map of the red wolf habitat suitability model based on the simple density calculations and unranked roads shows limited habitat patches. None measure more than 50 km².

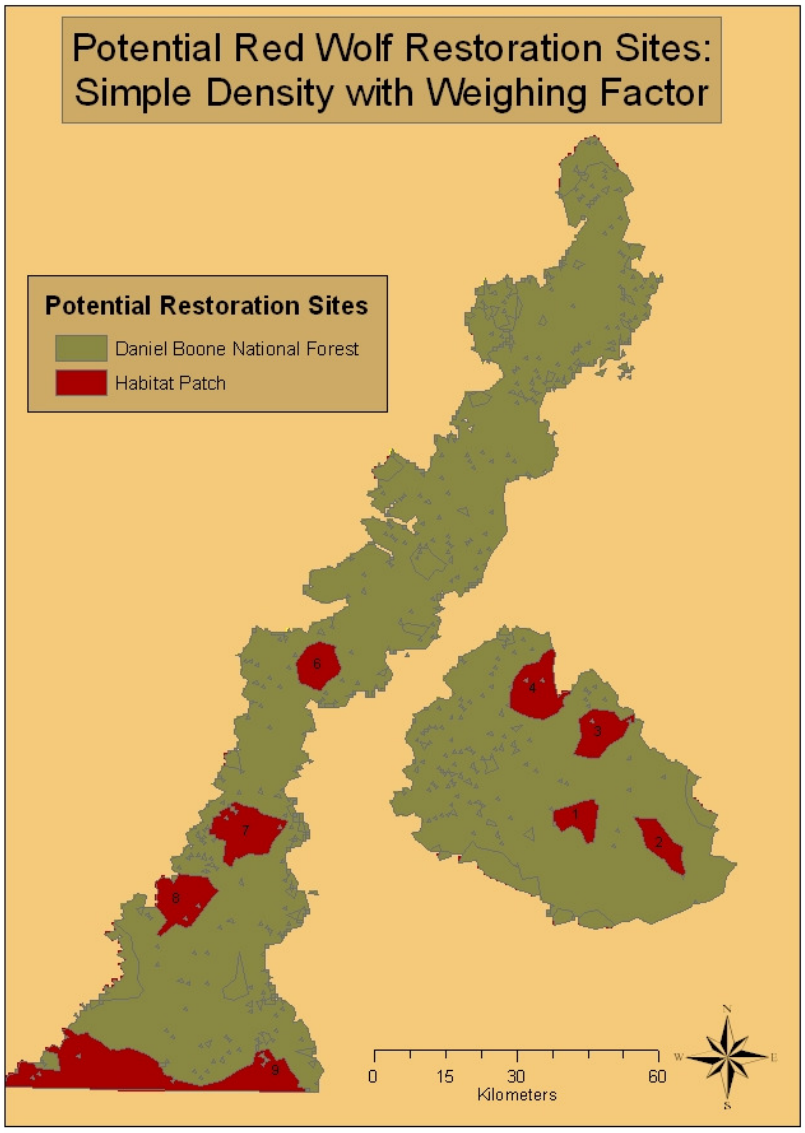


Figure 17: Potential Red Wolf Restoration Sites: Simple Density with Weighing Factor. Map of the potential red wolf reintroduction sites based on ranked roads and simple density. Patches have areas greater than 50 km², low road density and suitable habitat.

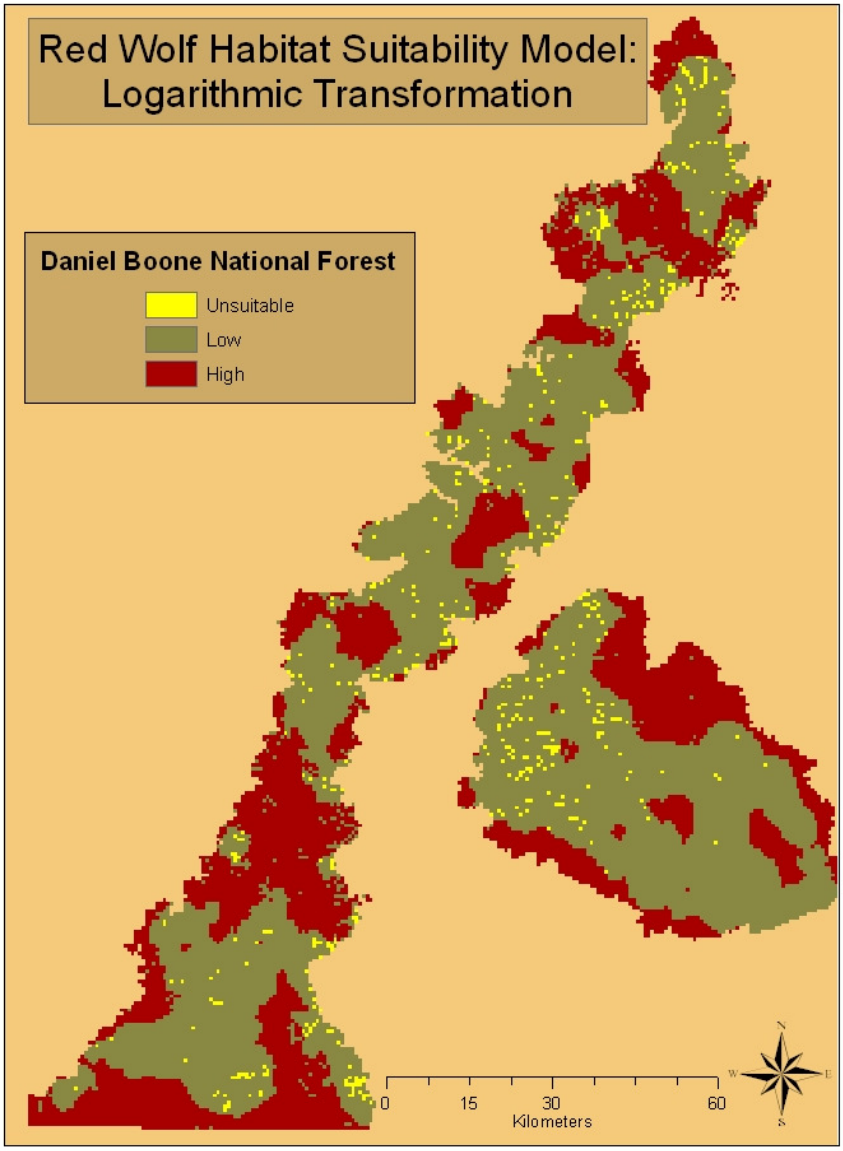


Figure 18: Red Wolf Habitat Suitability Model: Logarithmic Transformation. Logarithmic transformation produced many suitable but questionable habitat patches. Suitable habitat appears in unsuitable areas such as Red River Gorge, Cumberland Lake and Cave Run.

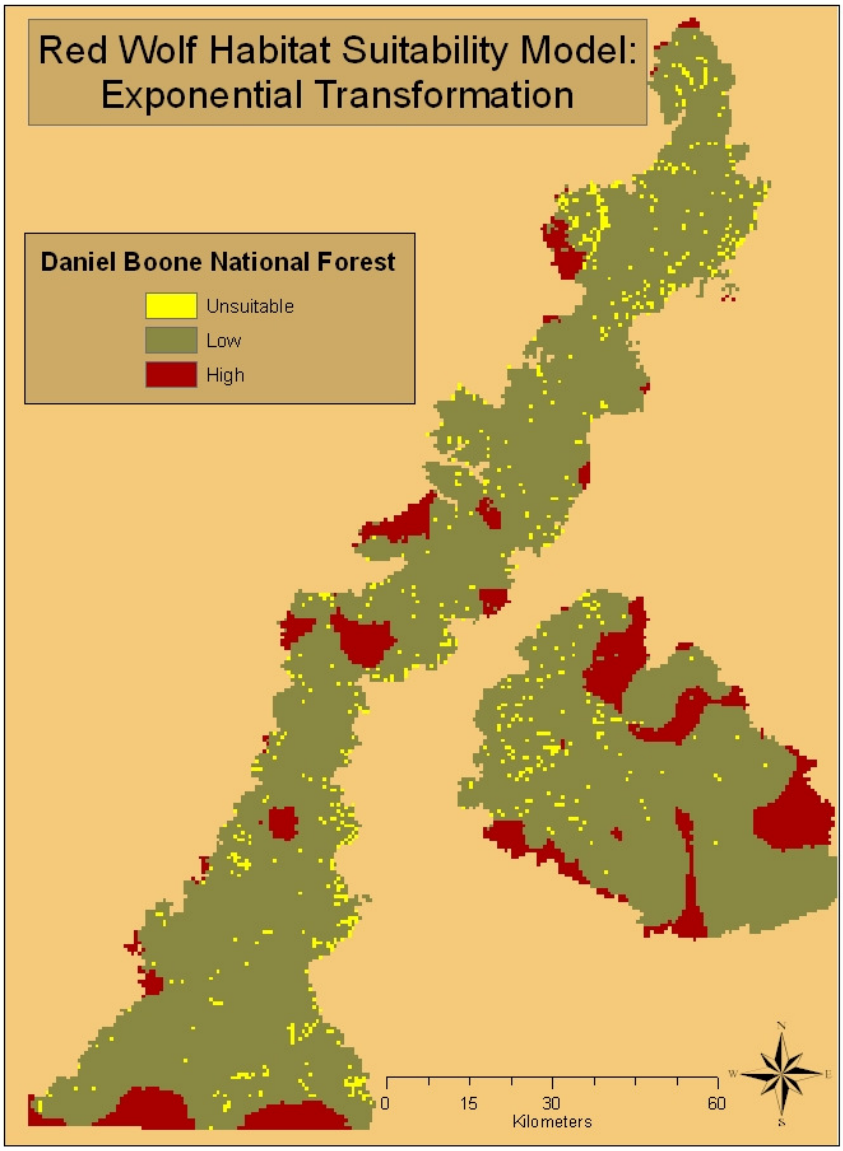


Figure 19: Red Wolf Habitat Suitability Model: Exponential Transformation. Exponential transformation produced fewer suitable habitat patches than the Log T; however, it does produce more than the simple density estimator.

4.5 Evaluation of Potential Reintroduction Sites

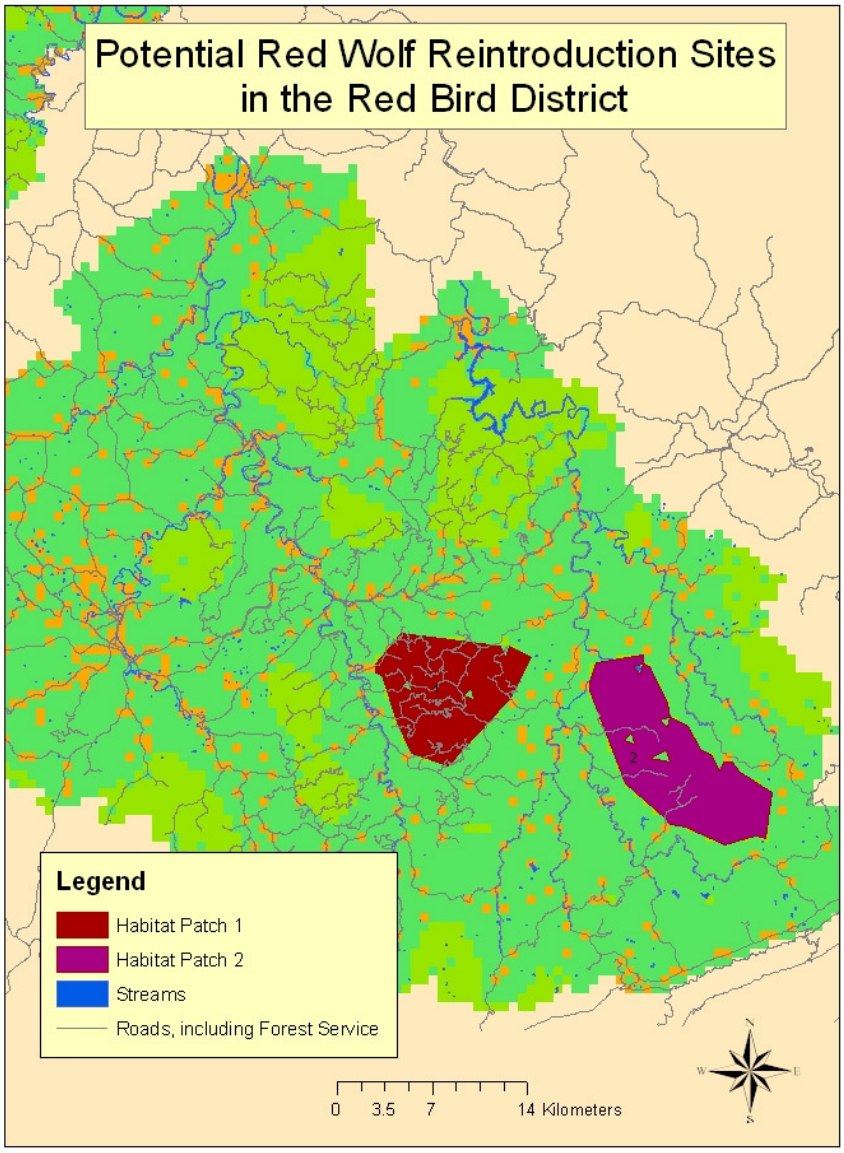


Figure 20: Potential Red Wolf Reintroduction Sites in the Red Bird District. Habitat Patch 1 and Habitat Patch 2 represent the two potential reintroduction sites considered for further investigation.

Out of the nine potential sites identified by the model, two sites seem to be more appropriate because of their forest buffers, connectivity to other patches and lack of agriculture. Referred to as HP1 and HP2, these patches will be further analyzed. Details such as proximity to streams, roads, and frequently visited areas in HP1 and HP2 (Fig. 20) were investigated. Measurements in GIS confirmed area of patch, proximity to streams, essential for thriving ecosystems and wolf survival, and the distance from roads (Table 3). Road densities at the cores ranged from 0.07 km/km² to 0.12 km/km² with road densities increasing toward the edges. With home ranges for red wolves between 25 km² and 130 km² (Phillips, Henry and Kelly 2003), HP1 and HP2 fulfill the minimal requirements. HP1 has an approximate area of 65 km², and the distance from the core to the Red Bird River is estimated at 12 km. HP2 has an approximate area 86 km², and distances from the core to the large stream networks range from 12 km to Kentucky River in the west, 6 km to Greasy Creek in the south, and 7 km to Grassy Fork in the east. However, observations of small streams and creeks did not appear in the GIS data, and it is assumed water within the habitat patches is adequate for wolf survival and may limit their need to travel outside the boundaries to access the larger streams. HP1 contains the Red Bird Wildlife Refuge as well as a significant portion of the Red Bird Crest Trail that allows hiking, biking, horseback riding, and ATV activities.

Patch	N	E	S	W
HP1	4.0 km	8.0 km	3.0 km	3.0 km
HP2	4.65 km	2.8 km	5.4 km	4.8 km

Table 3: Road Proximity to Potential Reintroduction Sites.
Approximate distances from northern, eastern, southern, and western borders to roadways.

Field observations of the rugged HP1 and HP2 indicated a need for slope analysis. Three major streams, the Kentucky River, Greasy Creek, and Grassy Fork, cut deep, steep-sided ravines that bordered HP2. With no roads traveling into the patch, access was restricted by the steep slopes. Slope analysis of HP1 (Fig. 21) and HP2 (Fig. 22) revealed hilly terrains in both patches, more so in HP2. The literature disagrees on the slope gradient threshold (20º or 40º), but Paquet, Wierzchowski and Callaghan (1996) state wolves prefer valley bottoms and elevations less than 1,850 meters. However, wolf migration corresponds to vertical migration of prey species (Paquet, Wierzchowski and Callaghan 1996). Snow depths greater than 40-50 centimeters restrict wolf movement below 1,700 meters, but wolves will use plowed roads and snowmobile trails to access higher elevations (Paquet, Wierzchowski and Callaghan 1996).

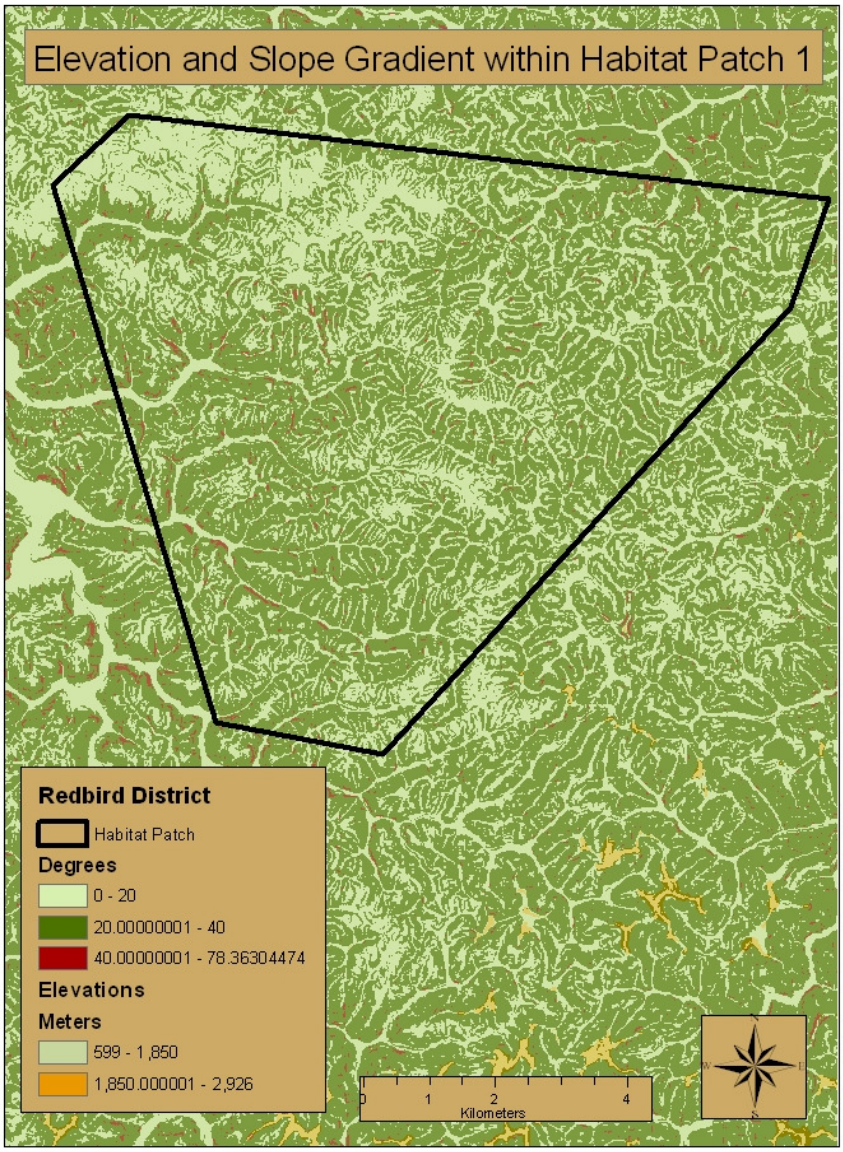


Figure 21: Elevation and Slope Gradient in Habitat Patch 1.
Slope analysis of Habitat Patch 1. Red indicates steeper slopes that wolves may not use.

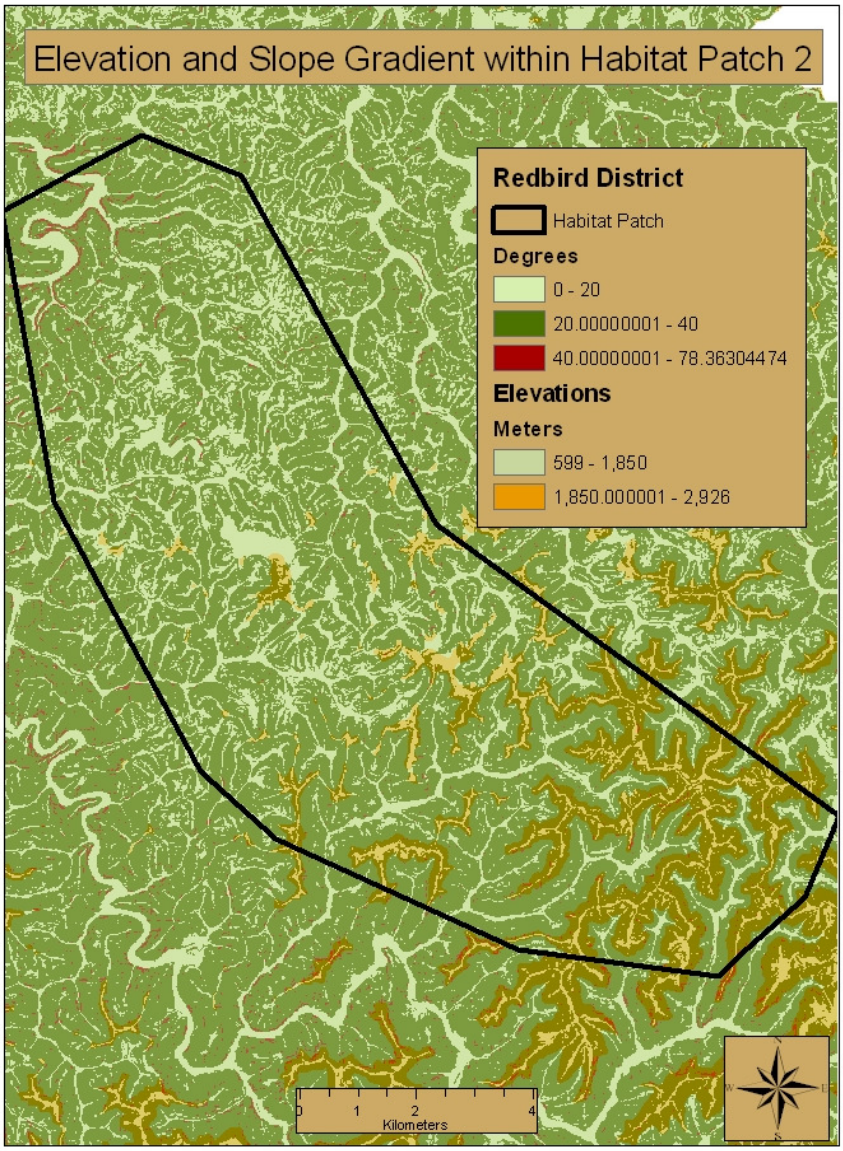


Figure 22: Elevation and Slope Gradient in Habitat Patch 2.
Elevation and slope analysis of Habitat Patch 2. Red indicates steeper slopes and yellow-orange indicates higher elevations that wolves may not use

In HP1 (Fig. 23), the extent of greenness value was 69.618, and vegetation cover represented 99.3% of the total land area. HP1 could, in theory, support an estimated deer density of 5.9895 deer/km². Vegetation cover in HP2 (Fig. 24) was determined to be

84.6% of the total land area, given its extent of greenness value of 76.121, whereby HP2 may have the capacity to support 6.336 deer/km². In regards to adequate prey base, both habitat patches meet the minimum requirement of 5 deer/km² for red wolf. Photographs of HP1 and HP 2 (Fig. 25, 26, 27 and 28) show a fraction of the suitable wildlands environments for the red wolf.

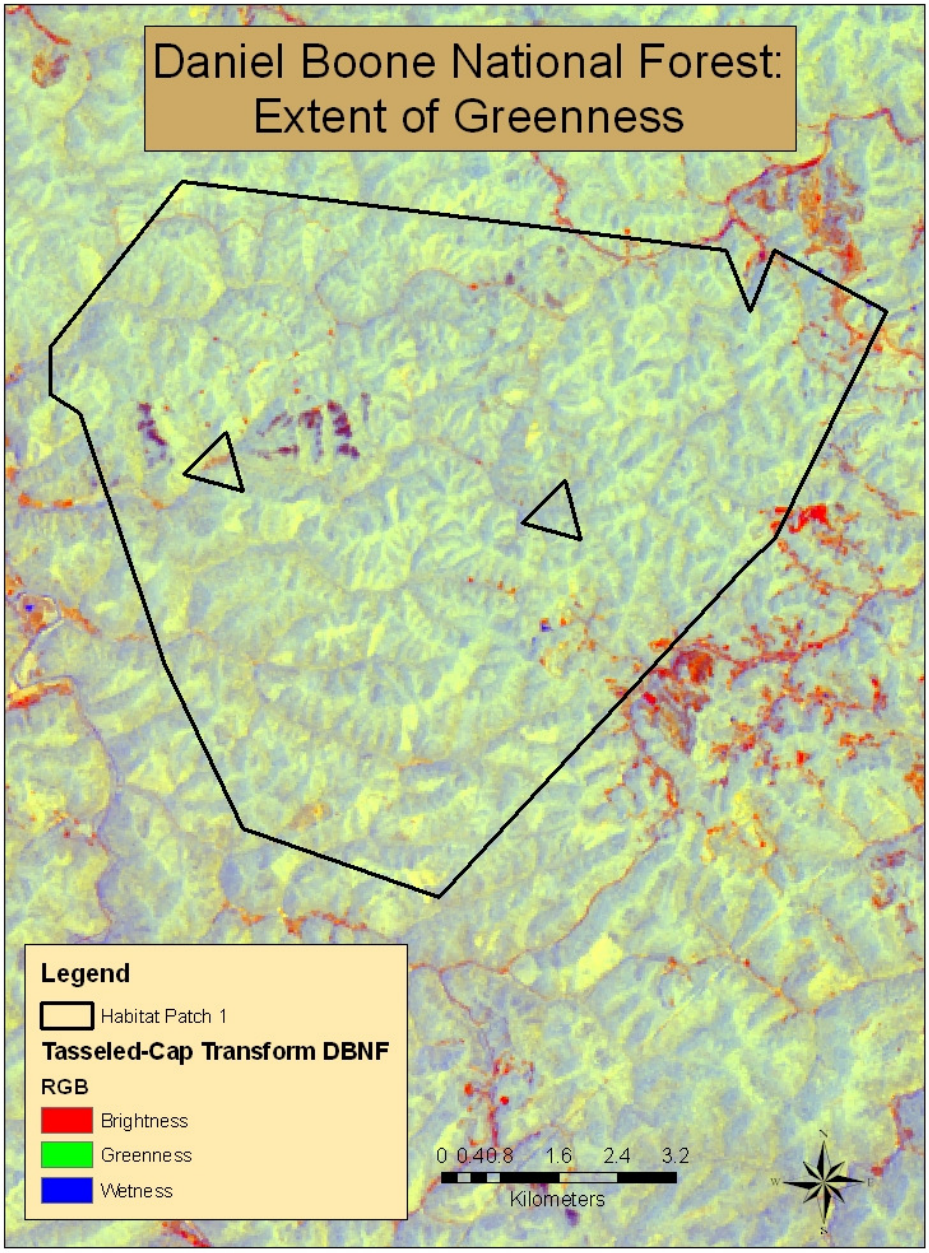


Figure 23: Extent of Greenness in Habitat Patch 1.
Remote sensing image of Habitat Patch 1 showing extent of greenness.

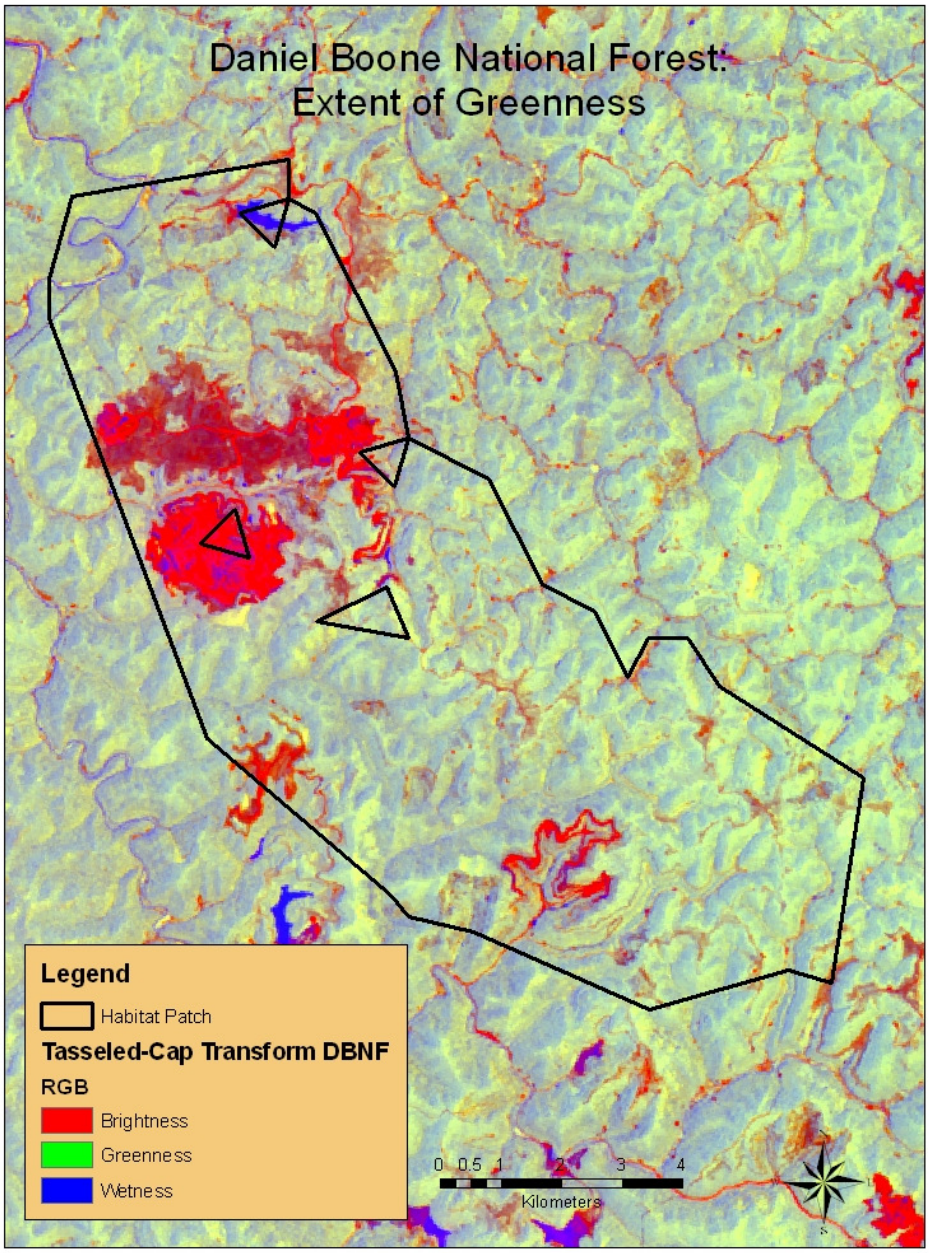


Figure 24: Extent of Greenness in Habitat Patch 2.
Remote sensing image of Habitat Patch 2 showing extent of greenness.



Figure 25: Photograph of Habitat Patch 1.
Meadow off one of the forestry service roads in Habitat Patch 1.



Figure 26: Photograph of Habitat Patch 1.
Stream running alongside forestry service road in Habitat Patch 1.



Figure 26: Panoramic Photograph of the Eastern Side of Habitat Patch 2.

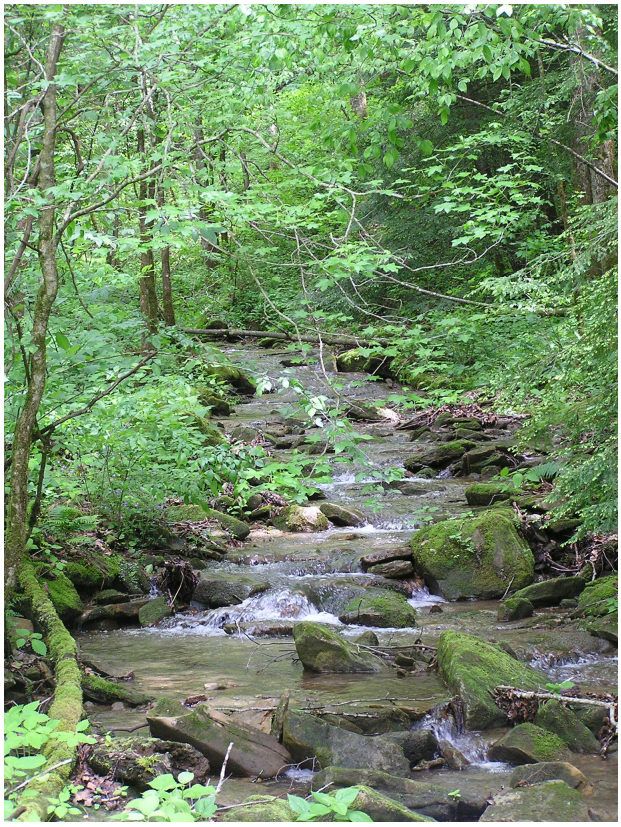


Figure 27: Photograph of Habitat Patch 2.
Small stream running through southern border of Habitat Patch 2.

Chapter Five

Discussion

For the reintroduction of rare and endangered species such as the red wolf, identifying high-quality, suitable habitat is vital. Poor pup survival from parvovirus further imperiled the wild population and led to the discontinuation of the red wolf recovery project in the Great Smokey Mountains National Park (USFWS 2007). This demonstrates the need to model as many abiotic and biotic influences on species' survivorship as possible.

While unfragmented and undisturbed habitat represents the optimal habitat for wolves (USFWS 2007), the extent of historic red wolf range encompasses the populated southeast of the United States (Nowak 1992). Pristine wildlands as the criterion for restoration of viable wolf populations may be an unattainable ideal. As documented in ARNWR, certain packs hunted on farmland and thrived in this capacity alongside humans (Phillips, Henry and Kelly 2003). Mladenoff et al. (2009), on re-examination of their original prediction model, discovered wolf occupation in habitats that were assumed unsuitable. This showed a lack of knowledge about the wolf's adaptability. The assumption that wolves do not belong in humanized landscapes may be unjustified (Lynn 2002). By permitting wolves use of fragmented habitats, wildlife biologists and ecologists may broaden their knowledge about the species' ability to persist in the human-disturbed wildlands. This knowledge may lead to the development of more effective management strategies to mitigate conflicts between man and wildlife in shared spaces.

The original logistic regression model introduced by Mladenoff et al. (1995) predicted the probability of wolf distribution and occupation in regions already inhabited by wolves. However, red wolves have not been present in Kentucky since the early 1900's (DeBlieu 1991), and the potential for red wolf restoration in one of the few remaining contiguous forests in the Southeastern United States had yet to be assessed.

Descriptions of red wolf habitats in ARNWR (Phillips, Henry and Kelly 2003; USFWS 2007) and habitat selection criteria specified by Shaffer (2007) provided the guidelines for this thesis research. Like ARNWR, with its mosaic of landscapes and mixed mesophytic forest, the DBNF contains favorable red wolf environments and adequate prey populations (USDA 2003; USFWS 2007). Road density as the best predictor for suitable wolf habitat was the main focus of this research's habitat selection (Mech 1995; Mladenoff et al.1995; Mladenoff and Sickley 1998; Harrison and Chapin 1998; Mladenoff et al. 1999; Ratti et al. 1999; Corsi et al. 1999; Unger 1999; Frair 1999; Houts1999; Kohn et al. 2000; Wydeven et al. 2001; Shaffer 2007; Mladenoff et al. 2009).

This thesis methodology, though, adopted a different and unique approach to evaluating road density in a study area. Instead of using the simple density calculations for road density, the red wolf habitat selection model incorporated the kernel density estimation as a smoothing method and a ranking system as a weighing factor for mortality risks based on road type. The type of road made a difference in the inquiry. Frequency and speed of travel is higher on asphalted highways and state byways than on gravel "country" roads, and, therefore, the chances of vehicular strikes with wildlife will increase on roads more often travelled. Rowan County in the northern Morehead District had the highest deer-car collisions, and the model did not predict any suitable habitat in

the region. On the contrary, Leslie and Clay Counties in the Red Bird District had very low deer-car collisions, and the model predicted four potential restoration sites. It would seem the assumption built into the methodology is realistic. In the model, the highways and state routes received the highest mortality-risk rank, and, in reality, the higher deer-car collisions occurred in the northern and southern regions of the DBNF, areas associated with State Route 60, Interstate 64, and Interstate 75.

Without the weighing factor, the road type does not make as much of a difference in the density probability, and the density is, therefore, greater in areas than where the type of road carries a theoretically lower mortality risk. The difference in the intensity and frequency of high density was greater in the simple density than even the kernel density without the weighing factor, indicative of the kernel density estimation being a weighted density probability function in and of itself. The weighing factor, therefore, had the greatest influence on the simple density model's performance. Without weighted roads, the simple density method resulted in a red wolf suitability habitat model with limited habitat patches and no potential restoration sites. The simple density in conjunction with the weighing factor, on the other hand, produced a habitat selection model more similar to the weighted kernel method model by identifying eight potential restoration sites. The red wolf suitability habitat model integrating the kernel methods and ranking system still performed more robustly than the weighted simple density model by identifying nine potential restoration sites with larger areas.

The final model displayed distinct spatial patterning of the nine potential restoration sites. Clusters occurred in the Red Bird District (Habitat Patches 1, 2, 3 and 4) and in the Somerset District (Habitat Patches 6 and 7), while random isolated patches

occurred in the London (Habitat Patch 5), Stearns (Habitat Patch 8) and Stanton Districts (Habitat Patch 9). In terms of connectivity, the patch clusters would better facilitate wolf movement and genetic flow. The corridors, however, are areas of high road density, and, while wolves do cross roads, the risk of mortality increases (Mladenoff et al. 1995).

Though adequate in acreage and forest cover, the DBNF is fragmented by human settlement and activity. Moreover, human lands use appears to cause minimal fragmentation in five of the nine potential restoration sites (Habitat Patches 3, 4, 6, 7 and 9). Wolf survivorship in such habitats depends upon the attitudes and behaviors of the people present as Mladenoff et al. (1995:282) noted, "As long as wolves are not killed, they appear to have the ability to occupy areas of greater human activity than previously assumed."

Demographics in the DBNF may preclude the co-existence with wolves. Studies showed that lower educational and economic status foster anti-wolf sentiments (Ratti et al. 1999). In the DBNF counties, average median household income ($27,736) and poverty levels (30%) fall below the average median household income ($40,299) and poverty levels (17.2%) of the state (US Census Bureau). 57% of county residents compared to 74% of state residents obtained a high school diploma, and 9% of county residents compared to 17% of state residents hold a Bachelor's degree or higher (US Census Bureau).

With public education and community involvement in decision-making about red wolf reintroduction and management, tolerance and acceptance may be fostered, and any existing negative attitudes may change towards the positive (Musiani and Paquet 2004; Fritts et al. 1997; Mech 1995; Phillips 1995). Conducting a survey of those living and

working in region and even of those visiting the DBNF would provide insights into the attitudes toward the red wolf and its restoration.

Despite this reservation, the findings of this research appears concordant with the elk restoration project in that optimal habitat occurs in the Red Bird District. Four potential patches (Habitat Patches 1, 2, 3 and 4) show more promise as core habitat ranges for red wolves, with Habitat Patches 1 and 2 the most promising with forest buffers and no agriculture. Further evaluation of Habitat Patches 1 and 2 suggested their viability for red wolf reintroduction.

Major streams such as the Red River, Kentucky River, Grassy Creek and Greasy Fork flow roughly parallel to roadways that border the habitat patches, but smaller streams and creeks flow within patch boundaries and cores. Abundant water and prey resources, such as deer and raccoon, indicate ecosystems in which the red wolf would thrive. In theory, HP1 and HP2 can support one or two packs, and gene flow between the two is possible. Smaller suitable habitats to the west and southwest and the larger suitable habitats to the northwest may provide home ranges for future generations of dispersing wolves.

With portions of the Redbird Wildlife Management Area and Redbird Crest Trails in Habitat Patch 1, an advantage includes the facilitation of red wolf monitoring for wildlife biologists and viewing for wildlife enthusiasts. The hunting, off-road vehicle traffic, horseback riding, biking, and hiking may seem disadvantageous for red wolf occupation and survival. However, red wolf populations in ARNWR and Pocosin Lakes National Wildlife Refuge have persisted in similar recreational areas.

Limited road access into Habitat Patch 2, on the other hand, makes it more isolated and remote than Habitat Patch 1. This isolation may increase suitability, despite the evident barrenness in the north and higher elevation taken from remote sensing imagery. Whether clear-cutting from logging, mountain-top removal from coal mining, or tree-stand death from disease or forest fire, the cause for the bright spot determined by the Tassel-Cap Transform is unknown.

In southeastern Kentucky, old-growth logging in the southern half of the DBNF has ceased due to the forest legacy program and partnerships in watershed restoration, and coal mining has been abandoned due to Federal Surface Mining, Reclamation and Enforcement Act in 1977. Conservation of the forests and watershed is fostered through the financial assistance to private landowners from programs such as the Forest Stewardship Program, the Conservation Reserve Program, the Environmental Quality Incentives Program, the Wetland Reserves Program, the Wildlife Habitat Incentive Program, the Kentucky Heritage Land Conservation Fund, and the Urban and Community Forestry Program.

Conservation of the forest, the watershed basin, and the 23 threatened and endangered extant species in the DBNF would benefit from the red wolf's return. In addition, the public should be educated about the values of wildlife and the importance of ecosystem diversity. The 74.2% of Kentuckians who opposed logging of public lands (UK Survey 1994) may support red wolf reintroduction, especially if the public understands the ecological role of the red wolf in maintaining ecosystem health and diversity.

Chapter Six

Conclusion

This thesis research identified nine potential red wolf restoration sites in the DBNF. The results from this research, however, are not final. Despite the potentiality, comprehensive knowledge is lacking on how well the red wolf will establish home ranges in coyote-inhabited territories and if coexistence of the two canids can happen without hybridizations. Further research on the intraspecific relationships between the two canids and data on the coyote density and distribution within the DBNF is necessary.

Other uncertainties include the actual effects of red wolf reintroduction on prey species and the ecosystem. For example, the elk reintroduction to the DBNF has raised some concerns on its effects on the plant community and existing white-tailed deer populations. The elk may drive the deer from the forest into farmland, and, if red wolves were present and dependent on the deer, then the wolves may follow the deer and come into conflict with landowners. Detailed studies on the ecological consequences of wolf reintroductions in other regions could provide a guide to the possible outcomes in the DBNF.

In the study region, highways and state byways, rather than gravel roads, carry the greater threat to wolf survivorship, and, by weighting the road class by mortality risk and road density function, the resultant map portrays a more realistic portrayal of the road influence on the potential of wolf habitat. The simple density function, even if roads are ranked by mortality risk, has a tendency to underestimate the extent of suitable habitats.

This thesis research improved the methodology in habitat selection models for wolves and contributed to RWSSP by the identification of reintroduction sites in the

DBNF and the evaluation of habitat viability. Further fieldwork, such as collection of ground truth data, vegetation sampling, observations of herbivore and mesopredator habitat use, and local climate variations, is recommended. However, only the restoration of experimental populations will confirm suitability.

To ascertain the validity of the model, the built-in assumptions need to be tested. A future study requires traffic volume data of the road network in the DBNF and gunshot mortality distribution points from ARNWR to determine proximity to the type of roads most associated with incidental or intentional shootings of red wolves. If the data are available, a follow-up study in North Carolina to test the model's predictive performance may help to further validate the model.

Revisiting previous predictions models with the weighted functions may also elucidate more on the effectiveness of the amended methodology. The original logistic regression model created by Mladenoff et al. (1995) may have predicted suitable habitat and wolf occupation with more accuracy if the road density variable had been determined by weighting the road class and performing the kernel density estimation. This thesis research methodology is not limited to the DBNF and could be applied to other study areas for predicting habitats where density is an important variable.

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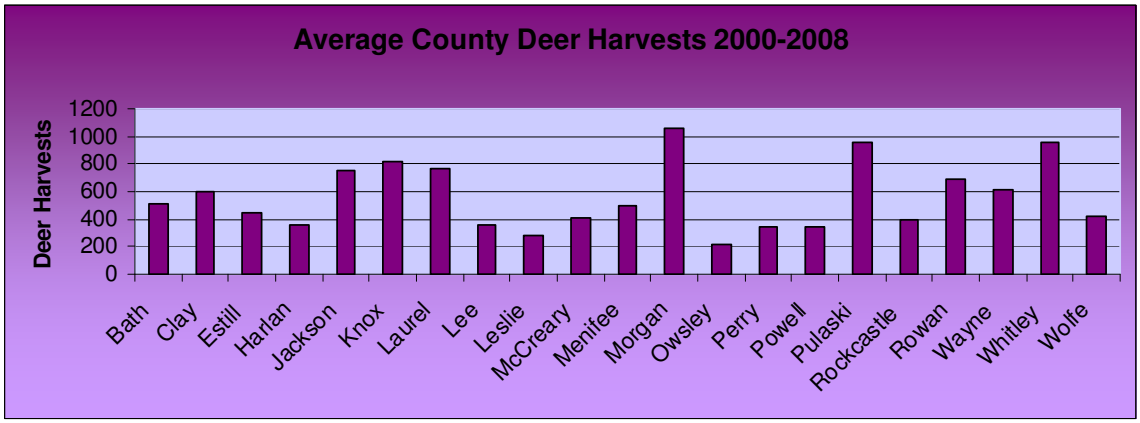
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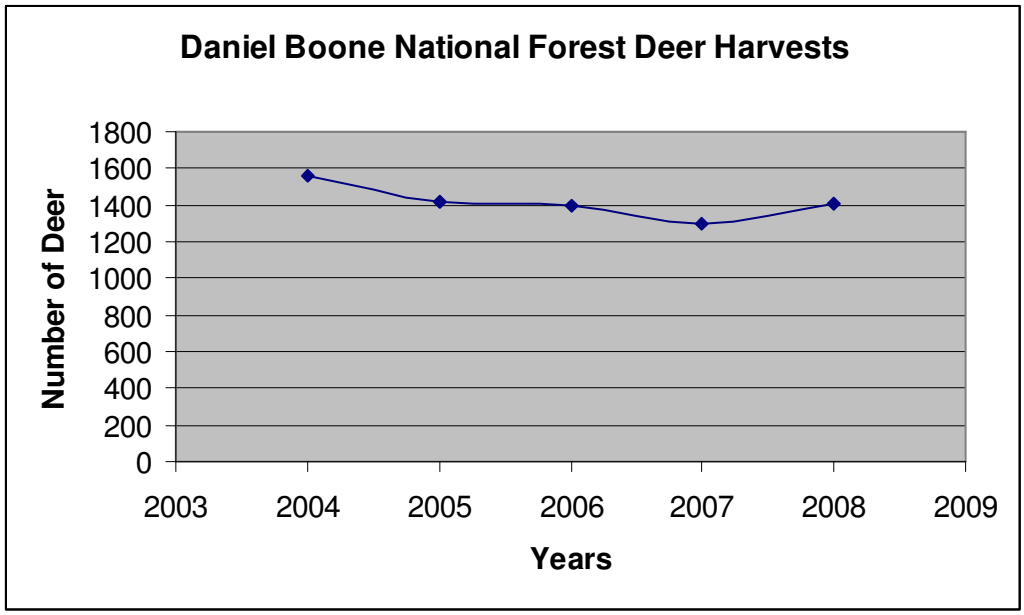
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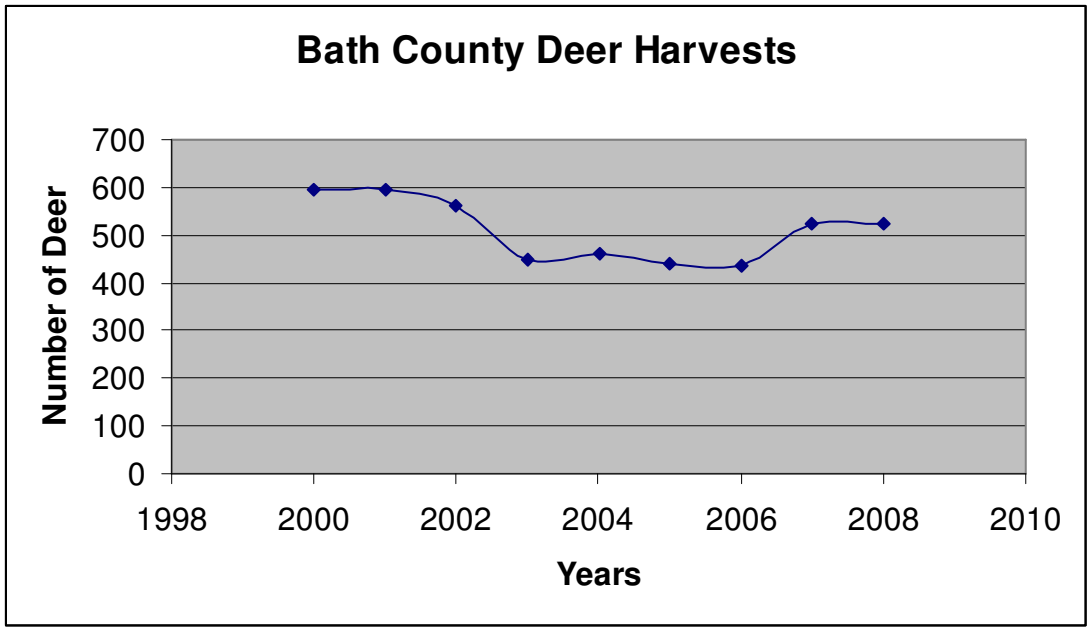
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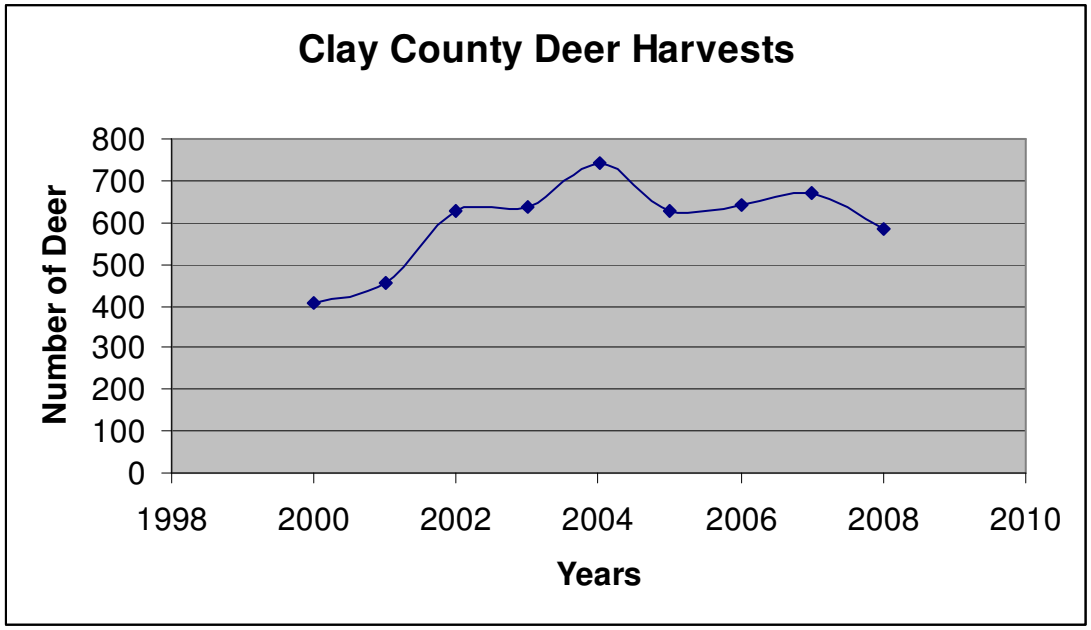
Appendix A: Average County Deer Harvests 2000-2008.
Data source: **http://fw.ky.gov/harvest/deerharvest.asp**
Kentucky Department of Fish and Wildlife



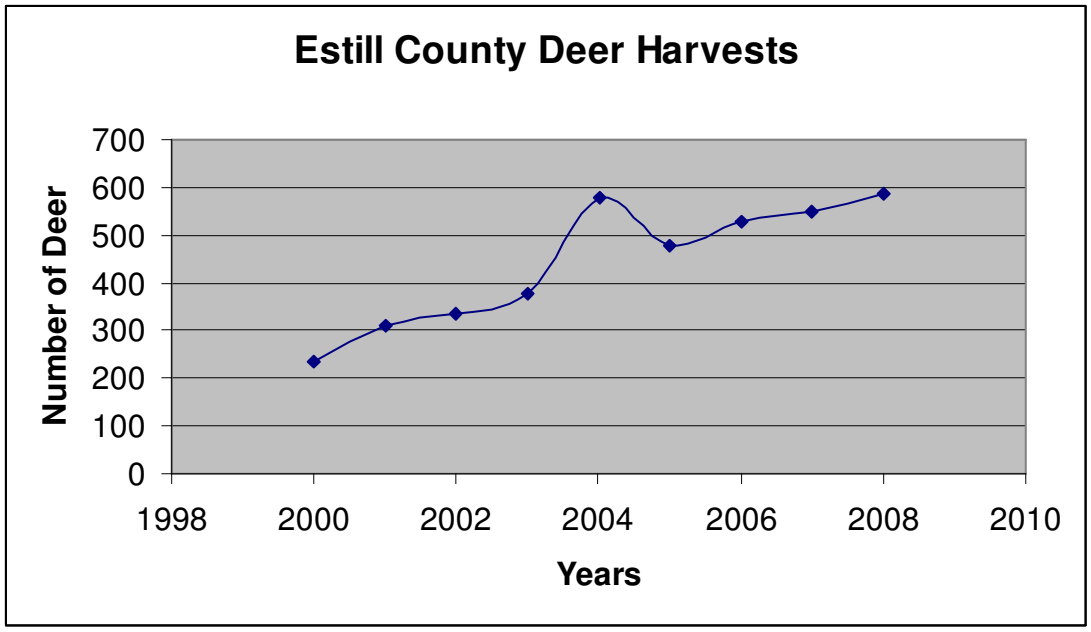
Appendix B: Daniel Boone National Forest Deer Harvests.
Data source: http://fw.ky.gov/harvest/deerharvest.asp
Kentucky Department of Fish and Wildlife



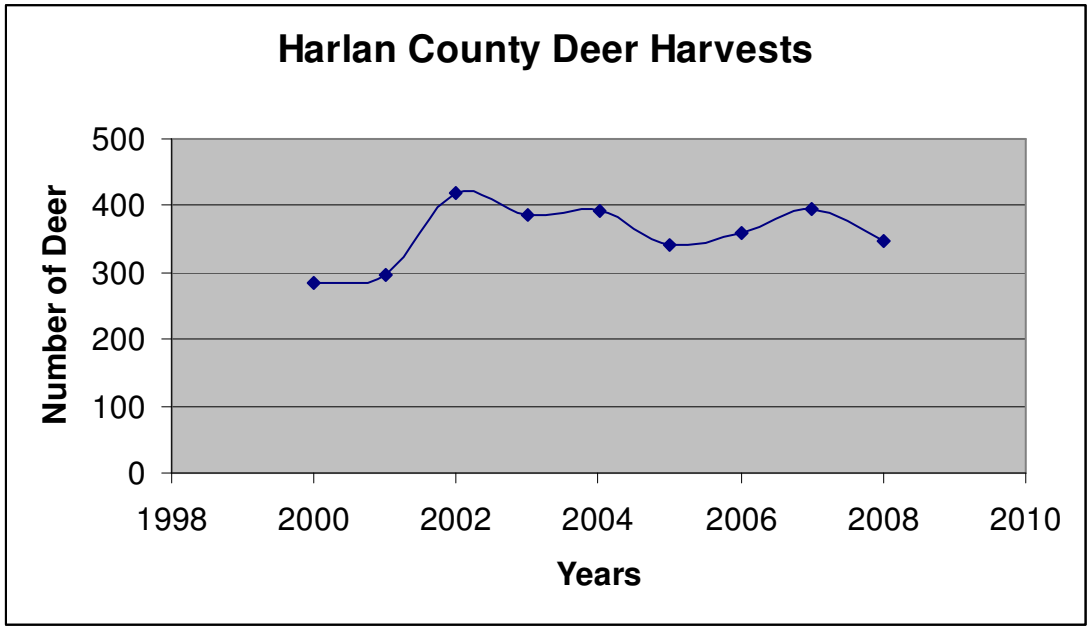
Appendix C: Bath County Deer Harvests.
Data source: http://fw.ky.gov/harvest/deerharvest.asp
Kentucky Department of Fish and Wildlife



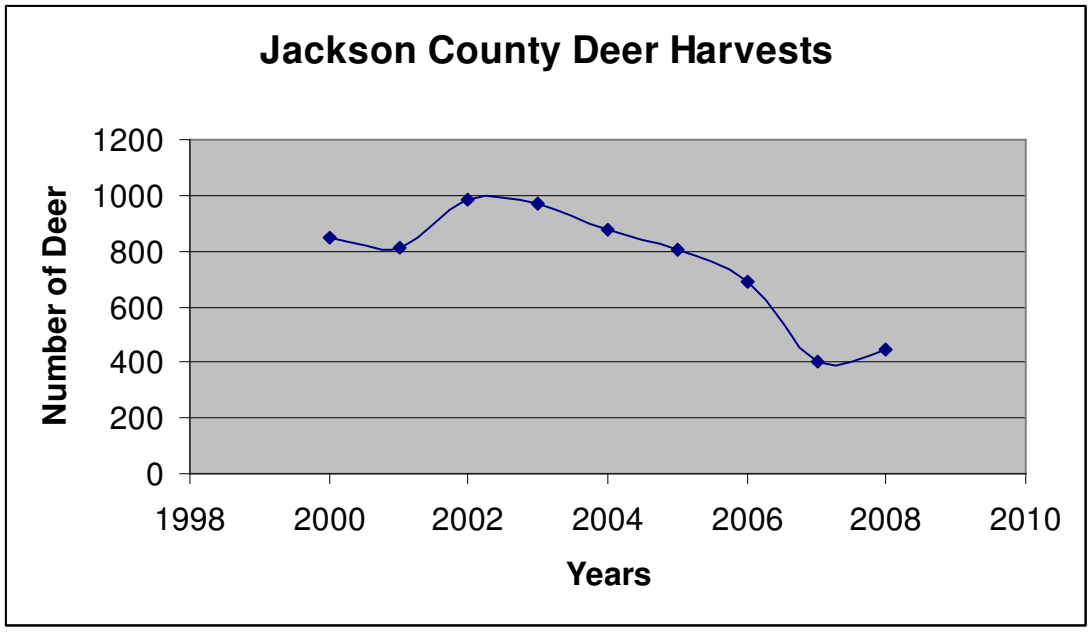
Appendix D: Clay County Deer Harvests.
Data source: http://fw.ky.gov/harvest/deerharvest.asp
Kentucky Department of Fish and Wildlife



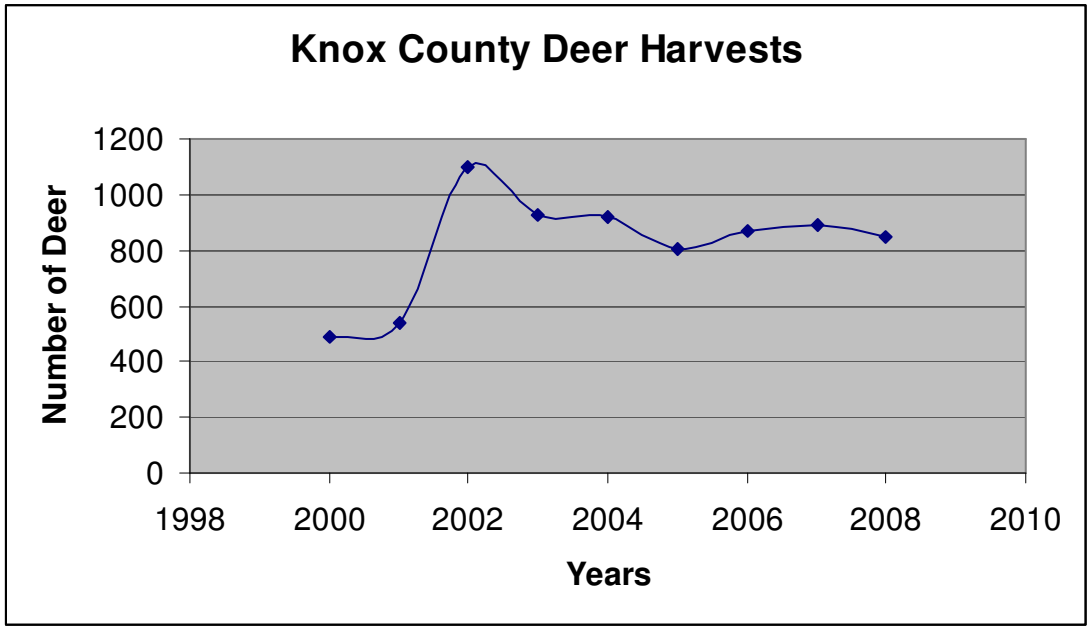
Appendix E: Estill County Deer Harvests.
Data source: http://fw.ky.gov/harvest/deerharvest.asp
Kentucky Department of Fish and Wildlife



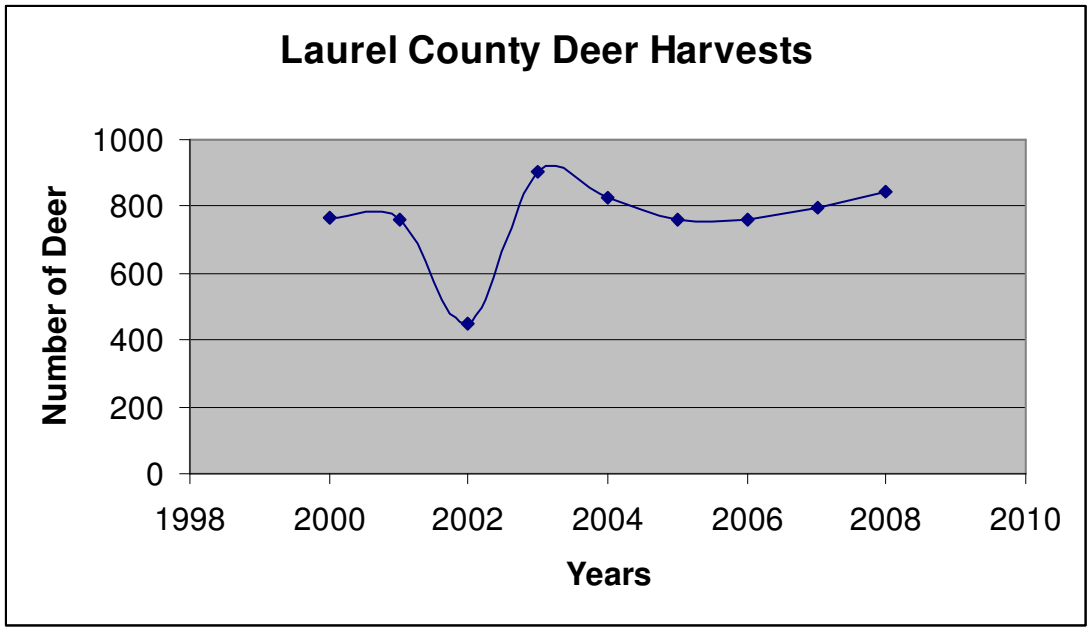
Appendix F: Harlan County Deer Harvests.
Data source: http://fw.ky.gov/harvest/deerharvest.asp
Kentucky Department of Fish and Wildlife



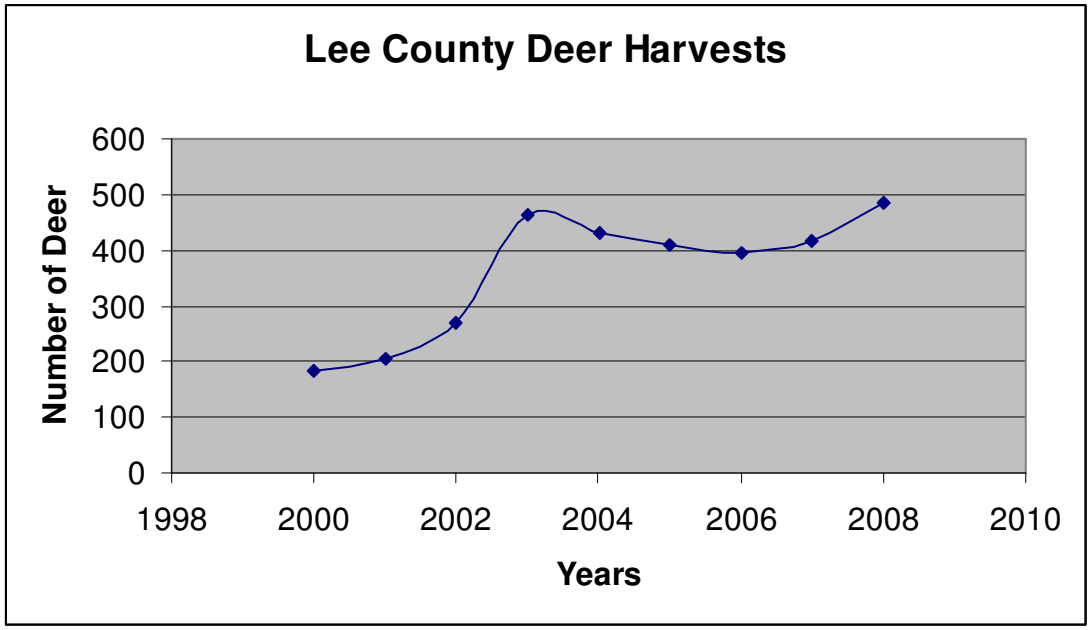
Appendix G: Jackson County Deer Harvests.
Data source: http://fw.ky.gov/harvest/deerharvest.asp
Kentucky Department of Fish and Wildlife



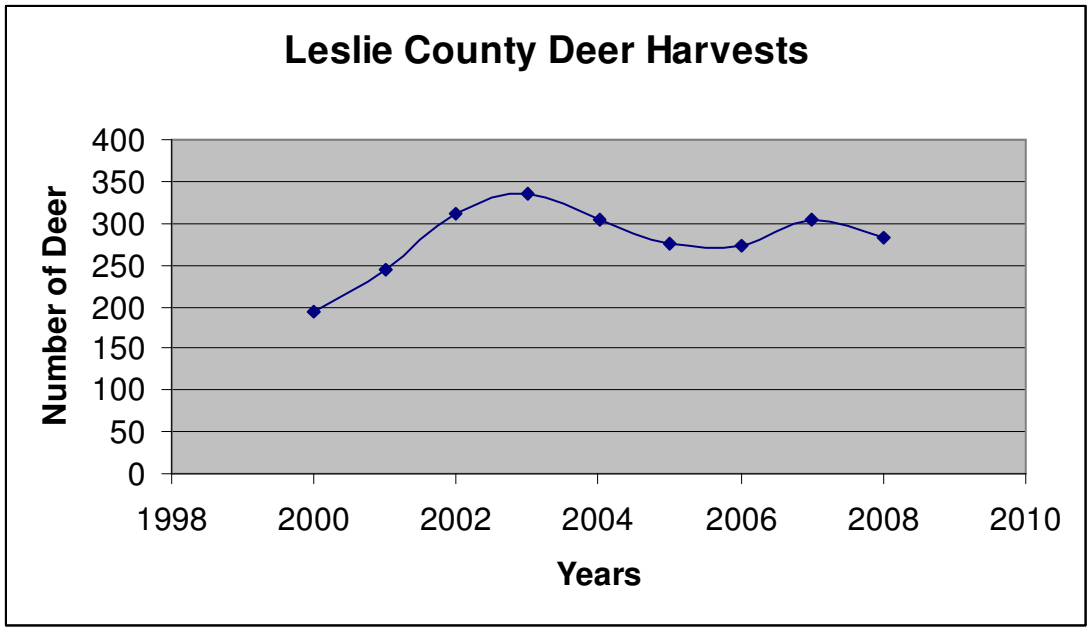
Appendix H: Knox County Deer Harvests.
Data source: http://fw.ky.gov/harvest/deerharvest.asp
Kentucky Department of Fish and Wildlife



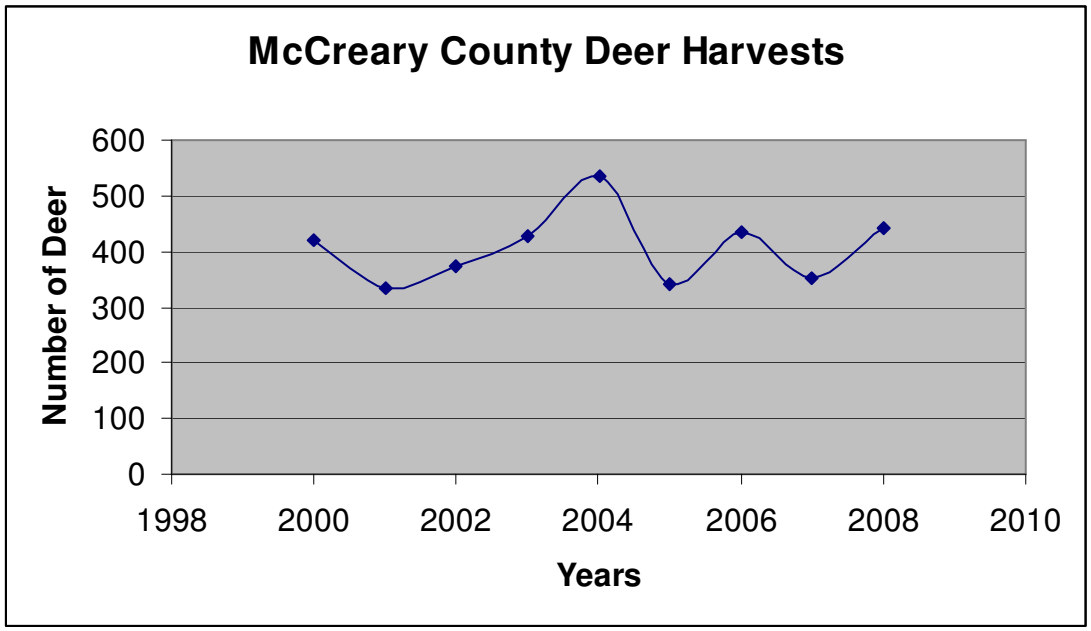
Appendix I: Laurel County Deer Harvests.
Data source: http://fw.ky.gov/harvest/deerharvest.asp
Kentucky Department of Fish and Wildlife



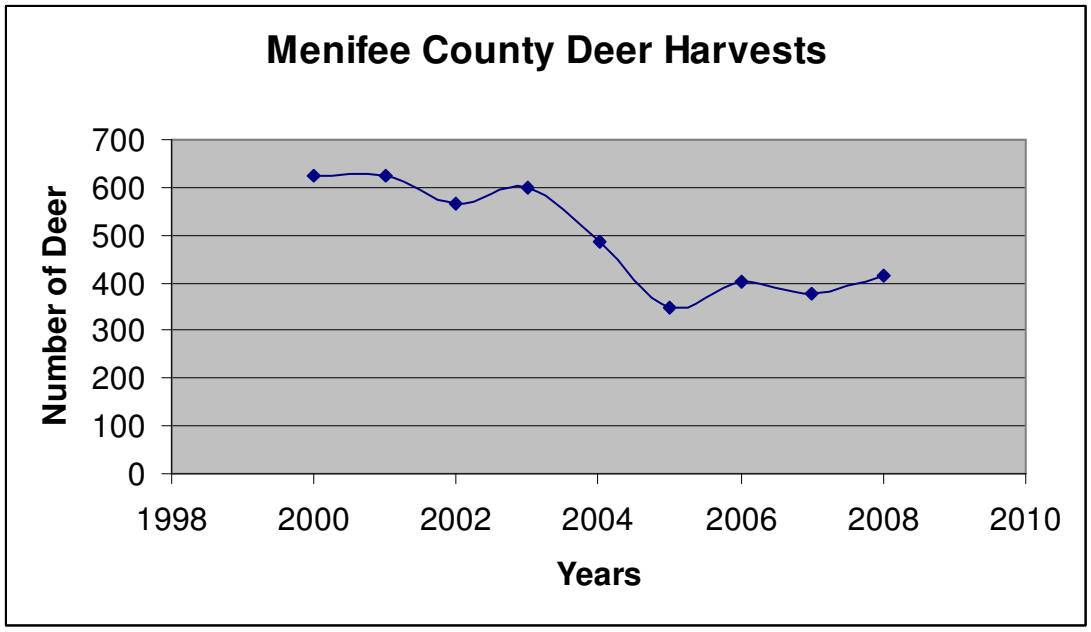
Appendix J: Lee County Deer Harvests.
Data source: http://fw.ky.gov/harvest/deerharvest.asp
Kentucky Department of Fish and Wildlife



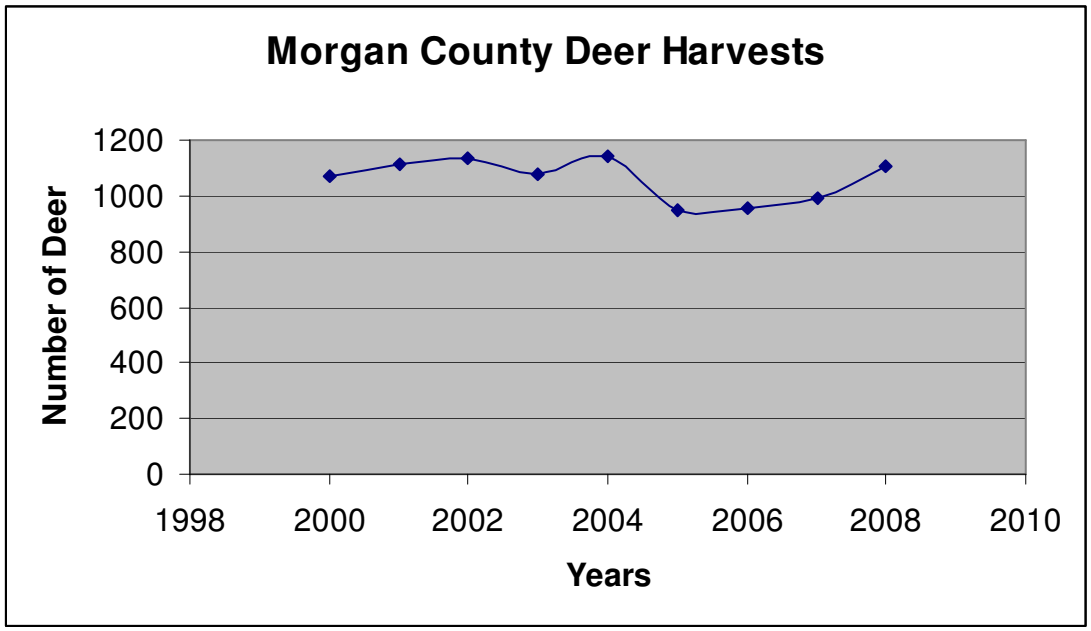
Appendix K: Leslie County Deer Harvests.
Data source: http://fw.ky.gov/harvest/deerharvest.asp
Kentucky Department of Fish and Wildlife



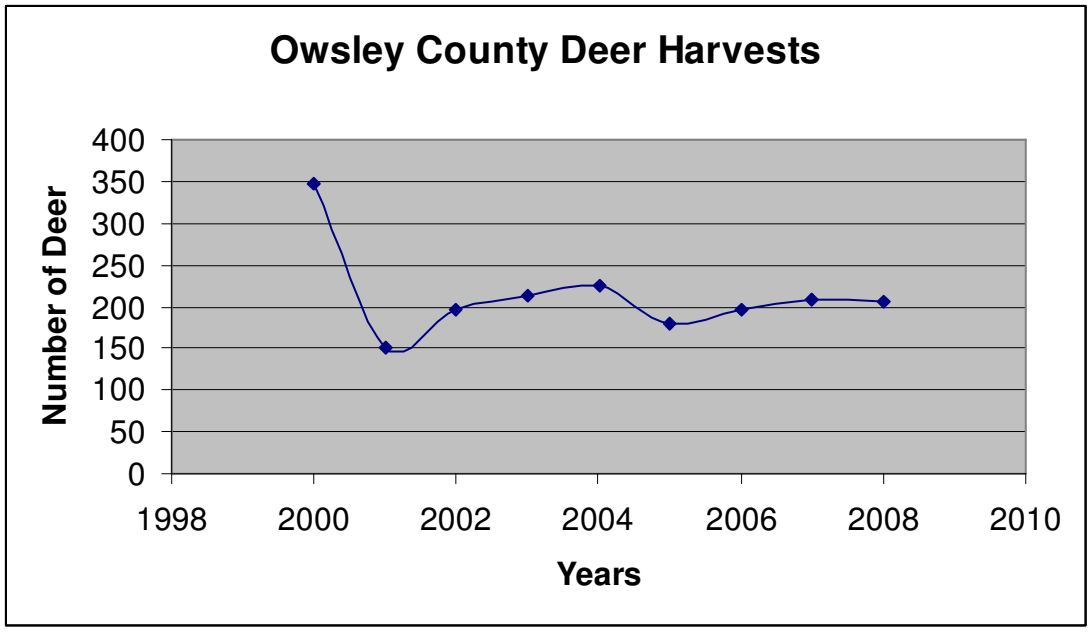
Appendix L: McCreary County Deer Harvests.
Data source: http://fw.ky.gov/harvest/deerharvest.asp
Kentucky Department of Fish and Wildlife



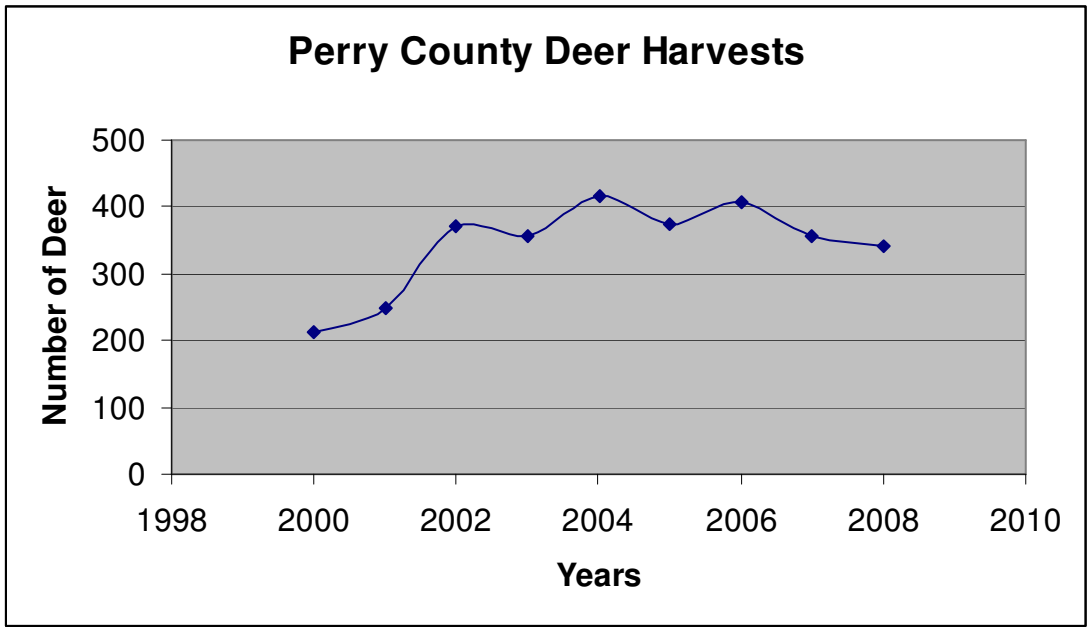
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Data source: http://fw.ky.gov/harvest/deerharvest.asp
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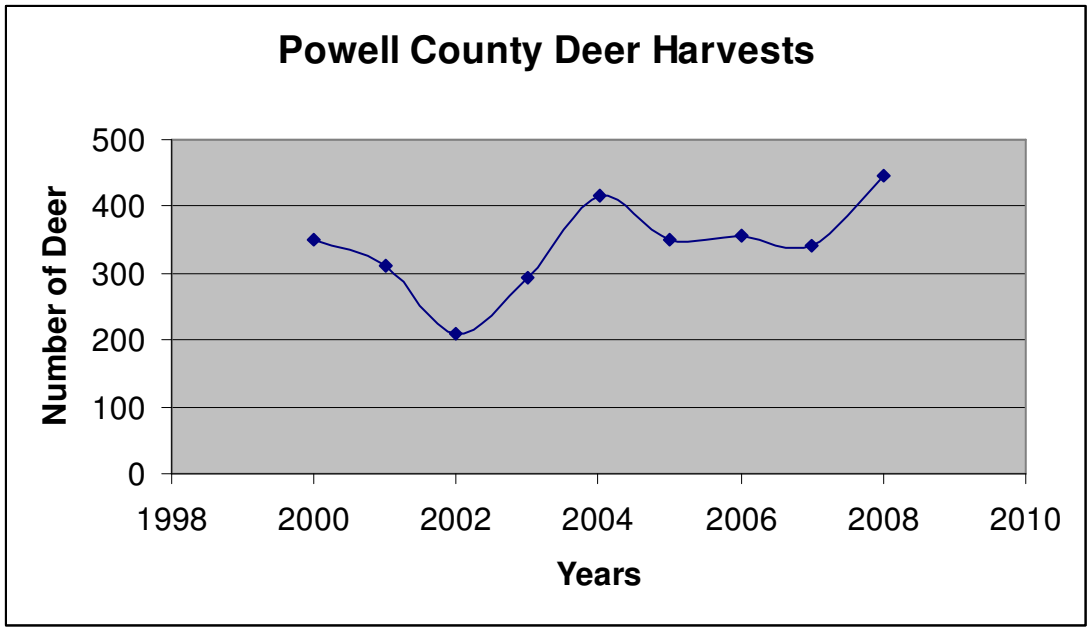
Appendix N: Morgan County Deer Harvests.
Data source: http://fw.ky.gov/harvest/deerharvest.asp
Kentucky Department of Fish and Wildlife



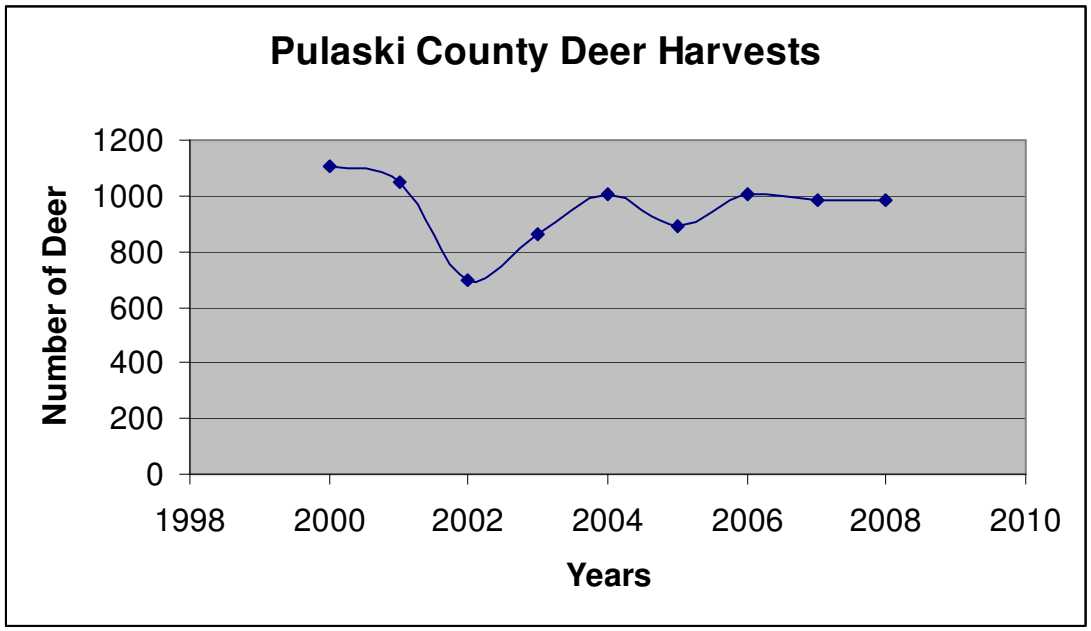
Appendix O: Owsley County Deer Harvests
Data source: http://fw.ky.gov/harvest/deerharvest.asp
Kentucky Department of Fish and Wildlife



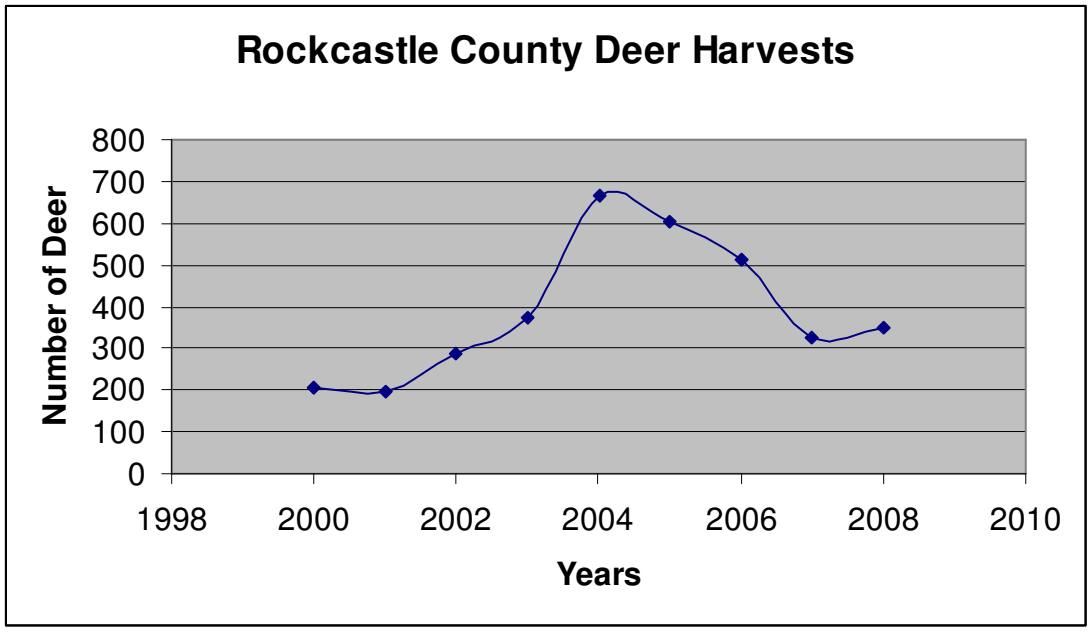
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Data source: http://fw.ky.gov/harvest/deerharvest.asp
Kentucky Department of Fish and Wildlife



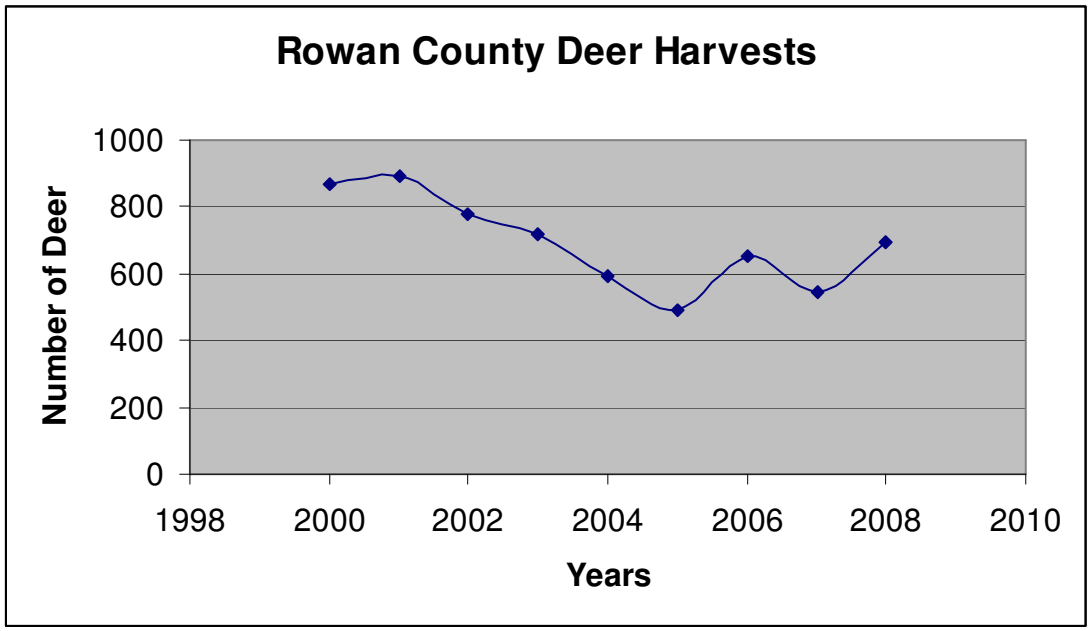
Appendix Q: Powell County Deer Harvests.
Data source: http://fw.ky.gov/harvest/deerharvest.asp
Kentucky Department of Fish and Wildlife



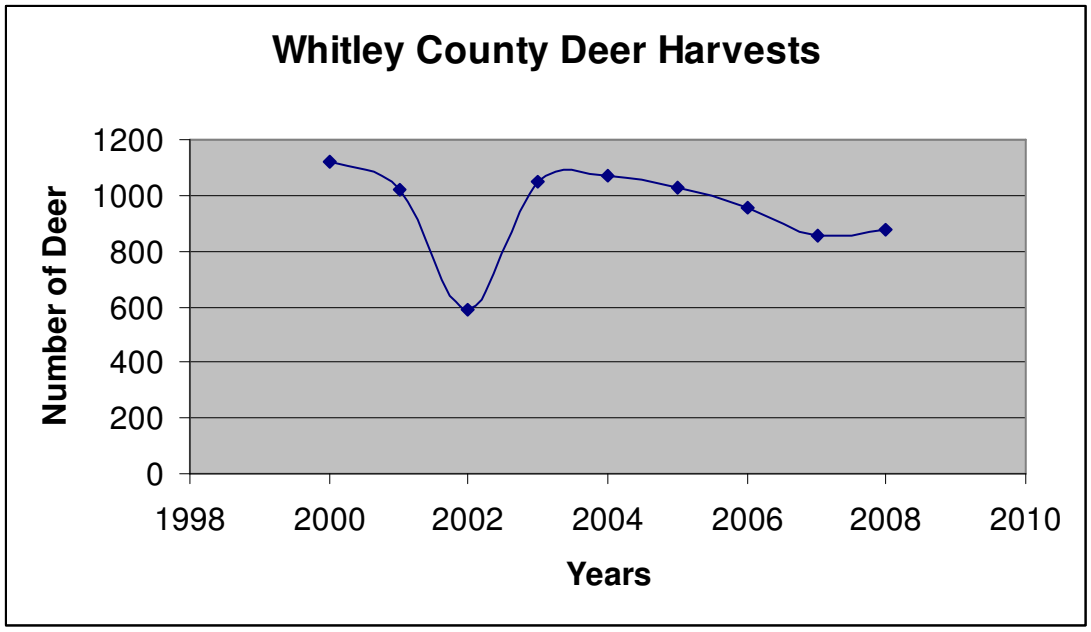
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Data source: http://fw.ky.gov/harvest/deerharvest.asp
Kentucky Department of Fish and Wildlife



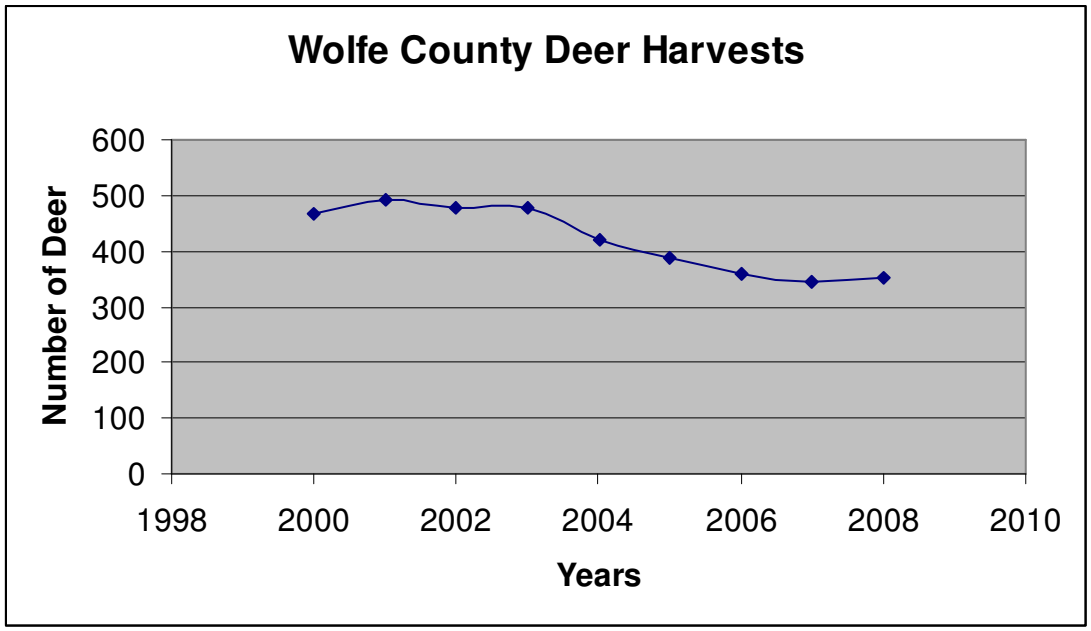
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Data source: http://fw.ky.gov/harvest/deerharvest.asp
Kentucky Department of Fish and Wildlife



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Kentucky Department of Fish and Wildlife



Appendix U: Whitley County Deer Harvests
Data source: http://fw.ky.gov/harvest/deerharvest.asp
Kentucky Department of Fish and Wildlife



Appendix V: Wolfe County Deer Harvests
Data source: http://fw.ky.gov/harvest/deerharvest.asp
Kentucky Department of Fish and Wildlife

	van Manen 2000	Chadwick et al. 2010	Dellinger et al. 2013
No. wolves	320 releases (202 wolves)	4	20 wolves, 32,000+ locations
Year(s)	1987-1997	Aug 2006, 2007, 2008	2007-2010
Landcover		multi grouped into: row-crop, mixed grasses-brush, forest	Ag fields, early successional fields, commercial pine plantations, natural areas (pocosin, lowland forests, wetlands)
study	ID correlates of release success, use correlates to evaluate prospective release areas	proportions of land-use types associated with wolf locations during ea 30-day interval.	how wolves select and use habitats associated with humans
Conclusion	Success was associated with human influences on landscape and level of wolf habituation to humans prior to release	substantial % of all locations for each wolf were in **ag areas** (40-68%); remaining locations found mostly in mixed wild grass-brush; fewest were in forest	red wolves will use **human-associated landscapes**, but modify their habitat selection patterns with increased human presence.
Notes	High humanpopulation D increase probability of conflict.negative effects of increasing road D and developed areas on release success likely reflects vulnerability of wolves to vehicle mortality and greater prob of conflict. Longer captive and acclimation periods may decrease release success due to habituation to people and subsequent need for recapture. Initial phase of release (<1 yr), management actions to prevent conflict may be reduced and survival increased by releasing in areas where conflicts are less likely (low D of humand, roads, and limited development), by using wild-reared wolves, and short acclimation pd. survival for 1-2 yr without need for management actions: estblishment of social structure may be linked to longer-term success. Coyote D and release season were important variables. Spring releases associated with forming cohesive groups and less likely to exhibit wide-ranging movements and experience conflicts.	Temporal Variation: July-Oct higher use of ag; Nov-May ag decrease while grass-brush and forest increase (coincides with harvesting, hunting for various game animals	At low human D, **Ag fields** selected over other types and in **areas close to roads;** avoid areas with high human density. Odds of use decreased as human D increased, distance to road increased, and distance to water decreased. Shift habitat use as human D and development increased.
Home Ranges		81.6-149.5 km2 - largest in late summer to winter, smallest in spring and summer	

Eastern TX	van Manen et al. 2000
Northern PA	van Manen et al. 2000
Northwestern AR	van Manen et al. 2000
Okefenokee ecosystem	van Manen et al. 2000
Southern MO	van Manen et al. 2000
Southwestern MS	van Manen et al. 2000
Eastern WV	van Manen et al. 2000
Northwestern AL	van Manen et al. 2000

Paquet et al. 1999. Wolf Reintroduction Feasibility in the Adirondack Park. GRAY WOLF

- Wolf population dynamics are believed to be largely dictated by the per capita amount of prey, vulnerability of prey, and degree of human exploitation (Keith 1983, Fuller 1989).
- The wolf shows high levels of ecological resilience compared to other large carnivores due to the species' exceptional adaptability and favorable life history traits (Weaver et al. 1996).
- Pg. 2 – High capacity to replace numbers, but usually have low populations due to…
- Generally, wolves locate their home ranges in area where adequate prey is available and human interference is low (Mladenoff et al. 1995).
- Dispersal is critical
- Pg. 3 – Citations for effects wolves have on prey
- Theoretical models suggest that habitat selection by wolves is predictable as various spatial scales.
    - Fieldwork has verified efficacy (See Appendix A)
- 4 Submodels
    - Core security area (areas where wolves least exposed to humans/activities)
        - Evaluated all cultural data layers as potential surrogates of human activities. Road layers were best proxy.
        - Buffered roads by 1 km – distance humans known to disturb wolves and distance wolves try to maintain between humans
    - Den suitability
        - 2 data layers: hydrology and soils (depth and drainage)
    - Physical
        - Created a map that reflects suitability of the physical environment to support wolves
    - Prey base
        - Abundance and distribution of the current prey base
        - Model is weak due to difficulty in monitoring prey
    - Displacement
        - Road Effects
        - Human population effects (citations for studies on effects p. 31).
- Conclusion: essential ecological requirements to sustain a breeding population:
    - Human attitude
    - Adequate and Accessible prey
    - High-quality habitat with little exposure to humans
    - Opportunities to move among habitats within home ranges
    - Connectivity/dispersal
    - Undisturbed and secure denning
    - Annual sustained mean mortality less than 30% of adult mortality
    - Permanent human densities <0.4 people/km2
    - Road D <0.27km/km2 within core areas

    - In areas outside protected landscapes, roads increase exposure to hunting; road D of traversable roads should be less than 0.6km/km2
    - Where wolves are protected, D of paved roads and railways should be less than 1.2 km/km2 within the home range
    - Traffic volume on highways accessible by wolves below 2,000 vehicles/day (mortality increases rapidly as approach 4,000)
    - Speed limits less than 70km/hr
    - Ideally where major highways exceed traffic volumes and speed limits should be elevated or buried where important wolf habitat or travel linkages occur.

Van Manen et al. 2000. Predicting Red Wolf Release Success in the Southeastern United States.

- Model applied to 31 prospective areas and calculated an index of release success for each area.
- Can be used to objectively rank prospective release areas.
- Evaluated release success (320 releases of 202 red wolves)
- Used 3 categories of independent variables that were potentially related to red wolf release success (van Manen et al. 1998)
    - Biological condition at release site (e.g., wolf pop size, coyote D, large prey index, med prey index).
    - Human influences at release site (measured livestock D, human D, improved and unimproved road D, and proportion of developed and ag area)
    - Characteristics of each release (sex, age, pre-weaning environment, previous period in the wild, number of previous releases, period in captivity, period of acclimation, translocation, release group size, and release season.
- 31 areas the model was applied to were given by USFWS – Don't know how these were ID'd
    - Areas within historic range, centered on large tracts of public land with potentially favorable habitat
- Calculated the predicted probability of release success based on habitat conditions of each area coupled with characteristics of wolves available for release.
- Applied 3 models:
    - Survival for >6 mo
    - Survival without the need for management actions for >6mo
    - Survival on federal property without management actions for >6 mo
- Results consistent with Phillips et al. 1995 and Mladenoff et al. 1995
- See page 900 for conclusions drawn on effects
- Result: Table of release sites with release success
    - 9/31 = high success potential (>0.8)
- Suggests certain criteria for individual wolves
- This approach used as an aid to biology based decisions

Region	No. of counties	Composite index
Western Florida panhandle	2	0.000
Southeastern North Carolina	7	0.333
Great Dismal Swamp ecosystem	5	0.333
Western North Carolina	11	0.364
Coastal South Carolina	7	0.429
Eastern Tennessee	10	0.500
Southern Ohio	12	0.500
North Georgia	17	0.510
Great Smoky Mountains	5	0.533
Eastern Kentucky-North central Tennessee	16	0.667
Central Louisiana	5	0.667
Southeastern Mississippi	14	0.667
Central Alabama	11	0.727
North-central South Carolina	10	0.733
Southwestern Kentucky-North-western Tennessee	4	0.750
Central coastal North Carolina	4	0.750
Southern Illinois	10	0.767
Southwestern North Carolina	6	0.778
Central Florida panhandle	6	0.778
Southern Indiana	8	0.792
Western Virginia	34	0.794
Southwestern Arkansas	13	0.795
Eastern Texas	12	0.806
Northern Pennsylvania	9	0.815
Northwestern Arkansas	14	0.833
Okefenokee ecosystem	4	0.833
Southern Missouri	28	0.857
Northern Mississippi	8	0.875
Southwestern Mississippi	7	0.905
Eastern West Virginia	9	0.926
Northwestern Alabama	3	1.000

Shaffer, Jon. 2007. "Analyzing a prospective red wolf (*Canis rufus)* reintroduction site for suitable habitat." Report 32 pages. [online] http://www.duke.edu/~jswenson/Shaffer.pdf

- Used 1 site identified by Van Manen et al. (2000)
- Does the site contain enough physically suitable habitat to support a reintroduction
- Analyzed: core habitat, connectivity, and protection of core area land
- Method similar to Paquet et al. 1999
- Patches of core habitat identified based on:
  - Road density of < 0.25km/km2 (used as appx of human D)
  - 1 km from highways
  - 2 km from incorporated towns
  - Land cover of 1 of following: deciduous, evergreen, or mized forest, shrub/scrub, grassland/herbaceous, woody wetlands, or emergent herbaceous wetlands
  - Deer D at least 5 deer/km2 (most important prey item Phillips et al. 2003)

    - Slopes no greater than 20° (great may be avoided by wolves Callaghan 1999)
    - Patch area of at least 45.6km2 (min home range size for a pack of red wolves Phillips et al. 2003)
- Low human D and distance from roads are among the most important predictors of potential red wolf habitat in NC (Kelly et al. 2004).

Jacobs, Teri. 2009. Putting the Wild Back into Wilderness: GIS Analysis of the Daniel Boone National Forest for Potential Red Wolf Reintroduction. MA Thesis. Univ. of Cincinnati.

- ID and evaluate potential sites within the Daniel Boone NF
- Instead of road D (because roads with higher traffic volumes and areas with greater road densities pose greater risks, road D may not be adequate) rank roads by mortality risk and weighed the road D to predict suitable habitat.
- Using this method ID'd 9 sites whereas using just road density ID'd 0.
- As indexes for wolf suitability, researchers on reintroductions focus mainly on D of prey, roads, and humans.
- In general, wolf D correlates with prey D (Oakleaf et al. 2006).
- Only roads with moderate to heavy traffic pose problems for wolves due to increased risk of mortality; wolves do not have aversion to roads with lower traffic volumes (Wyden et al. 2001, Mladenoff et al. 2009).
- Major roads with frequent traffic form significant barrier to wildlife movement (Heilman et al. 2002).
- Pg. 34 – studies of wolf D and road D
- Scale: 0.37-0.45km/km2 = 50-75% chance of supporting wolves; 0.63-0.84 km/km2 have highest natural mortality; 0.84-1.14 km/km2 have highest human-induced mortality.
- Pg. 35 – sustainable thresholds at 0.7 km/km2 and less than 4 humans/km2.
- Criteria for potential sites:
    - Areas with low road D (<0.7km/km2)
    - Forested, non-agriculture landscapes
    - Min area of 50 km2
- Field work used to verify suitability
    - Proximity to streams and roads
    - Slope analysis
    - Vegetation cover as surrogate for prey availability

Dellinger et al

- Uses habitat-based ratio estimator (16), along with current pop size to predict population sizes for the reintroduction sites identified.
- Uses Resource Selection Functions Resource Selection Functions were developed by estimating coefficients for landscape attributes from fixed-effects logistic regression of used versus available locations [20, 21], yielding a relative probability that can be used to rank habitats and identify areas of relatively suitable habitat for the species of interest [22].
    - Habitat Type
    - Human Density
    - Distance to Nearest Road
    - Contagion
    - Patch Density
- RSF coefficient estimates were extrapolated to historic range, resulting in a layer ranging from 0-1 with respect to relative probability of use by wolves.
- Possible reintroduction sites were areas greater than 1,500 km2 (at least 15 breeding pairs might be able to persist)
- 22 potential reintroduction sites

Fish and Wildlife Service NEPA Reference Handbook

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- **Section 4(f) of the Department of Transportation Act of 1966, as amended**

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- **Executive Order 12114, Environmental Effects Abroad of Major Federal Actions, January 4, 1979**
- **Executive Order 11988, Floodplain Management May 24, 1977**
- **Executive Order 11990, Protection of Wetlands, May 24, 1977**
- **Executive Order 12898, Environmental Justice, February 11, 1994**

CEQ NEPA REGULATIONS

- **Council on Environmental Quality's Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act (40 CFR 1500-1508, July 1986)**

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- **Council on Environmental Quality's Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations (46 FR `18026, March 23, 1981)**
- **Council on Environmental Quality's Guidance Regarding NEPA Regulations (49 FR 34236, July 28, 1983)**
- **Council on Environmental Quality's Designation of non-Federal Agencies to be Cooperating Agencies in Implementing the procedural Requirements of the National Environmental Policy Act (40 CFR 1508.5, July 28, 1999)**
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- **"Procedures for Approving and Filing Environmental Impact Statements," Department of the Interior, Environmental Statement Memorandum ESM98-2**
- **"EIS Filing Address Information for EPA," Department of the Interior, Environmental Statement Memorandum ESM00-2**
- **Handbook on Departmental review of Section 4(f) Evaluations, February 2002**
- **"Section 4(f) of the Department of the Transportation Act," Department of the Interior, Environmental Review Memorandum ERM94-4**
- **"Interventions in Proceedings of the Federal Energy Regulatory Commission (FERC)," Department of the Interior, Environmental Review Memorandum ERM99-2**
- **"Departmental Participation in Hydroelectric Power Licensing by the Federal Energy Regulatory Commission (FERC)," Department of the Interior, Environmental Review Memorandum ERM00-2**
- **Proposed Revised Department of the Interior Categorical Exclusion in 516 DM2, Appendix 1**
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- **Service Memorandum from Deputy Director to the Service Directorate regarding "The Fish and Wildlife Service and the National Environmental Policy Act," April 6, 1993**
- **Documenting and Implementing Decisions, Fish and Wildlife Service Manual (550 FW 3)**
- **Service NEPA Procedures in Departmental manual (516 DM6, Appendix 1) published in the Federal Register Vol. 62, No. 11, January 16, 1997**
- **Interagency Coordination, Environmental Responsibilities, Fish and Wildlife Service Manual (505 FW 1-5)**
- **National Environmental Policy Act Compliance Checklist, Director's Order No. 127, and Amendment 1, September 28, 2001**
- **"Proposed" National Environmental Policy Act – Policy and Responsibilities (550 FW 1) and Compliance Guidance (550 FW 2)**

CHECKLISTS FOR PREPARING ENVIRONMENTAL DOCUMENTS

- **Checklist for the Contents of a Record of Decision (ROD)**
- **Checklist for the Contents of a Finding of No Significant Impact (FONSI)**
- **NEPA Compliance Checklist (FWS Federal Financial Assistance Actions)**
- **Checklist for Refuges NEPA Compliance**
- **Checklist for Social Impacts**

- **Checklist for Section 4(f) Compliance**
- **Checklist for Economic Impacts**
- **Example of a Good EA/EIS Outline**

OTHER REFERENCES CITED

The following references are cited for your information, but are not included in full text in the NEPA Reference Handbook. To obtain copies of these please contact the Washington Office Environmental Coordinator at 703/358-2183.

1. **CEQ. "Considering Cumulative Effects Under the National Environmental Policy Act," dated January 1997.**
2. **CEQ. "Memorandum to Heads of Agencies on the Application of the National Environmental Policy Act to Proposed Federal Actions in the United States with Transboundary Effects," dated July 1, 1997.**
3. **CEQ. "Incorporating Biodiversity Considerations into Environmental Impact Analysis Under the National Environmental Policy Act," dated January 1993.**
4. **Department of the Interior. Environmental Memoranda (selected)**

    - **ESM94-3 Number of Review Copies of Environmental Statements Required by Other Federal and Federal-State Agencies**
    - **ESM94-5 Environmental Impacts on Groundwater**
    - **ESM94-6 Nationwide Inventory of Potential Wild and Scenic Rivers**
    - **ESM94-7 Prime and Unique Agricultural Lands**
    - **ESM94-8 Time Periods for Review of a Draft EIS**
    - **ESM94-9 Federal and Federal-State Agency NEPA Contacts**
    - **ESM94-10 Federal and Federal-State Agencies with Jurisdiction by Law or Special Expertise on Environmental Quality Issues**
    - **ESM94-11 Federal and Federal-State Offices for Receiving and Commenting on Other Agencies - Environmental Documents**
    - **ESM94-13 U.S. Public Health Service**
    - **ESM94-14 Other Environmental Review and Consultation Requirements**
    - **ESM94-15 National Environmental Policy Act; Pollution Prevention**
    - **ESM94-16 Procedures for Review and Approval of Bureau NEPA Appendices (516 DM 6), Handbooks, Categorical Exclusions, and Other Procedures**
    - **ESM95-3 Filing Guidance for Environmental Impact Statements**
    - **ESM96-3 Quarterly Report of Environmental Impact Statements**
    - **ESM97-2 Application of NEPA to Proposed Federal Actions in the United States with Transboundary Effects**
    - **ESM97-3 NEPA Compliance in Emergency Situations**
    - **ESM98-3 Procedures for Intra-Departmental Review of National Environmental Policy Act Compliance Documents Prepared by Bureaus and Office**
    - **ESM99-2 Designation of Non-Federal Agencies to be Cooperating Agencies in Implementing the Procedural Requirements of the National Environmental Policy Act**
    - **ESM00-3 State and Local Agency Review of Environmental Statements**
    - **ESM00-4 Publication and Distribution of Department of the Interior National Environmental Policy Act (NEPA) Compliance Documents via Electronic Methods**
    - **ESM02-2 Cooperating Agencies in Implementing the Procedural Requirements of the National Environmental Policy Act**
    - **ERM94-2 Procedures for Reviewing Project and Environmental Reports Prepared by or for Non-Federal Agencies**
    - **ERM94-3 Interim Guidance on Referrals to CEQ of Proposed Federal Actions Found to be Environmentally Unsatisfactory**

- **ERM94-7 Request for Copies of Non-Federal Review Documents**
- **ERM99-2 Interventions in Proceedings of the Federal Energy Regulatory Commission (FERC)**
- **ECM94-2 Compliance with Underground Storage Tank Requirements**
- **ECM95-3 National Environmental Policy Act (NEPA) Responsibilities Under the Departmental Environmental Justice Policy**
- **ECM97-2 Departmental Responsibilities for Indian Trust Resources and Indian Sacred Sites on Federal Lands**
- **ECM98-2 CEQ Environmental Justice Guidance under the NEPA**

5. Department of the Interior. Memorandum from Associate Solicitor, Division of General Law to Distribution List, regarding "Federal Advisory Committee Act (FACA)", dated March 4, 1996.
6. Department of the Interior. Memorandum from Assistant Solicitor to Director, OEPC, regarding "Applicability of Section 4(f) of the Department of Transportation Act to the Bowden National Fish Hatchery," dated December 24, 1975.
7. Department of the Interior. Letter from the Secretary of the Interior to the Secretary, Department of Transportation, regarding applicability of Section 4(f) to Department of the Interior Lands and Interests, dated June 25, 1980.
8. Fish and Wildlife Service. Manual, Refuge Planning, 602 FW 1-3.
9. Fish and Wildlife Service. Manual, Federal Aid Manual, 521, 522, and 523 FW.
10. Fish and Wildlife Service. Habitat Conservation Planning Handbook, November 1996.
11. Fish and Wildlife Service. Memorandum from Deputy Director to Regional Directors, Regarding "Guidance Document - Federal Highway Administrations Consideration of Wetlands in the Planning of Federal Aid Highways," dated October 1, 1990.
12. Fish and Wildlife Service. Memorandum from Acting Director to Service Directorate, Regarding "Role of Ecological Services and the Office of Human Resources in Environmental Justice," dated December 17, 1996.
13. Fish and Wildlife Service. Interagency Agreement Between National Park Service, Fish and Wildlife Service, Bureau of Land Management, and the Federal Aviation Administration Regarding Low-Level Flying Aircraft Over Natural Resource Areas, dated January 15, 1993.
14. Fish and Wildlife Service. NEPA Handbook, NEPA Policy and Internal Service Compliance, (30 AM 2-3).
15. Fish and Wildlife Service. NEPA Guidance to States Participating in the Federal Aid Program
16. Fish and Wildlife Service. Memorandum from Acting Director to Regional Directors, Regarding "Partners for Fish and Wildlife Program and NEPA Compliance," dated November 21, 2002.
17. Fish and Wildlife Service. Agreement Between the U.S. Fish and Wildlife Service and the U.S. Army Corps of Engineers for Conducting Fish and Wildlife Coordination Act Activities, January 22, 2003.
18. Fish and Wildlife Service. Memorandum of Agreement Between the U.S. Fish and Wildlife Service and the U.S. Army Corps of Engineers, January 22, 2003.
19. Fish and Wildlife Service. Partnership Agreement for Water Resources and Fish and Wildlife. U.S. Fish and Wildlife Service and U.S. Army Corps of Engineers, January 22, 2003.

Purpose of the NEPA Reference Handbook

The purpose of the NEPA Reference Handbook, as authorized in 505 FW1.7 and 550 FW 1, is to provide Fish and Wildlife Service personnel with full texts of various NEPA authorities, selected NEPA-related authorities, and NEPA-related checklists. The Handbook includes documents cited in Service NEPA guidance and Departmental procedures and memoranda. The Handbook is an accompanying document to the Service NEPA guidelines.

NEPA GLOSSARY

Affected Environment - A description of the existing environment to be affected by the proposed action (40 CFR 1502.15).

Alternative - A reasonable way to fix the identified problem or satisfy the stated need (40 CFR 1502.4).

Categorical Exclusion (CX)-A category of actions that do not individually or cumulatively have a significant effect on the human environment and have been found to have no such effect in procedures adopted by a Federal agency pursuant to NEPA (40 CFR 1508.4).

Council on Environmental Quality (CEQ) - Established under Title II of NEPA to develop Federal agency-wide policy and regulations for implementing the procedural provisions of NEPA, resolve interagency disagreements concerning proposed major Federal actions, and to ensure that Federal agency programs and procedures are in compliance with NEPA.

Cumulative Effect - The incremental environmental impact or effect of the proposed action, together with impacts of past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time (40 CFR 1508.7).

Environmental Consequences - Environmental effects of project alternatives, including the proposed action, any adverse environmental effects which cannot be avoided, the relationship between short-term uses of the human environment, and any irreversible or irretrievable commitments of resources which would be involved if the proposal should be implemented (40 CFR 1502.16).

Environmental Action Statement (EAS) - A Service-required document prepared to improve the Service's administrative record for categorically excluded actions that may be controversial, emergency actions under CEQ's NEPA regulations (40 CFR 1506.1 1), decisions based on EAs to prepare an EIS, and any decision where improved documentation of the administrative record is desirable, and to facilitate internal program review and final approval when a FONSI is to be signed at the FWS-WO and FWS-RO level (550 FW ')).

Environmental Impact Statement (EIS) - A detailed written statement required by section 102(2)(C) of NEPA, analyzing the environmental impacts of a proposed action, adverse effects of the project that cannot be avoided, alternative courses of action, short-term uses of the enviromnent versus the maintenance and enhancement of long-term productivity, and any irreversible and irretrievable commitment of resources (40 CFR 1508.1 1).

Environmental Assessment (EA) - A concise public document, prepared in compliance with NEPA, that briefly discusses the purpose and need for an action, alternatives to such action, and provides sufficient evidence and analysis of impacts to determine whether to prepare an environmental impact statement or finding of no significant impact (40 CFR 1508.9).

Finding of No Significant Impact (FONSI) - A document prepared in compliance with NEPA, supported by an environmental assessment, that analyzes whether a Federal action will have no significant effect on the human environment and for which an environmental impact statement, therefore, will not be prepared 40 CFR 1508.13).

Human Environment - Includes the natural and physical environment and the relationship of people with the environment (40 CFR 1508.14).

Impact (Effect) - A direct result of an action which occurs at the same time and place; or an indirect result of an action which occurs later in time or in a different place and is reasonably foreseeable; or the cumulative results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions (40 CFR 1508.8).

Lead Agency - The agency or agencies responsible for preparing the environmental impact statement (40 CFR 1508.16).

Major Federal Action - Actions with effects that may be major and which are potentially subject to Federal control and responsibility (40 CFR 1508.18).

Mitigation - Planning actions taken to avoid an impact altogether to minimize the degree or magnitude of the impact, reduce the impact over time, rectify the impact, or compensate for the impact (40 CFR 1508.20)

National Environmental Policy Act of 1969 (NEPA) -Requires all agencies, including the Service, to examine the environmental impacts of their actions, incorporate environmental information, and utilize public participation in the planning and implementation of all actions. Federal agencies must integrate NEPA with other planning requirements and prepare appropriate NEPA documents to facilitate better environmental decision making. NEPA requires Federal agencies to review and comment on Federal agency environmental plans/documents when the agency has jurisdiction by law or special expertise with respect to any environmental impacts involved. (42 U.S.C. 4321-4327) (40 CFR 1500-1508).

Notice of Intent (NOI) - A notice that an environmental impact statement will be prepared and considered (40 CFR 1508.22).

No Action Alternative - The alternative where current conditions and trends are projected into the future without another proposed action (40 CFR 1502.14(d)).

Proposed Action - A plan that contains sufficient details about the intended actions to be taken, or that will result, to allow alternatives to be developed and its environmental impacts analyzed (40 CFR 1508.23).
Record of Decision (ROD) - A concise public record of decision prepared by the Federal agency, pursuant to NEPA. that contains a statement of the decision, identification of all alternatives considered, identification of the environmentally preferable alternative, a statement as to whether all practical means to avoid or minimize environmental harm from the alternative selected have been adopted (and if not, why they were not), and a summary of monitoring and enforcement where applicable for any mitigation (40 CFR 1505.2).

Relationship of Short-Term Uses and Long-Term Productivity - The balance or trade-off between short-term uses and long-term productivity need to be defined in relation to the proposed activity in question. Each resource, of necessity, has to be provided with its own definitions of short- term and long-term (40 CFR 1502.16).

Scope - The range of actions, alternatives, and impacts to be considered in an environmental impact statement (40 CFR 1508.25).

Scoping - An early and open process for determining the extent and variety of issues to be addressed and for identifying the significant issues related to a proposed action (40 CFR 1501.7).

Significant - Use in NEPA requires consideration of both context and intensity (40 CFR 1508.27):

> Context - significance of an action must be analyzed in its current and proposed short-and long-term effects on the whole of a given resource (e.g.-affected region) Intensity - Refers to the severity of the effect

Tiering - The coverage of general matters in broader environmental impact statements with subsequent narrower statements of environmental analysis, incorporating by reference, the general discussions and concentrating on specific issues (40 CFR 1508.28).

Unavoidable Adverse Effects - Effects that can not be avoided due to constraints in alternatives. These effects do not have to be avoided by the planning agency, but they must be disclosed, discussed, and mitigated, if possible (40 CFR 1500.2(e).

ABBREVIATIONS AND ACRONYMS

AD-ES	Assistant Director - Ecological Services
BLM	Bureau of Land Management
BR	Bureau of Reclamation
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
CG	U.S. Coast Guard
Corps	U.S. Army Corps of Engineers
CX	Categorical Exclusion
DHC	Division of Habitat Conservation
Director	Director, U.S. Fish and Wildlife Service
D-J	Dingell-Johnson Act (Federal Aid in Sport Fish Restoration Act)
DOI or Department	Department of Interior
DOT	Department of Transportation
EA	Environmental Assessment
EC	Environmental Coordination
ED	Environmental Document
EIS	Environmental Impact Statement
EO	Executive Order
EPA	Environmental Protection Agency
ER	Environmental Review
ES	Ecological Services
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FERC	Federal Energy Regulatory Commission
FHWA	Federal Highway Administration
FONSI	Finding of No Significant Impact
FWCA	Fish and Wildlife Coordination Act
ES Transmittal	ES Environmental Review Distribution Transmittal
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MMPA	Marine Mammal Protection Act
NEPA	National Environmental Policy Act
NEPA Regulations	CEQ Regulations for Implementing the Procedural Provisions of NEPA
NOA	Notice of Availability
NOI	Notice of Intent
NPS	National Park Service
OEA	Office of Environmental Affairs (DOI)
P-R	Pittman-Robertson Act (Federal Aid in Wildlife Restoration Act)
PNRS	Preliminary Natural Resources Survey
REC	Regional Environmental Coordinator (Service)
REO	Regional Environmental Officer (DOI)

Secretary	Secretary of the Interior
Service	U.S. Fish and Wildlife Service
SOW	Scope of Work
WO	Washington Office

The National Environmental Policy Act of 1969

The National Environmental Policy Act of 1969, as amended

(Pub. L. 91-190, 42 U.S.C. 4321-4347, January 1, 1970, as amended by Pub. L. 94-52, July 3, 1975, Pub. L. 94-83, August 9, 1975, and Pub. L. 97-258, § 4(b), Sept. 13, 1982)

An Act to establish a national policy for the environment, to provide for the establishment of a Council on Environmental Quality, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "National Environmental Policy Act of 1969."

Purpose

Sec. 2 [42 USC § 4321].

The purposes of this Act are: To declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality.

TITLE I

CONGRESSIONAL DECLARATION OF NATIONAL ENVIRONMENTAL POLICY

Sec. 101 [42 USC § 4331].

(a) The Congress, recognizing the profound impact of man's activity on the interrelations of all components of the natural environment, particularly the profound influences of population growth, high-density urbanization, industrial expansion, resource exploitation, and new and expanding technological advances and recognizing further the critical importance of restoring and maintaining environmental quality to the overall welfare and development of man, declares that it is the continuing policy of the Federal Government, in cooperation with State and local governments, and other concerned public and private organizations, to use all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans.

(b) In order to carry out the policy set forth in this Act, it is the continuing responsibility of the Federal Government to use all practicable means, consist with other essential considerations of national policy, to improve and coordinate Federal plans, functions,

programs, and resources to the end that the Nation may --

1. fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;

2. assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings;

3. attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences;

4. preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity, and variety of individual choice;

5. achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities; and

6. enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

(c) The Congress recognizes that each person should enjoy a healthful environment and that each person has a responsibility to contribute to the preservation and enhancement of the environment.

Sec. 102 [42 USC § 4332].

The Congress authorizes and directs that, to the fullest extent possible: (1) the policies, regulations, and public laws of the United States shall be interpreted and administered in accordance with the policies set forth in this Act, and (2) all agencies of the Federal Government shall --

(A) utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decisionmaking which may have an impact on man's environment;

(B) identify and develop methods and procedures, in consultation with the Council on Environmental Quality established by title II of this Act, which will insure that presently unquantified environmental amenities and values may be given appropriate consideration in decisionmaking along with economic and technical considerations;

(C) include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on --

(i) the environmental impact of the proposed action,

(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,

(iii) alternatives to the proposed action,

(iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

(v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Prior to making any detailed statement, the responsible Federal official shall consult with and obtain the comments of any Federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved. Copies of such statement and the comments and views of the appropriate Federal, State, and local agencies, which are authorized to develop and enforce environmental standards, shall be made available to the President, the Council on Environmental Quality and to the public as provided by section 552 of title 5, United States Code, and shall accompany the proposal through the existing agency review processes;

(D) Any detailed statement required under subparagraph (C) after January 1, 1970, for any major Federal action funded under a program of grants to States shall not be deemed to be legally insufficient solely by reason of having been prepared by a State agency or official, if:

(i) the State agency or official has statewide jurisdiction and has the responsibility for such action,

(ii) the responsible Federal official furnishes guidance and participates in such preparation,

(iii) the responsible Federal official independently evaluates such statement prior to its approval and adoption, and

(iv) after January 1, 1976, the responsible Federal official provides early notification to, and solicits the views of, any other State or any Federal land management entity of any action or any alternative thereto which may have significant impacts upon such State or affected Federal land management entity and, if there is any disagreement on such impacts, prepares a written assessment of such impacts and views for incorporation into such detailed statement.

The procedures in this subparagraph shall not relieve the Federal official of his responsibilities for the scope, objectivity, and content of the entire statement or of any other responsibility under this Act; and further, this subparagraph does not affect the legal sufficiency of statements prepared by State agencies with less than statewide jurisdiction.

(E) study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources;

(F) recognize the worldwide and long-range character of environmental problems and,

where consistent with the foreign policy of the United States, lend appropriate support to initiatives, resolutions, and programs designed to maximize international cooperation in anticipating and preventing a decline in the quality of mankind's world environment;

(G) make available to States, counties, municipalities, institutions, and individuals, advice and information useful in restoring, maintaining, and enhancing the quality of the environment;

(H) initiate and utilize ecological information in the planning and development of resource-oriented projects; and

(I) assist the Council on Environmental Quality established by title II of this Act.

Sec. 103 [42 USC § 4333].

All agencies of the Federal Government shall review their present statutory authority, administrative regulations, and current policies and procedures for the purpose of determining whether there are any deficiencies or inconsistencies therein which prohibit full compliance with the purposes and provisions of this Act and shall propose to the President not later than July 1, 1971, such measures as may be necessary to bring their authority and policies into conformity with the intent, purposes, and procedures set forth in this Act.

Sec. 104 [42 USC § 4334].

Nothing in section 102 [42 USC § 4332] or 103 [42 USC § 4333] shall in any way affect the specific statutory obligations of any Federal agency (1) to comply with criteria or standards of environmental quality, (2) to coordinate or consult with any other Federal or State agency, or (3) to act, or refrain from acting contingent upon the recommendations or certification of any other Federal or State agency.

Sec. 105 [42 USC § 4335].

The policies and goals set forth in this Act are supplementary to those set forth in existing authorizations of Federal agencies.

TITLE II

COUNCIL ON ENVIRONMENTAL QUALITY

Sec. 201 [42 USC § 4341].

The President shall transmit to the Congress annually beginning July 1, 1970, an Environmental Quality Report (hereinafter referred to as the "report") which shall set forth (1) the status and condition of the major natural, manmade, or altered environmental classes of the Nation, including, but not limited to, the air, the aquatic, including marine, estuarine, and fresh water, and the terrestrial environment, including, but not limited to, the forest, dryland, wetland, range, urban, suburban an rural environment; (2) current and foreseeable trends in the quality, management and utilization of such environments and the effects of those trends on the social, economic, and other requirements of the Nation; (3) the adequacy of available natural resources for fulfilling human and economic requirements of the Nation

in the light of expected population pressures; (4) a review of the programs and activities (including regulatory activities) of the Federal Government, the State and local governments, and nongovernmental entities or individuals with particular reference to their effect on the environment and on the conservation, development and utilization of natural resources; and (5) a program for remedying the deficiencies of existing programs and activities, together with recommendations for legislation.

Sec. 202 [42 USC § 4342].

There is created in the Executive Office of the President a Council on Environmental Quality (hereinafter referred to as the "Council"). The Council shall be composed of three members who shall be appointed by the President to serve at his pleasure, by and with the advice and consent of the Senate. The President shall designate one of the members of the Council to serve as Chairman. Each member shall be a person who, as a result of his training, experience, and attainments, is exceptionally well qualified to analyze and interpret environmental trends and information of all kinds; to appraise programs and activities of the Federal Government in the light of the policy set forth in title I of this Act; to be conscious of and responsive to the scientific, economic, social, aesthetic, and cultural needs and interests of the Nation; and to formulate and recommend national policies to promote the improvement of the quality of the environment.

Sec. 203 [42 USC § 4343].

(a) The Council may employ such officers and employees as may be necessary to carry out its functions under this Act. In addition, the Council may employ and fix the compensation of such experts and consultants as may be necessary for the carrying out of its functions under this Act, in accordance with section 3109 of title 5, United States Code (but without regard to the last sentence thereof).

(b) Notwithstanding section 1342 of Title 31, the Council may accept and employ voluntary and uncompensated services in furtherance of the purposes of the Council.

Sec. 204 [42 USC § 4344].

It shall be the duty and function of the Council --

1. to assist and advise the President in the preparation of the Environmental Quality Report required by section 201 [42 USC § 4341] of this title;

2. to gather timely and authoritative information concerning the conditions and trends in the quality of the environment both current and prospective, to analyze and interpret such information for the purpose of determining whether such conditions and trends are interfering, or are likely to interfere, with the achievement of the policy set forth in title I of this Act, and to compile and submit to the President studies relating to such conditions and trends;

3. to review and appraise the various programs and activities of the Federal Government in the light of the policy set forth in title I of this Act for the purpose of determining the extent to which such programs and activities are contributing to the achievement

of such policy, and to make recommendations to the President with respect thereto;

4. to develop and recommend to the President national policies to foster and promote the improvement of environmental quality to meet the conservation, social, economic, health, and other requirements and goals of the Nation;

5. to conduct investigations, studies, surveys, research, and analyses relating to ecological systems and environmental quality;

6. to document and define changes in the natural environment, including the plant and animal systems, and to accumulate necessary data and other information for a continuing analysis of these changes or trends and an interpretation of their underlying causes;

7. to report at least once each year to the President on the state and condition of the environment; and

8. to make and furnish such studies, reports thereon, and recommendations with respect to matters of policy and legislation as the President may request.

Sec. 205 [42 USC § 4345].

In exercising its powers, functions, and duties under this Act, the Council shall --

1. consult with the Citizens' Advisory Committee on Environmental Quality established by Executive Order No. 11472, dated May 29, 1969, and with such representatives of science, industry, agriculture, labor, conservation organizations, State and local governments and other groups, as it deems advisable; and

2. utilize, to the fullest extent possible, the services, facilities and information (including statistical information) of public and private agencies and organizations, and individuals, in order that duplication of effort and expense may be avoided, thus assuring that the Council's activities will not unnecessarily overlap or conflict with similar activities authorized by law and performed by established agencies.

Sec. 206 [42 USC § 4346].

Members of the Council shall serve full time and the Chairman of the Council shall be compensated at the rate provided for Level II of the Executive Schedule Pay Rates [5 USC § 5313]. The other members of the Council shall be compensated at the rate provided for Level IV of the Executive Schedule Pay Rates [5 USC § 5315].

Sec. 207 [42 USC § 4346a].

The Council may accept reimbursements from any private nonprofit organization or from any department, agency, or instrumentality of the Federal Government, any State, or local government, for the reasonable travel expenses incurred by an officer or employee of the Council in connection with his attendance at any conference, seminar, or similar meeting conducted for the benefit of the Council.

Sec. 208 [42 USC § 4346b].

The Council may make expenditures in support of its international activities, including expenditures for: (1) international travel; (2) activities in implementation of international agreements; and (3) the support of international exchange programs in the United States and in foreign countries.

Sec. 209 [42 USC § 4347].

There are authorized to be appropriated to carry out the provisions of this chapter not to exceed $300,000 for fiscal year 1970, $700,000 for fiscal year 1971, and $1,000,000 for each fiscal year thereafter.

The Environmental Quality Improvement Act, as amended (Pub. L. No. 91- 224, Title II, April 3, 1970; Pub. L. No. 97-258, September 13, 1982; and Pub. L. No. 98-581, October 30, 1984.

42 USC § 4372.

(a) There is established in the Executive Office of the President an office to be known as the Office of Environmental Quality (hereafter in this chapter referred to as the "Office"). The Chairman of the Council on Environmental Quality established by Public Law 91-190 shall be the Director of the Office. There shall be in the Office a Deputy Director who shall be appointed by the President, by and with the advice and consent of the Senate.

(b) The compensation of the Deputy Director shall be fixed by the President at a rate not in excess of the annual rate of compensation payable to the Deputy Director of the Office of Management and Budget.

(c) The Director is authorized to employ such officers and employees (including experts and consultants) as may be necessary to enable the Office to carry out its functions ;under this chapter and Public Law 91-190, except that he may employ no more than ten specialists and other experts without regard to the provisions of Title 5, governing appointments in the competitive service, and pay such specialists and experts without regard to the provisions of chapter 51 and subchapter III of chapter 53 of such title relating to classification and General Schedule pay rates, but no such specialist or expert shall be paid at a rate in excess of the maximum rate for GS-18 of the General Schedule under section 5332 of Title 5.

(d) In carrying out his functions the Director shall assist and advise the President on policies and programs of the Federal Government affecting environmental quality by --

1. providing the professional and administrative staff and support for the Council on Environmental Quality established by Public Law 91- 190;

2. assisting the Federal agencies and departments in appraising the effectiveness of existing and proposed facilities, programs, policies, and activities of the Federal Government, and those specific major projects designated by the President which

do not require individual project authorization by Congress, which affect environmental quality;

3. reviewing the adequacy of existing systems for monitoring and predicting environmental changes in order to achieve effective coverage and efficient use of research facilities and other resources;

4. promoting the advancement of scientific knowledge of the effects of actions and technology on the environment and encouraging the development of the means to prevent or reduce adverse effects that endanger the health and well-being of man;

5. assisting in coordinating among the Federal departments and agencies those programs and activities which affect, protect, and improve environmental quality;

6. assisting the Federal departments and agencies in the development and interrelationship of environmental quality criteria and standards established throughout the Federal Government;

7. collecting, collating, analyzing, and interpreting data and information on environmental quality, ecological research, and evaluation.

(e) The Director is authorized to contract with public or private agencies, institutions, and organizations and with individuals without regard to section 3324(a) and (b) of Title 31 and section 5 of Title 41 in carrying out his functions.

42 USC § 4373. Each Environmental Quality Report required by Public Law 91-190 shall, upon transmittal to Congress, be referred to each standing committee having jurisdiction over any part of the subject matter of the Report.

42 USC § 4374. There are hereby authorized to be appropriated for the operations of the Office of Environmental Quality and the Council on Environmental Quality not to exceed the following sums for the following fiscal years which sums are in addition to those contained in Public Law 91- 190:

(a) $2,126,000 for the fiscal year ending September 30, 1979.

(b) $3,000,000 for the fiscal years ending September 30, 1980, and September 30, 1981.

(c) $44,000 for the fiscal years ending September 30, 1982, 1983, and 1984.

(d) $480,000 for each of the fiscal years ending September 30, 1985 and 1986.

42 USC § 4375.

(a) There is established an Office of Environmental Quality Management Fund (hereinafter referred to as the "Fund") to receive advance payments from other agencies or accounts that may be used solely to finance --

1. study contracts that are jointly sponsored by the Office and one or more other Federal agencies; and

2. Federal interagency environmental projects (including task forces) in which the Office participates.

(b) Any study contract or project that is to be financed under subsection (a) of this section may be initiated only with the approval of the Director.

(c) The Director shall promulgate regulations setting forth policies and procedures for operation of the Fund.

Office of Federal Activities

Section 309 - Clean Air Act

(a) The Administrator shall review and comment in writing on the environmental impact of any matter relating to duties and responsibilites granted pursuant to this Act or other provisions of the authority of the Administrator, contained in any (1) legislation proposed by any Federal department or agency, (2) newly authorized Federal projects for construction and any major Federal agency action (other than a project for construction) to which Section 102(2)(C) of Public Law 91-190[*] applies, and (3) proposed regulations published by any department or agency of the Federal government. Such written comment shall be made public at the conclusion of any such review.

(b) In the event the Administrator determines that any such legislation, action, or regulation is unsatisfactory from the standpoint of public health or welfare to environmental quality, he shall publish his determination and the matter shall be referred to the Council on Environmental Quality.

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[*] NEPA (42 USC 4332(2)(C) et seq.)

Section 4(f) of the DOT ACT

Section 4(f) fo the Department of Transportation Act (80 Stat. 931; Public Law 89-670) as amended in Section 18 of the Federal Aid Highway Act of 1968 (82 Stat. 815; Public Law 90-495).

A(f) It is hereby declared to be the national policy that special effort should be made to preserve the natural beauty of the countryside and public park and recreation lands, wildlife and waterfowl refuges, and historic sites. The Secretary of Transportation shall cooperate and consult with the Secretaries of the Interior, Housing and Urban Development, and Agriculture, and with the States in developing transportation plans and programs that include measures to maintain or enhance the natural beauty of the lands traversed. After the effective date of the Federal-Aid Highway Act of 1968, the Secretary shall not approve any program or project which requires the use of any publicly owned land from fowl refuge of national, State, or local significance as determined by the Federal, State, or local officials having jurisdiction thereof, or any land from an historic site of national, State, or local significance as so determined by such officials unless (1) there is no feasible and prudent alternative to the use of such land, and (2) such program includes all possible planning to minimize harm to such park, recreational area, wildlife and waterfowl refuge, or historic site resulting from such use.@

Section 4(f) is Codified in:

23 U.S.C. 138 and 49 U.S.C. 163 (f)

Executive Order 12114 of January 4,1979

Environmental Effects Abroad of Major Federal Actions

By virtue of the authority vested in me by the Constitution and the laws of the United States, and as President of the United States, in order to further environmental objectives consistent with the foreign policy and national security policy of the United States, it is ordered as follows:

Section 1.

1-1. Purpose and Scope. The purpose of this Executive Order is to enable responsible officials of Federal agencies having ultimate responsibility for authorizing and approving actions encompassed by this Order to be informed of pertinent environmental considerations and to take such considerations into account, with other pertinent considerations of national policy, in making decisions regarding such actions. While based on independent authority, this Order furthers the purpose of the National Environmental Policy Act and the Marine Protection Research and Sanctuaries Act and the Deepwater Port Act consistent with the foreign policy and national security policy of the United States. and represents the United States government's exclusive and complete determination of the procedural and other actions to be taken by Federal agencies to further the purpose of the National Environmental Policy Act. with respect to the environment outside the United States, its territories and possessions.

Sec. 2.

2-1. Agency Procedures. Every Federal agency taking major Federal actions encompassed hereby and not exempted herefrom having significant effects on the environment outside the geographical borders of the United States and its territories and possessions shall within eight months after the effective date of this Order have in effect procedures to implement this Order. Agencies shall consult with the Department of State and the Council on Environmental Quality concerning such procedures prior to placing them in effect.

2-2. Information Exchange. To assist in effectuating the foregoing purpose, the Department of State and the Council on Environmental Quality in collaboration with other interested Federal agencies and other nations shall conduct a program for exchange on a continuing basis of information concerning the environment. The objectives of this program shall be to provide information for use by decision makers to heighten awareness of

and interest in environmental concerns and, as appropriate, to facilitate environmental cooperation with foreign nations.

2-3. *Actions Included.* Agencies in their procedures under Section 2-1 shall establish procedures by which their officers having ultimate responsibility for authorizing and approving actions in one of the following categories encompassed by this Order, take into consideration in making decisions concerning such actions, a document described in Section 2-4(a):

(a) major Federal actions significantly affecting the environment of the global commons outside the jurisdiction of any nation (e.g.; the oceans or Antarctica);

(b) major Federal actions significantly affecting the environment of a foreign nation not participating with the United States and not otherwise involved in the action;

(c) major Federal actions significantly affecting the environment of a foreign nation which provide to that nation:

(1) a product, or physical project producing a principal product or an emission or effluent, which is prohibited or strictly regulated by Federal law in the United States because its toxic effects on the environment create a serious public health risk; or

(2) a physical project which in the United States is prohibited or strictly regulated by Federal law to protect the environment against radioactive substances.

(d) major Federal actions outside the United States, its territories and possessions which significantly affect natural or ecological resources of global importance designated for protection under this subsection by the President, or, in the case of such a resource protected by international agreement binding on the United States, by the Secretary of State. Recommendations to the President under this subsection shall be accompanied by the views of the Council an Environmental Quality and the Secretary of State.

2-4. Applicable Procedures. (a) There are the following types of documents to be used in connection with actions described in Section 2-3:

(i) environmental impact statements (including generic, program and specific statements):

(ii) bilateral or multilateral environmental studies, relevant or related to the proposed action, by the United States and one more foreign nations, or by an international body or organization in which the United States is a member or participant; or

(iii) concise reviews of the environmental issues involved, including environmental assessments, summary environmental analyses or other appropriate documents.

(b) Agencies shall in their procedures provide for preparation of documents described in Section 2-4(a, with respect to actions described in Section 2-3, as follows:

(i) for effects described in Section 2-3(a), an environmental impact statement described in Section 2-4(a)(i);

(ii) for effects described in Section 2-3(b), a document described in Section 2-4(a)(ii) or (iii) as determined by the agency;

(iii) for effects described in Section 2-3(a), a document described in Section 2-4(a)(ii) or (iii), as determined by the agency;

(iv) for effects described in Section 2-3(d), a document described in Section 2-4(a)(i), (ii) or (iii). As determined by the agency.

Such procedures may provide that an agency need not prepare a new document when a document described in Sec 2-4(a) already exists.

(c) Nothing in this Order shall serve to invalidate any existing regulations of any agency which have been adopted pursuant to court order or pursuant to judicial settlement of any case or to prevent any agency from providing in its procedures for measures in addition to those provided for herein to further the purpose of the National Environmental Policy Act and other environmental laws, including the Marine Protection Research and Sanctuaries Act and the Deepwater Port Act, consistent with the foreign and national security policies of the United States.

(d) Except as provided in Section 2-5(b), agencies taking action encompassed by this Order shall, as soon as feasible, inform other Federal agencies with relevant expertise of the availability of environmental documents prepared under this Order.

Agencies in their procedures under Section 2-1 shall make appropriate provision for determining when an affected nation shall be informed in accordance with Section 3-2 of this Order of the availability of environmental documents prepared pursuant to those procedures.

In order to avoid duplication of resources, agencies in their procedures shall provide for appropriate utilization of the resources of other Federal agencies with relevant environmental jurisdiction or expertise.

2-5. Exemptions and considerations. (a) Notwithstanding Section 2-3, the following actions are exempt from this Order:

(i) actions not having a significant effect on the environment outside the United States as determined by the agency;

(ii) actions taken by the President;

(iii) actions taken by or pursuant to the direction of the President or Cabinet officer when the national security or interest is involved or when the action occurs in the course of an armed conflict;

(iv) intelligence activities and arms transfers;

(v) export licenses or permits or export approvals, and actions relating to nuclear activities except actions providing to a foreign nation a nuclear production or utilization facility as defined in the Atomic Energy Act of 1954, as amended, or a nuclear waste management facility;

(vi) votes and other actions in international conferences and organizations;

(vii) disaster and emergency relief action.

(b) Agency procedures under Section 2-1 implementing Section 2-4 may provide for appropriate modifications in the contents, timing and availability of documents to other affected Federal agencies and affected nations, where necessary to:

(i) enable the agency to decide and act promptly as and when required;

(ii) avoid adverse impacts on foreign relations or infringement in fact or appearance of other nations' sovereign responsibilities, or

(iii) ensure appropriate reflection of:

(1) diplomatic factors;

(2) international commercial, competitive and export promotion factors;

(3) needs for governmental or commercial confidentiality;

(4) national security considerations;

(5) difficulties of obtaining information and agency ability to analyze meaningfully environmental effects of a proposed action; and

(6) the degree to which the agency is involved in or able to affect a decision to be made.

(c) Agency procedure under Section 2-1 may provide for categorical exclusions and for such exemptions in addition to those specified in subsection (a) of this Section as may be necessary to meet emergency circumstances, situations involving exceptional foreign policy and national security sensitivities and other such special circumstances. In utilizing such additional exemptions agencies shall, as soon as feasible, consult with the Department of State and the Council on Environmental Quality.

(d) The provisions of Section 2-5 do not apply to actions described in Section 2-3(a) unless permitted by law.

Sec. 3.

3-2. Rights of Action. This Order is solely for the purpose of establishing internal procedures for Federal agencies to consider the significant effects of their actions on the environment outside the United States, its territories and possessions, and nothing in this Order shall be construed to create a cause of action.

3-2. Foreign Relations. The Department of State shall coordinate all communications by agencies with foreign governments concerning environmental agreements and other arrangements in implementation of this Order.

3-3. Mufti-Agency Actions. Where more than one Federal agency is involved in an action or program, a lead agency, as determined by the agencies involved, shall have responsibility for implementation of this Order.

3-4. Certain Terms. For purposes of this Order, "environment" means the natural and physical environment and excludes social, economic and other environments; and an action significantly affects the environment if it does significant harm to the environment even though on balance the agency believes the action to be beneficial to the environment. The term "export approvals" in Section 2-5(a)(v) does not mean or include direct loans to finance exports.

3-5. Multiple Impacts. If a major Federal action having effects on the environment of the United States or the global commons requires preparation of an environmental impact statement, and if the action also has effects on the environment of a foreign nation, an environmental impact statement need not be prepared with respect to the effects on the environment of the foreign nation.

The White House.
January 4,1979

[FR Doc. 79-869
Filed 1-5-79; 3:38 pm]

EXECUTIVE ORDER 11988

FLOODPLAIN MANAGEMENT

HISTORY: May 24, 1977; 42 FR 26951, 3 CFR, 1977 Comp., p. 117; Amended by Executive Order 12148, July 20, 1979; 44 FR 43239, 3 CFR, 1979 Comp., p. 412

[EDITOR'S NOTE: Executive Order 12148 --Federal Emergency Management, July 20, 1979, substituted "Director of the Federal Emergency Management Agency" for "Federal Insurance Administration" in Section 2(d).]

By virtue of the authority vested in me by the Constitution and statutes of the United States of America, and as President of the United States of America, in furtherance of the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321 et seq.), the National Flood Insurance Act of 1968, as amended (42 U.S.C. 4001 et seq.), and the Flood Disaster Protection Act of 1973 (Public Law 93-234, 87 Stat. 975), in order to avoid to the extent possible the long and short term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct or indirect support of floodplain development wherever there is a practicable alternative, it is hereby ordered as follows:

Section 1.

Each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities for (1) acquiring, managing, and disposing of Federal lands and facilities; (2) providing Federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities. Sec. 2.

In carrying out the activities described in Section 1 of this Order, each agency has a responsibility to evaluate the potential effects of any actions it may take in a floodplain; to ensure that its planning programs and budget requests reflect consideration of flood hazards and floodplain management; and to prescribe procedures to implement the policies and requirements of this Order, as follows:

(a)(1) Before taking an action, each agency shall determine whether the proposed action will occur in a floodplain -- for major Federal actions significantly affecting the quality of the human environment, the evaluation required below will be included in any statement prepared under Section 102(2)(C) of the National Environmental Policy Act. This determination shall be made according to a Department of Housing and Urban Development (HUD) floodplain map or a more detailed map of an area, if available. If such maps are not available, the agency shall make a determination of the location of the floodplain based on the best available information. The Water Resources Council shall issue guidance on this information not later than October l, 1977.

(2) If an agency has determined to, or proposes to, conduct, support, or allow an action to be located in a floodplain, the agency shall consider alternatives to avoid adverse effects and incompatible development in the floodplains. If the head of the agency finds that the only

practicable alternative consistent with the law and with the policy set forth in this Order requires siting in a floodplain, the agency shall, prior to taking action, (i) design or modify its action in order to minimize potential harm to or within the floodplain, consistent with regulations issued in accord with Section 2(d) of this Order, and (ii) prepare and circulate a notice containing an explanation of why the action is proposed to be located in the floodplain.

(3) For programs subject to the Office of Management and Budget Circular A-95, the agency shall send the notice, not to exceed three pages in length including a location map, to the state and areawide A-95 clearinghouses for the geographic areas affected. The notice shall include: (i) the reasons why the action is proposed to be located in a floodplain; (ii) a statement indicating whether the action conforms to applicable state or local floodplain protection standards and (iii) a list of the alternatives considered. Agencies shall endeavor to allow a brief comment period prior to taking any action.

(4) Each agency shall also provide opportunity for early public review of any plans or proposals for actions in floodplains, in accordance with Section 2(b) of Executive Order No. 11514, as amended, including the development of procedures to accomplish this objective for Federal actions whose impact is not significant enough to require the preparation of an environmental impact statement under Section 102(2)(C) of the National Environmental Policy Act of 1969, as amended.

(b) Any requests for new authorizations or appropriations transmitted to the Office of Management and Budget shall indicate, if an action to be proposed will be located in a floodplain, whether the proposed action is in accord with this Order.

(c) Each agency shall take floodplain management into account when formulating or evaluating any water and land use plans and shall require land and water resources use appropriate to the degree of hazard involved. Agencies shall include adequate provision for the evaluation and consideration of flood hazards in the regulations and operating procedures for the licenses, permits, loan or grants-in-aid programs that they administer. Agencies shall also encourage and provide appropriate guidance to applicants to evaluate the effects of their proposals in floodplains prior to submitting applications for Federal licenses, permits, loans or grants.

(d) As allowed by law, each agency shall issue or amend existing regulations and procedures within one year to comply with this Order. These procedures shall incorporate the Unified National Program for Floodplain Management of the Water Resources Council, and shall explain the means that the agency will employ to pursue the nonhazardous use of riverine, coastal and other floodplains in connection with the activities under its authority. To the extent possible, existing processes, such as those of the Council on Environmental Quality and the Water Resources Council, shall be utilized to fulfill the requirements of this Order. Agencies shall prepare their procedures in consultation with the Water Resources Council, the Director of the Federal Emergency Management Agency, and the Council on Environmental Quality, and shall update such procedures as necessary.

Sec. 3.

In addition to the requirements of Section 2, agencies with responsibilities for Federal real property and facilities shall take the following measures:

(a) The regulations and procedures established under Section 2(d) of this Order shall, at a minimum, require the construction of Federal structures and facilities to be in accordance with the standards and criteria and to be consistent with the intent of those promulgated under the National Flood Insurance Program. They shall deviate only to the extent that the standards of the Flood Insurance Program are demonstrably inappropriate for a given type of structure or facility.

(b) If, after compliance with the requirements of this Order, new construction of structures or facilities are to be located in a floodplain, accepted floodproofing and other flood protection measures shall be applied to new construction or rehabilitation. To achieve flood protection, agencies shall, wherever practicable, elevate structures above the base flood level rather than filling in land.

(c) If property used by the general public has suffered flood damage or is located in an identified flood hazard area, the responsible agency shall provide on structures, and other places where appropriate, conspicuous delineation of past and probable flood height in order to enhance public awareness of and knowledge about flood hazards.

(d) When property in floodplains is proposed for lease, easement, right-of-way, or disposal to non-Federal public or private parties, the Federal agency shall (1) reference in the conveyance those uses that are restricted under identified Federal, State or local floodplain regulations; and (2) attach other appropriate restrictions to the uses of properties by the grantee or purchaser and any successors, except where prohibited by law; or (3) withhold such properties from conveyance.

Sec. 4.

In addition to any responsibilities under this Order and Sections 202 and 205 of the Flood Disaster Protection Act of 1973, as amended (42 U.S.C. 4106 and 4128), agencies which guarantee, approve, regulate, or insure any financial transaction which is related to an area located in a floodplain shall, prior to completing action on such transaction, inform any private parties participating in the transaction of the hazards of locating structures in the floodplain.

Sec. 5.

The head of each agency shall submit a report to the Council on Environmental Quality and to the Water Resources Council on June 30, 1978, regarding the status of their procedures and the impact of this Order on the agency's operations. Thereafter, the Water Resources Council shall periodically evaluate agency procedures and their effectiveness.

Sec. 6.

As used in this Order: (a) The term "agency" shall have the same meaning as the term "Executive agency" in Section 105 of Title 5 of the United States Code and shall include the military departments; the directives contained in this Order, however, are meant to apply only to those agencies which perform the activities described in Section l which are located in or affecting

floodplains.

(b) The term "base flood" shall mean that flood which has a one percent or greater chance of occurrence in any given year.

(c) The term "floodplain" shall mean the lowland and relatively flat areas adjoining inland and coastal waters including floodprone areas of offshore islands, including at a minimum, that area subject to a one percent or greater chance of flooding in any given year.

Sec. 7.

Executive Order No. 11296 of August 10, 1966, is hereby revoked. All actions, procedures, and issuances taken under that Order and still in effect shall remain in effect until modified by appropriate authority under the terms of this Order.

Sec. 8.

Nothing in this Order shall apply to assistance provided for emergency work essential to save lives and protect property and public health and safety, performed pursuant to Sections 305 and 306 of the Disaster Relief Act of 1974 (88 Stat. 148, 42 U.S.C. 5145 and 5146).

Sec. 9.

To the extent the provisions of Section 2(a) of this Order are applicable to projects covered by Section 104(h) of the Housing and Community Development Act of 1974, as amended (88 Stat. 640, 42 U.S.C. 5304(h)), the responsibilities under those provisions may be assumed by the appropriate applicant, if the applicant has also assumed, with respect to such projects, all of the responsibilities for environmental review, decisionmaking, and action pursuant to the National Environmental Policy Act of l969, as amended.

/s/JIMMY CARTER
THE WHITE HOUSE
May 24, 1977

Office of the White House Press Secretary May 24, 1977

THE WHITE HOUSE

EXECUTIVE ORDER 11990
PROTECTION OF WETLANDS

By virtue of the authority vested in me by the Constitution and statutes of the United States of America, and as President of the United States of America, in furtherance of the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321 et seq.), in order to avoid to the extent possible the long and short term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative, it is hereby ordered as follows:

Section 1. (a) Each agency :shall provide leadership and shall take action to the destruction, loss or degradation of wetlands, and to preserve and enhance natural and beneficial values of wetlands in carrying out the agency's responsibilities (1) acquiring, managing, and disposing of Federal lands and facilities; and (2) providing Federally undertaken, financed, or assisted construction and improvement; and 3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.

(b) This order does not apply to the issuance by Federal agencies of permits, licenses, or allocations to private parties for activities involving wetlands on non-Federal

Sec. 2. (a) In furtherance of Section 101(b)(3) of the National Environmental Policy Act of 1969 (42 U.S.C. 4331(b)(3)) to improve and coordinate Federal plans, functions, programs and resources to the end that the Nation may attain the widest range of beneficial uses of the environment without degradation risk to health or safety, each agency, to the extent permitted by law, shall avoid undertaking or providing assistance for new construction located in wetlands unless the head of the agency finds (1) that there is practicable alternative to such construction, and (2) that the proposed action includes all practicable measures to minimize harm to wetlands which may result from such use. In making this finding the head of the agency may take into account economic, environmental and other pertinent factors.

(b) Each agency shall also provide opportunity for early public review of any plans or proposals for new construction in wetlands, in accordance with Section 2(b) of Executive Order No. 11514, as amended, including the development of procedures to accomplish this objective for Federal actions whose impact is not significant enough to require the preparation of an environmental impact statement under on 102(2)(C) of the National Environmental Policy Act of 1969, as amended.

Sec. 3. Any requests for new authorizations or appropriations transmitted to the Office of Management and Budget shall indicate, if an action to be proposed will be located in wetlands, whether the proposed action is in accord with this Order.

Sec. 4. When Federally-owned wetlands or portions of wetlands are proposed for load, easement, right-of-way or disposal to non-Federal public or private parties, the Federal agency shall (a) reference in the conveyance those uses that are restricted under identified Federal, State or local wetlands regulations; and (b) attach other appropriate restrictions to the uses of properties by the grantee or purchaser and any successor. except where prohibited by law; or (c) withhold such properties from disposal.

Sec. 5. In carrying out the activities described in Section 1 of this Order, each agency shall consider factors relevant to a proposal's effect on the survival and quality of the wetlands. Among these factors are:

(a) public health, safety, and welfare, including water supply, quality, recharge and discharge; pollution; flood and storm hazards, and sediment and erosion;

(b) maintenance of natural systems, including conservation and long term productivity of existing flora and fauna, species and habitat diversity and stability, hydrologic utility, fish, wildlife, timber, and food and fiber resources; and

(c) other uses of wetlands in the public interest, including recreational, scientific, and cultural uses.

Sec. 6. As allowed by law, agencies shall issue or amend their existing procedures in order to comply with this Order. To the extent possible, existing processes, such as those of the Council on Environmental Quality and the Water Resources Council, shall be utilized to fulfill the requirements of this Order.

Sec. 7. As used in this Order:

(a) The term "agency" shall have the same meaning as the term "Executive agency" in Section 105 of Title 5 of the United States Code and shall include the military departments; the directives contained in this Order, however, are meant to apply only to those agencies which perform the activities described in Section 1 which are located in or affecting wetlands.

(b) The term "new construction" shall include draining, dredging, channelizing, filling, diking, impounding, and related activities and any structures or facilities begun or authorized after the effective date of this Order.

(c) The term "wetlands" means those areas that are inundated by surface or ground water with a frequency sufficient to support and under normal circumstances does or would support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, bogs, and similar areas such as sloughs, potholes, wet meadows, river overflows, mud flats, and natural ponds.

Sec. 8. This Order does not apply to projects presently under construction, or to projects for

which all of the funds have been appropriated through fiscal Year 1977, or to projects and programs for which a draft or final environmental impact statement will be filed prior to October 1, 1977. The provisions of Section 2 of this Order shall be implemented by each agency not later than October 1, 1977.

Sec. 9. Nothing in this Order shall apply to assistance provided for emergency work, essential to save lives and protect property and public health and safety, performed pursuant to Sections 305 and 306 of the Disaster Relief Act of 1974 (88 Stat. 148, 42 U.S.C. 5145 and 5146).

Sec.10 To the extent the provisions of Sections 2 and 5 of this Order are applicable to projects covered by Section 104(h) of the Housing and Community Development Act of 1974, as amended (88 Stat. 640, 42 U.S.C. 5304(h)), the responsibilities under those provisions may be assumed by the appropriate applicant, it the applicant has also assumed, with respect to such projects, all of the responsibilities for environmental review, decision imaking, and action pursuant to the National Environmental Policy Act of 1969, as amended.

Jimmy Carter

The White House

May 24, 1977

Title: Executive Order 12898: Env. Justice for Minority Populations
Author: The White House
Date: Feb 11, 1994

THE WHITE HOUSE
Office of the Press Secretary

For Immediate Release
February 11, 1994

EXECUTIVE ORDER
12898
FEDERAL ACTIONS TO ADDRESS ENVIRONMENTAL JUSTICE
IN MINORITY POPULATIONS AND LOW-INCOME POPULATIONS

By the authority vested in me as President by the Constitution and the laws of the United States of America, it is hereby ordered as follows:

Section 1-1. Implementation.

1-101. Agency Responsibilities. To the greatest extent practicable and permitted by law, and consistent with the principles set forth in the report on the National Performance Review, each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions, the District of Columbia, the Commonwealth of Puerto Rico, and the Commonwealth of the Mariana Islands.

1-102. Creation of an Interagency Working Group on Environmental Justice.

a. Within 3 months of the date of this order, the Administrator of the Environmental Protection Agency ("Administrator") or the Administrator's designee shall convene an interagency Federal Working Group on Environmental Justice ("Working Group"). The Working Group shall comprise the heads of the following executive agencies and offices, or their designees: (a) Department of Defense; (b) Department of Health and Human Services; (c) Department of Housing and Urban Development; (d) Department of Labor; (e) Department of Agriculture; (f) Department of Transportation; (g) Department of Justice; (h) Department of the Interior; (i) Department of Commerce; (j) Department of Energy; (k) Environmental Protection Agency; (l) Office of Management and Budget;

(m) Office of Science and Technology Policy; (n) Office of the Deputy Assistant to the President for Environmental Policy; (o) Office of the Assistant to the President for Domestic Policy; (p) National Economic Council; (q) Council of Economic Advisers; and (r) such other Government officials as the President may designate. The Working Group shall report to the President through the Deputy Assistant to the President for Environmental Policy and the Assistant to the President for Domestic Policy.

b. The Working Group shall:

1. provide guidance to Federal agencies on criteria for identifying disproportionately high and adverse human health or environmental effects on minority populations and low-income populations;

2. coordinate with, provide guidance to, and serve as a clearinghouse for, each Federal agency as it develops an environmental justice strategy as required by section 1-103 of this order, in order to ensure that the administration, interpretation and enforcement of programs, activities and policies are undertaken in a consistent manner;

3. assist in coordinating research by, and stimulating cooperation among, the Environmental Protection Agency, the Department of Health and Human Services, the Department of Housing and Urban Development, and other agencies conducting research or other activities in accordance with section 3-3 of this order;

4. assist in coordinating data collection, required by this order;

5. examine existing data and studies on environmental justice;

6. hold public meetings as required in section 5-502(d) of this order; and

7. develop interagency model projects on environmental justice that evidence cooperation among Federal agencies.

1-103. Development of Agency Strategies.

Except as provided in section 6-605 of this order, each Federal agency shall develop an agency-wide environmental justice strategy, as set forth in subsections (b)-(e) of this section that identifies and addresses disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations. The environmental justice strategy shall list programs, policies, planning and public participation processes, enforcement, and/or rulemakings related to human health or the environment that should be revised to, at a minimum: (1) promote enforcement of all health and environmental statutes in areas with minority populations and low-income populations; (2) ensure greater public participation; (3) improve research and data collection relating to the health of and environment of minority populations and low-income populations; and (4) identify differential patterns of consumption of natural resources among minority populations and low-income populations. In addition, the environmental justice strategy shall include, where appropriate, a timetable for undertaking identified

revisions and consideration of economic and social implications of the revisions.

a. Within 4 months of the date of this order, each Federal agency shall identify an internal administrative process for developing its environmental justice strategy, and shall inform the Working Group of the process.

b. Within 6 months of the date of this order, each Federal agency shall provide the Working Group with an outline of its proposed environmental justice strategy.

c. Within 10 months of the date of this order, each Federal agency shall provide the Working Group with its proposed environmental justice strategy.

d. Within 12 months of the date of this order, each Federal agency shall finalize its environmental justice strategy and provide a copy and written description of its strategy to the Working Group. During the 12 month period from the date of this order, each Federal agency, as part of its environmental justice strategy, shall identify several specific projects that can be promptly undertaken to address particular concerns identified during the development of the proposed environmental justice strategy, and a schedule for implementing those projects.

e. Within 24 months of the date of this order, each Federal agency shall report to the Working Group on its progress in implementing its agency-wide environmental justice strategy.

f. Federal agencies shall provide additional periodic reports to the Working Group as requested by the Working Group.

1-104. Reports to the President. Within 14 months of the date of this order, the Working Group shall submit to the President, through the Office of the Deputy Assistant to the President for Environmental Policy and the Office of the Assistant to the President for Domestic Policy, a report that describes the implementation of this order, and includes the final environmental justice strategies described in section 1-103(e) of this order.

Sec. 2-2. Federal Agency Responsibilities for Federal Programs.

Each Federal agency shall conduct its programs, policies, and activities that substantially affect human health or the environment, in a manner that ensures that such programs, policies, and activities do not have the effect of excluding persons (including populations) from participation in, denying persons (including populations) the benefits of, or subjecting persons (including populations) to discrimination under, such programs, policies, and activities, because of their race, color, or national origin.

Sec. 3-3. Research, Data Collection, and Analysis.

3-301. Human Health and Environmental Research and Analysis.

1. Environmental human health research, whenever practicable and appropriate, shall include diverse segments of the population in epidemiological and clinical studies, including segments at high risk from environmental hazards, such as minority

populations, low-income populations and workers who may be exposed to substantial environmental hazards.

2. Environmental human health analyses, whenever practicable and appropriate, shall identify multiple and cumulative exposures.

3. Federal agencies shall provide minority populations and low-income populations the opportunity to comment on the development and design of research strategies undertaken pursuant to this order.

3-302. Human Health and Environmental Data Collection and Analysis. To the extent permitted by existing law, including the Privacy Act, as amended (5 U.S.C. section 552a):

a. each Federal agency, whenever practicable and appropriate, shall collect, maintain, and analyze information assessing and comparing environmental and human health risks borne by populations identified by race, national origin, or income. To the extent practical and appropriate, Federal agencies shall use this information to determine whether their programs, policies, and activities have disproportionately high and adverse human health or environmental effects on minority populations and low-income populations;

b. In connection with the development and implementation of agency strategies in section 1-103 of this order, each Federal agency, whenever practicable and appropriate, shall collect, maintain and analyze information on the race, national origin, income level, and other readily accessible and appropriate information for areas surrounding facilities or sites expected to have a substantial environmental, human health, or economic effect on the surrounding populations, when such facilities or sites become the subject of a substantial Federal environmental administrative or judicial action. Such information shall be made available to the public, unless prohibited by law; and

c. Each Federal agency, whenever practicable and appropriate, shall collect, maintain, and analyze information on the race, national origin, income level, and other readily accessible and appropriate information for areas surrounding Federal facilities that are: (1) subject to the reporting requirements under the Emergency Planning and Community Right-to-Know Act, 42 U.S.C. section 11001- 11050 as mandated in Executive Order No. 12856; and (2) expected to have a substantial environmental, human health, or economic effect on surrounding populations. Such information shall be made available to the public, unless prohibited by law.

d. In carrying out the responsibilities in this section, each Federal agency, whenever practicable and appropriate, shall share information and eliminate unnecessary duplication of efforts through the use of existing data systems and cooperative agreements among Federal agencies and with State, local, and tribal governments.

Sec. 4-4. Subsistence Consumption of Fish and Wildlife.

4-401. Consumption Patterns. In order to assist in identifying the need for ensuring protection of populations with differential patterns of subsistence consumption of fish and wildlife, Federal agencies, whenever practicable and appropriate, shall collect, maintain, and analyze information

on the consumption patterns of populations who principally rely on fish and/or wildlife for subsistence. Federal agencies shall communicate to the public the risks of those consumption patterns.

4-402. Guidance. Federal agencies, whenever practicable and appropriate, shall work in a coordinated manner to publish guidance reflecting the latest scientific information available concerning methods for evaluating the human health risks associated with the consumption of pollutant-bearing fish or wildlife. Agencies shall consider such guidance in developing their policies and rules.

Sec. 5-5. Public Participation and Access to Information.

1. The public may submit recommendations to Federal agencies relating to the incorporation of environmental justice principles into Federal agency programs or policies. Each Federal agency shall convey such recommendations to the Working Group.

2. Each Federal agency may, whenever practicable and appropriate, translate crucial public documents, notices, and hearings relating to human health or the environment for limited English speaking populations.

3. Each Federal agency shall work to ensure that public documents, notices, and hearings relating to human health or the environment are concise, understandable, and readily accessible to the public.

4. The Working Group shall hold public meetings, as appropriate, for the purpose of fact-finding, receiving public comments, and conducting inquiries concerning environmental justice. The Working Group shall prepare for public review a summary of the comments and recommendations discussed at the public meetings.

Sec. 6-6. General Provisions.

6-601. Responsibility for Agency Implementation. The head of each Federal agency shall be responsible for ensuring compliance with this order. Each Federal agency shall conduct internal reviews and take such other steps as may be necessary to monitor compliance with this order.

6-602. Executive Order No. 12250. This Executive order is intended to supplement but not supersede Executive Order No. 12250, which requires consistent and effective implementation of various laws prohibiting discriminatory practices in programs receiving Federal financial assistance. Nothing herein shall limit the effect or mandate of Executive Order No. 12250.

6-603. Executive Order No. 12875. This Executive order is not intended to limit the effect or mandate of Executive Order No. 12875.

6-604. Scope. For purposes of this order, Federal agency means any agency on the Working Group, and such other agencies as may be designated by the President, that conducts any Federal program or activity that substantially affects human health or the environment. Independent agencies are requested to comply with the provisions of this order.

6-605. Petitions for Exemptions. The head of a Federal agency may petition the President for an exemption from the requirements of this order on the grounds that all or some of the petitioning agency's programs or activities should not be subject to the requirements of this order.

6-606. Native American Programs. Each Federal agency responsibility set forth under this order shall apply equally to Native American programs. In addition, the Department of the Interior, in coordination with the Working Group, and, after consultation with tribal leaders, shall coordinate steps to be taken pursuant to this order that address Federally-recognized Indian Tribes.

6-607. Costs. Unless otherwise provided by law, Federal agencies shall assume the financial costs of complying with this order.

6-608. General. Federal agencies shall implement this order consistent with, and to the extent permitted by, existing law.

6-609. Judicial Review. This order is intended only to improve the internal management of the executive branch and is not intended to, nor does it create any right, benefit, or trust responsibility, substantive or procedural, enforceable at law or equity by a party against the United States, its agencies, its officers, or any person. This order shall not be construed to create any right to judicial review involving the compliance or noncompliance of the United States, its agencies, its officers, or any other person with this order.

WILLIAM J. CLINTON

THE WHITE HOUSE,
February 11, 1994.

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PART 1500--PURPOSE, POLICY, AND MANDATE

Sec. 1500.1 Purpose.
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1500.6 Agency authority.

Authority: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 et seq.), sec. 309 of the Clean Air Act, as amended (42 U.S.C. 7609) and E.O. 11514, Mar. 5, 1970, as amended by E.O. 11991, May 24, 1977).

Source: 43 FR 55990, Nov. 28, 1978, unless otherwise noted.

Sec. 1500.1 Purpose.

(a) The National Environmental Policy Act (NEPA) is our basic national charter for protection of the environment. It establishes policy, sets goals (section 101), and provides means (section 102) for carrying out the policy. Section 102(2) contains "action-forcing" provisions to make sure that federal agencies act according to the letter and spirit of the Act. The regulations that follow implement section 102(2). Their purpose is to tell federal agencies what they must do to comply with the procedures and achieve the goals of the Act. The President, the federal agencies, and the courts share responsibility for enforcing the Act so as to achieve the substantive requirements of section 101.

(b) NEPA procedures must insure that environmental information is available to public officials and citizens before decisions are made and before actions are taken. The information must be of high quality. Accurate scientific analysis, expert agency comments, and public scrutiny are essential to implementing NEPA. Most important, NEPA documents must concentrate on the issues that are truly significant to the action in question, rather than amassing needless detail.

(c) Ultimately, of course, it is not better documents but better decisions that count. NEPA's purpose is not to generate paperwork--even excellent paperwork--but to foster excellent action. The NEPA process is intended to help public officials make decisions that are based on understanding of environmental consequences, and take actions that protect, restore, and enhance the environment. These regulations provide the direction to achieve this purpose.

Sec. 1500.2 Policy.

Federal agencies shall to the fullest extent possible:

(a) Interpret and administer the policies, regulations, and public laws of the United States

in accordance with the policies set forth in the Act and in these regulations.

(b) Implement procedures to make the NEPA process more useful to decisionmakers and the public; to reduce paperwork and the accumulation of extraneous background data; and to emphasize real environmental issues and alternatives. Environmental impact statements shall be concise, clear, and to the point, and shall be supported by evidence that agencies have made the necessary environmental analyses.

(c) Integrate the requirements of NEPA with other planning and environmental review procedures required by law or by agency practice so that all such procedures run concurrently rather than consecutively.

(d) Encourage and facilitate public involvement in decisions which affect the quality of the human environment.

(e) Use the NEPA process to identify and assess the reasonable alternatives to proposed actions that will avoid or minimize adverse effects of these actions upon the quality of the human environment.

(f) Use all practicable means, consistent with the requirements of the Act and other essential considerations of national policy, to restore and enhance the quality of the human environment and avoid or minimize any possible adverse effects of their actions upon the quality of the human environment.

Sec. 1500.3 Mandate.

Parts 1500 through 1508 of this title provide regulations applicable to and binding on all Federal agencies for implementing the procedural provisions of the National Environmental Policy Act of 1969, as amended (Pub. L. 91-190, 42 U.S.C. 4321 et seq.) (NEPA or the Act) except where compliance would be inconsistent with other statutory requirements. These regulations are issued pursuant to NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 et seq.) section 309 of the Clean Air Act, as amended (42 U.S.C. 7609) and Executive Order 11514, Protection and Enhancement of Environmental Quality (March 5, 1970, as amended by Executive Order 11991, May 24, 1977). These regulations, unlike the predecessor guidelines, are not confined to sec. 102(2)(C) (environmental impact statements). The regulations apply to the whole of section 102(2). The provisions of the Act and of these regulations must be read together as a whole in order to comply with the spirit and letter of the law. It is the Council's intention that judicial review of agency compliance with these regulations not occur before an agency has filed the final environmental impact statement, or has made a final finding of no significant impact (when such a finding will result in action affecting the environment), or takes action that will result in irreparable injury. Furthermore, it is the Council's intention that any trivial violation of these regulations not give rise to any independent cause of action.

Sec. 1500.4 Reducing paperwork.

Agencies shall reduce excessive paperwork by:

(a) Reducing the length of environmental impact statements (Sec. 1502.2(c)), by means such as setting appropriate page limits (Secs. 1501.7(b)(1) and 1502.7).

(b) Preparing analytic rather than encyclopedic environmental impact statements (Sec. 1502.2(a)).

(c) Discussing only briefly issues other than significant ones (Sec. 1502.2(b)).

(d) Writing environmental impact statements in plain language (Sec. 1502.8).

(e) Following a clear format for environmental impact statements (Sec. 1502.10).

(f) Emphasizing the portions of the environmental impact statement that are useful to decisionmakers and the public (Secs. 1502.14 and 1502.15) and reducing emphasis on background material (Sec. 1502.16).

(g) Using the scoping process, not only to identify significant environmental issues deserving of study, but also to deemphasize insignificant issues, narrowing the scope of the environmental impact statement process accordingly (Sec. 1501.7).

(h) Summarizing the environmental impact statement (Sec. 1502.12) and circulating the summary instead of the entire environmental impact statement if the latter is unusually long (Sec. 1502.19).

(i) Using program, policy, or plan environmental impact statements and tiering from statements of broad scope to those of narrower scope, to eliminate repetitive discussions of the same issues (Secs. 1502.4 and 1502.20).

(j) Incorporating by reference (Sec. 1502.21).

(k) Integrating NEPA requirements with other environmental review and consultation requirements (Sec. 1502.25).

(l) Requiring comments to be as specific as possible (Sec. 1503.3). (m) Attaching and circulating only changes to the draft environmental impact statement, rather than rewriting and circulating the entire statement when changes are minor (Sec. 1503.4(c)).

(n) Eliminating duplication with State and local procedures, by providing for joint preparation (Sec. 1506.2), and with other Federal procedures, by providing that an agency may adopt appropriate environmental documents prepared by another agency (Sec. 1506.3).

(o) Combining environmental documents with other documents (Sec. 1506.4).

(p) Using categorical exclusions to define categories of actions which do not individually or cumulatively have a significant effect on the human environment and which are therefore exempt from requirements to prepare an environmental impact statement (Sec. 1508.4).

(q) Using a finding of no significant impact when an action not otherwise excluded will

not have a significant effect on the human environment and is therefore exempt from requirements to prepare an environmental impact statement (Sec. 1508.13).

[43 FR 55990, Nov. 29, 1978; 44 FR 873, Jan. 3, 1979]

Sec. 1500.5 Reducing delay.

Agencies shall reduce delay by:

(a) Integrating the NEPA process into early planning (Sec. 1501.2).

(b) Emphasizing interagency cooperation before the environmental impact statement is prepared, rather than submission of adversary comments on a completed document (Sec. 1501.6).

(c) Insuring the swift and fair resolution of lead agency disputes (Sec. 1501.5).

(d) Using the scoping process for an early identification of what are and what are not the real issues (Sec. 1501.7).

(e) Establishing appropriate time limits for the environmental impact statement process (Secs. 1501.7(b)(2) and 1501.8).

(f) Preparing environmental impact statements early in the process (Sec. 1502.5).

(g) Integrating NEPA requirements with other environmental review and consultation requirements (Sec. 1502.25).

(h) Eliminating duplication with State and local procedures by providing for joint preparation (Sec. 1506.2) and with other Federal procedures by providing that an agency may adopt appropriate environmental documents prepared by another agency (Sec. 1506.3).

(i) Combining environmental documents with other documents (Sec. 1506.4).

(j) Using accelerated procedures for proposals for legislation (Sec. 1506.8).

(k) Using categorical exclusions to define categories of actions which do not individually or cumulatively have a significant effect on the human environment (Sec. 1508.4) and which are therefore exempt from requirements to prepare an environmental impact statement.

(l) Using a finding of no significant impact when an action not otherwise excluded will not have a significant effect on the human environment (Sec. 1508.13) and is therefore exempt from requirements to prepare an environmental impact statement.

Sec. 1500.6 Agency authority.

Each agency shall interpret the provisions of the Act as a supplement to its existing authority and as a mandate to view traditional policies and missions in the light of the Act's national

environmental objectives. Agencies shall review their policies, procedures, and regulations accordingly and revise them as necessary to insure full compliance with the purposes and provisions of the Act. The phrase "to the fullest extent possible" in section 102 means that each agency of the Federal Government shall comply with that section unless existing law applicable to the agency's operations expressly prohibits or makes compliance impossible.

PART 1501--NEPA AND AGENCY PLANNING

Sec. 1501.1 Purpose.
1501.2 Apply NEPA early in the process.
1501.3 When to prepare an environmental assessment.
1501.4 Whether to prepare an environmental impact statement.
1501.5 Lead agencies.
1501.6 Cooperating agencies.
1501.7 Scoping.
1501.8 Time limits.

Authority: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 et seq.), sec. 309 of the Clean Air Act, as amended (42 U.S.C. 7609, and E.O. 11514 (Mar. 5, 1970, as amended by E.O. 11991, May 24, 1977).

Source: 43 FR 55992, Nov. 29, 1978, unless otherwise noted.

Sec. 1501.1 Purpose.

The purposes of this part include:

(a) Integrating the NEPA process into early planning to insure appropriate consideration of NEPA's policies and to eliminate delay.

(b) Emphasizing cooperative consultation among agencies before the environmental impact statement is prepared rather than submission of adversary comments on a completed document.

(c) Providing for the swift and fair resolution of lead agency disputes.

(d) Identifying at an early stage the significant environmental issues deserving of study and deemphasizing insignificant issues, narrowing the scope of the environmental impact statement accordingly.

(e) Providing a mechanism for putting appropriate time limits on the environmental impact statement process.

Sec. 1501.2 Apply NEPA early in the process.

Agencies shall integrate the NEPA process with other planning at the earliest possible time to insure that planning and decisions reflect environmental values, to avoid delays later in the process, and to head off potential conflicts. Each agency shall:

(a) Comply with the mandate of section 102(2)(A) to "utilize a systematic,

interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decisionmaking which may have an impact on man's environment," as specified by Sec. 1507.2.

(b) Identify environmental effects and values in adequate detail so they can be compared to economic and technical analyses. Environmental documents and appropriate analyses shall be circulated and reviewed at the same time as other planning documents.

(c) Study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources as provided by section 102(2)(E) of the Act.

(d) Provide for cases where actions are planned by private applicants or other non-Federal entities before Federal involvement so that:

1. Policies or designated staff are available to advise potential applicants of studies or other information foreseeably required for later Federal action.

2. The Federal agency consults early with appropriate State and local agencies and Indian tribes and with interested private persons and organizations when its own involvement is reasonably foreseeable.

3. The Federal agency commences its NEPA process at the earliest possible time.

Sec. 1501.3 When to prepare an environmental assessment.

(a) Agencies shall prepare an environmental assessment (Sec. 1508.9) when necessary under the procedures adopted by individual agencies to supplement these regulations as described in Sec. 1507.3. An assessment is not necessary if the agency has decided to prepare an environmental impact statement.

(b) Agencies may prepare an environmental assessment on any action at any time in order to assist agency planning and decisionmaking.

Sec. 1501.4 Whether to prepare an environmental impact statement.

In determining whether to prepare an environmental impact statement the Federal agency shall:

(a) Determine under its procedures supplementing these regulations (described in Sec. 1507.3) whether the proposal is one which:

1. Normally requires an environmental impact statement, or

2. Normally does not require either an environmental impact statement or an environmental assessment (categorical exclusion).

(b) If the proposed action is not covered by paragraph (a) of this section, prepare an

environmental assessment (Sec. 1508.9). The agency shall involve environmental agencies, applicants, and the public, to the extent practicable, in preparing assessments required by Sec. 1508.9(a)(1).

(c) Based on the environmental assessment make its determination whether to prepare an environmental impact statement.

(d) Commence the scoping process (Sec. 1501.7), if the agency will prepare an environmental impact statement.

(e) Prepare a finding of no significant impact (Sec. 1508.13), if the agency determines on the basis of the environmental assessment not to prepare a statement.

1. The agency shall make the finding of no significant impact available to the affected public as specified in Sec. 1506.6.

2. certain limited circumstances, which the agency may cover in its procedures under Sec. 1507.3, the agency shall make the finding of no significant impact available for public review (including State and areawide clearinghouses) for 30 days before the agency makes its final determination whether to prepare an environmental impact statement and before the action may begin. The circumstances are:

   (i) The proposed action is, or is closely similar to, one which normally requires the preparation of an environmental impact statement under the procedures adopted by the agency pursuant to Sec. 1507.3, or

   (ii) The nature of the proposed action is one without precedent.

Sec. 1501.5 Lead agencies.

(a) A lead agency shall supervise the preparation of an environmental impact statement if more than one Federal agency either:

1. Proposes or is involved in the same action; or

2. Is involved in a group of actions directly related to each other because of their functional interdependence or geographical proximity.

(b) Federal, State, or local agencies, including at least one Federal agency, may act as joint lead agencies to prepare an environmental impact statement (Sec. 1506.2).

(c) If an action falls within the provisions of paragraph (a) of this section the potential lead agencies shall determine by letter or memorandum which agency shall be the lead agency and which shall be cooperating agencies. The agencies shall resolve the lead agency question so as not to cause delay. If there is disagreement among the agencies, the following factors (which are listed in order of descending importance) shall determine lead agency designation:

1. Magnitude of agency's involvement.

2. Project approval/disapproval authority.

3. Expertise concerning the action's environmental effects.

4. Duration of agency's involvement.

5. Sequence of agency's involvement.

(d) Any Federal agency, or any State or local agency or private person substantially affected by the absence of lead agency designation, may make a written request to the potential lead agencies that a lead agency be designated.

(e) If Federal agencies are unable to agree on which agency will be the lead agency or if the procedure described in paragraph (c) of this section has not resulted within 45 days in a lead agency designation, any of the agencies or persons concerned may file a request with the Council asking it to determine which Federal agency shall be the lead agency. A copy of the request shall be transmitted to each potential lead agency. The request shall consist of:

1. A precise description of the nature and extent of the proposed action.

2. A detailed statement of why each potential lead agency should or should not be the lead agency under the criteria specified in paragraph (c) of this section.

(f) A response may be filed by any potential lead agency concerned within 20 days after a request is filed with the Council. The Council shall determine as soon as possible but not later than 20 days after receiving the request and all responses to it which Federal agency shall be the lead agency and which other Federal agencies shall be cooperating agencies.

[43 FR 55992, Nov. 29, 1978; 44 FR 873, Jan. 3, 1979]

Sec. 1501.6 Cooperating agencies.

The purpose of this section is to emphasize agency cooperation early in the NEPA process. Upon request of the lead agency, any other Federal agency which has jurisdiction by law shall be a cooperating agency. In addition any other Federal agency which has special expertise with respect to any environmental issue, which should be addressed in the statement may be a cooperating agency upon request of the lead agency. An agency may request the lead agency to designate it a cooperating agency.

(a) The lead agency shall:

1. Request the participation of each cooperating agency in the NEPA process at the earliest possible time.

2. Use the environmental analysis and proposals of cooperating agencies with jurisdiction by law or special expertise, to the maximum extent possible

consistent with its responsibility as lead agency.

3. Meet with a cooperating agency at the latter's request.

(b) Each cooperating agency shall:

1. Participate in the NEPA process at the earliest possible time.

2. Participate in the scoping process (described below in Sec. 1501.7).

3. Assume on request of the lead agency responsibility for developing information and preparing environmental analyses including portions of the environmental impact statement concerning which the cooperating agency has special expertise.

4. Make available staff support at the lead agency's request to enhance the latter's interdisciplinary capability.

5. Normally use its own funds. The lead agency shall, to the extent available funds permit, fund those major activities or analyses it requests from cooperating agencies. Potential lead agencies shall include such funding requirements in their budget requests.

(c) A cooperating agency may in response to a lead agency's request for assistance in preparing the environmental impact statement (described in paragraph (b)(3), (4), or (5) of this section) reply that other program commitments preclude any involvement or the degree of involvement requested in the action that is the subject of the environmental impact statement. A copy of this reply shall be submitted to the Council.

Sec. 1501.7 Scoping. There shall be an early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action. This process shall be termed scoping. As soon as practicable after its decision to prepare an environmental impact statement and before the scoping process the lead agency shall publish a notice of intent (Sec. 1508.22) in the Federal Register except as provided in Sec. 1507.3(e).

(a) As part of the scoping process the lead agency shall:

1. Invite the participation of affected Federal, State, and local agencies, any affected Indian tribe, the proponent of the action, and other interested persons (including those who might not be in accord with the action on environmental grounds), unless there is a limited exception under Sec. 1507.3(c). An agency may give notice in accordance with Sec. 1506.6.

2. Determine the scope (Sec. 1508.25) and the significant issues to be analyzed in depth in the environmental impact statement.

3. Identify and eliminate from detailed study the issues which are not significant or which have been covered by prior environmental review (Sec. 1506.3),

narrowing the discussion of these issues in the statement to a brief presentation of why they will not have a significant effect on the human environment or providing a reference to their coverage elsewhere.

4. Allocate assignments for preparation of the environmental impact statement among the lead and cooperating agencies, with the lead agency retaining responsibility for the statement.

5. Indicate any public environmental assessments and other environmental impact statements which are being or will be prepared that are related to but are not part of the scope of the impact statement under consideration.

6. Identify other environmental review and consultation requirements so the lead and cooperating agencies may prepare other required analyses and studies concurrently with, and integrated with, the environmental impact statement as provided in Sec. 1502.25.

7. Indicate the relationship between the timing of the preparation of environmental analyses and the agency's tentative planning and decisionmaking schedule.

(b) As part of the scoping process the lead agency may:

1. Set page limits on environmental documents (Sec. 1502.7).

2. Set time limits (Sec. 1501.8).

3. Adopt procedures under Sec. 1507.3 to combine its environmental assessment process with its scoping process.

4. Hold an early scoping meeting or meetings which may be integrated with any other early planning meeting the agency has. Such a scoping meeting will often be appropriate when the impacts of a particular action are confined to specific sites.

(c) An agency shall revise the determinations made under paragraphs (a) and (b) of this section if substantial changes are made later in the proposed action, or if significant new circumstances or information arise which bear on the proposal or its impacts.

Sec. 1501.8 Time limits.

Although the Council has decided that prescribed universal time limits for the entire NEPA process are too inflexible, Federal agencies are encouraged to set time limits appropriate to individual actions (consistent with the time intervals required by Sec. 1506.10). When multiple agencies are involved the reference to agency below means lead agency.

(a) The agency shall set time limits if an applicant for the proposed action requests them: Provided, That the limits are consistent with the purposes of NEPA and other essential considerations of national policy.

(b) The agency may:

1. Consider the following factors in determining time limits:

   (i) Potential for environmental harm.
   (ii) Size of the proposed action.
   (iii) State of the art of analytic techniques.
   (iv) Degree of public need for the proposed action, including the consequences of delay.
   (v) Number of persons and agencies affected.
   (vi) Degree to which relevant information is known and if not known the time required for obtaining it.
   (vii) Degree to which the action is controversial.
   (viii) Other time limits imposed on the agency by law, regulations, or executive order.

2. Set overall time limits or limits for each constituent part of the NEPA process, which may include:

   (i) Decision on whether to prepare an environmental impact statement (if not already decided).
   (ii) Determination of the scope of the environmental impact statement.
   (iii) Preparation of the draft environmental impact statement.
   (iv) Review of any comments on the draft environmental impact statement from the public and agencies.
   (v) Preparation of the final environmental impact statement.
   (vi) Review of any comments on the final environmental impact statement.
   (vii) Decision on the action based in part on the environmental impact statement.

3. Designate a person (such as the project manager or a person in the agency's office with NEPA responsibilities) to expedite the NEPA process.

(c) State or local agencies or members of the public may request a Federal Agency to set time limits.

PART 1502--ENVIRONMENTAL IMPACT STATEMENT

Sec. 1502.1 Purpose.
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1502.3 Statutory requirements for statements.
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1502.25 Environmental review and consultation requirements.

Authority: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 et seq.), sec. 309 of the Clean Air Act, as amended (42 U.S.C. 7609), and E.O. 11514 (Mar. 5, 1970, as amended by E.O. 11991, May 24, 1977).

Source: 43 FR 55994, Nov. 29, 1978, unless otherwise noted.

Sec. 1502.1 Purpose.

The primary purpose of an environmental impact statement is to serve as an action-forcing device to insure that the policies and goals defined in the Act are infused into the ongoing programs and actions of the Federal Government. It shall provide full and fair discussion of significant environmental impacts and shall inform decisionmakers and the public of the reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the human environment. Agencies shall focus on significant environmental issues

and alternatives and shall reduce paperwork and the accumulation of extraneous background data. Statements shall be concise, clear, and to the point, and shall be supported by evidence that the agency has made the necessary environmental analyses. An environmental impact statement is more than a disclosure document. It shall be used by Federal officials in conjunction with other relevant material to plan actions and make decisions.

Sec. 1502.2 Implementation.

To achieve the purposes set forth in Sec. 1502.1 agencies shall prepare environmental impact statements in the following manner:

(a) Environmental impact statements shall be analytic rather than encyclopedic.

(b) Impacts shall be discussed in proportion to their significance. There shall be only brief discussion of other than significant issues. As in a finding of no significant impact, there should be only enough discussion to show why more study is not warranted.

(c) Environmental impact statements shall be kept concise and shall be no longer than absolutely necessary to comply with NEPA and with these regulations. Length should vary first with potential environmental problems and then with project size.

(d) Environmental impact statements shall state how alternatives considered in it and decisions based on it will or will not achieve the requirements of sections 101 and 102(1) of the Act and other environmental laws and policies.

(e) The range of alternatives discussed in environmental impact statements shall encompass those to be considered by the ultimate agency decisionmaker.

(f) Agencies shall not commit resources prejudicing selection of alternatives before making a final decision (Sec. 1506.1).

(g) Environmental impact statements shall serve as the means of assessing the environmental impact of proposed agency actions, rather than justifying decisions already made.

Sec. 1502.3 Statutory requirements for statements.

As required by sec. 102(2)(C) of NEPA environmental impact statements (Sec. 1508.11) are to be included in every recommendation or report.

On proposals (Sec. 1508.23).
For legislation and (Sec. 1508.17).
Other major Federal actions (Sec. 1508.18).
Significantly (Sec. 1508.27).
Affecting (Secs. 1508.3, 1508.8).
The quality of the human environment (Sec. 1508.14).

Sec. 1502.4 Major Federal actions requiring the preparation of environmental impact statements.

(a) Agencies shall make sure the proposal which is the subject of an environmental impact statement is properly defined. Agencies shall use the criteria for scope (Sec. 1508.25) to determine which proposal(s) shall be the subject of a particular statement. Proposals or parts of proposals which are related to each other closely enough to be, in effect, a single course of action shall be evaluated in a single impact statement.

(b) Environmental impact statements may be prepared, and are sometimes required, for broad Federal actions such as the adoption of new agency programs or regulations (Sec. 1508.18). Agencies shall prepare statements on broad actions so that they are relevant to policy and are timed to coincide with meaningful points in agency planning and decisionmaking.

(c) When preparing statements on broad actions (including proposals by more than one agency), agencies may find it useful to evaluate the proposal(s) in one of the following ways:

1. Geographically, including actions occurring in the same general location, such as body of water, region, or metropolitan area.

2. Generically, including actions which have relevant similarities, such as common timing, impacts, alternatives, methods of implementation, media, or subject matter.

3. By stage of technological development including federal or federally assisted research, development or demonstration programs for new technologies which, if applied, could significantly affect the quality of the human environment. Statements shall be prepared on such programs and shall be available before the program has reached a stage of investment or commitment to implementation likely to determine subsequent development or restrict later alternatives.

(d) Agencies shall as appropriate employ scoping (Sec. 1501.7), tiering (Sec. 1502.20), and other methods listed in Secs. 1500.4 and 1500.5 to relate broad and narrow actions and to avoid duplication and delay.

Sec. 1502.5 Timing.

An agency shall commence preparation of an environmental impact statement as close as possible to the time the agency is developing or is presented with a proposal (Sec. 1508.23) so that preparation can be completed in time for the final statement to be included in any recommendation or report on the proposal. The statement shall be prepared early enough so that it can serve practically as an important contribution to the decisionmaking process and will not be used to rationalize or justify decisions already made (Secs. 1500.2(c), 1501.2, and 1502.2). For instance:

(a) For projects directly undertaken by Federal agencies the environmental impact statement shall be prepared at the feasibility analysis (go-no go) stage and may be supplemented at a later stage if necessary.

(b) For applications to the agency appropriate environmental assessments or statements shall be commenced no later than immediately after the application is received. Federal agencies are encouraged to begin preparation of such assessments or statements earlier, preferably jointly with applicable• State or local agencies.

(c) For adjudication, the final environmental impact statement shall normally precede the final staff recommendation and that portion of the public hearing related to the impact study. In appropriate circumstances the statement may follow preliminary hearings designed to gather information for use in the statements.

(d) For informal rulemaking the draft environmental impact statement shall normally accompany the proposed rule.

Sec. 1502.6 Interdisciplinary preparation.

Environmental impact statements shall be prepared using an inter- disciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts (section 102(2)(A) of the Act). The disciplines of the preparers shall be appropriate to the scope and issues identified in the scoping process (Sec. 1501.7).

Sec. 1502.7 Page limits.

The text of final environmental impact statements (e.g., paragraphs (d) through (g) of Sec. 1502.10) shall normally be less than 150 pages and for proposals of unusual scope or complexity shall normally be less than 300 pages.

Sec. 1502.8 Writing.

Environmental impact statements shall be written in plain language and may use appropriate graphics so that decisionmakers and the public can readily understand them. Agencies should employ writers of clear prose or editors to write, review, or edit statements, which will be based upon the analysis and supporting data from the natural and social sciences and the environmental• design arts.

Sec. 1502.9 Draft, final, and supplemental statements.

Except for proposals for legislation as provided in Sec. 1506.8 environmental impact statements shall be prepared in two stages and may be supplemented.

(a) Draft environmental impact statements shall be prepared in accordance with the scope decided upon in the scoping process. The lead agency shall work with the cooperating

agencies and shall obtain comments as required in Part 1503 of this chapter. The draft statement must fulfill and satisfy to the fullest extent possible the requirements established for final statements in section 102(2)(C) of the Act. If a draft statement is so inadequate as to preclude meaningful analysis, the agency shall prepare and circulate a revised draft of the appropriate portion. The agency shall make every effort to disclose and discuss at appropriate points in the draft statement all major points of view on the environmental impacts of the alternatives including the proposed action.

(b) Final environmental impact statements shall respond to comments as required in Part 1503 of this chapter. The agency shall discuss at appropriate points in the final statement any responsible opposing view which was not adequately discussed in the draft statement and shall indicate the agency's response to the issues raised.

(c) Agencies:

1. Shall prepare supplements to either draft or final environmental• impact statements if:

   (i) The agency makes substantial changes in the proposed action that are relevant to environmental concerns; or

   (ii) There are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts.

2. May also prepare supplements when the agency determines that the purposes of the Act will be furthered by doing so.

3. Shall adopt procedures for introducing a supplement into its formal administrative record, if such a record exists.

4. Shall prepare, circulate, and file a supplement to a statement in the same fashion (exclusive of scoping) as a draft and final statement unless alternative procedures are approved by the Council.

Sec. 1502.10 Recommended format.

Agencies shall use a format for environmental impact statements which will encourage good analysis and clear presentation of the alternatives including the proposed action. The following standard format for environmental impact statements should be followed unless the agency determines that there is a compelling reason to do otherwise:

(a) Cover sheet.
(b) Summary.
(c) Table of contents.
(d) Purpose of and need for action.
(e) Alternatives including proposed action (sections 102(2)(C)(iii) and 102(2)(E) of the Act).
(f) Affected environment.

(g) Environmental consequences (especially sections 102(2)(C)(i), (ii), (iv), and (v) of the Act).
(h) List of preparers.
(i) List of Agencies, Organizations, and persons to whom copies of the statement are sent.
(j) Index.
(k) Appendices (if any).

If a different format is used, it shall include paragraphs (a), (b), (c), (h), (i), and (j), of this section and shall include the substance of paragraphs (d), (e), (f), (g), and (k) of this section, as further described in Secs. 1502.11 through 1502.18, in any appropriate format.

Sec. 1502.11 Cover sheet.

The cover sheet shall not exceed one page. It shall include:

(a) A list of the responsible agencies including the lead agency and any cooperating agencies.

(b) The title of the proposed action that is the subject of the statement (and if appropriate the titles of related cooperating agency actions), together with the State(s) and county(ies) (or other jurisdiction if applicable) where the action is located.

(c) The name, address, and telephone number of the person at the agency who can supply further information.

(d) A designation of the statement as a draft, final, or draft or final supplement.

(e) A one paragraph abstract of the statement.

(f) The date by which comments must be received (computed in cooperation with EPA under Sec. 1506.10).

The information required by this section may be entered on Standard Form 424 (in items 4, 6, 7, 10, and 18).

Sec. 1502.12 Summary.

Each environmental impact statement shall contain a summary which adequately and accurately summarizes the statement. The summary shall stress the major conclusions, areas of controversy (including issues raised by agencies and the public), and the issues to be resolved (including the choice among alternatives). The summary will normally not exceed 15 pages.

Sec. 1502.13 Purpose and need.

The statement shall briefly specify the underlying purpose and need to which the agency is

responding in proposing the alternatives including the proposed action.

Sec. 1502.14 Alternatives including the proposed action.

This section is the heart of the environmental impact statement. Based on the information and analysis presented in the sections on the Affected Environment (Sec. 1502.15) and the Environmental Consequences (Sec. 1502.16), it should present the environmental impacts of the proposal and the alternatives in comparative form, thus sharply defining the issues and providing a clear basis for choice among options by the decisionmaker and• the public. In this section agencies shall:

(a) Rigorously explore and objectively evaluate all reasonable alternatives, and for alternatives which were eliminated from detailed study, briefly discuss the reasons for their having been eliminated.

(b) Devote substantial treatment to each alternative considered in detail including the proposed action so that reviewers may evaluate their comparative merits.

(c) Include reasonable alternatives not within the jurisdiction of the lead agency.

(d) Include the alternative of no action.

(e) Identify the agency's preferred alternative or alternatives, if one or more exists, in the draft statement and identify such alternative in the final statement unless another law prohibits the expression of such a preference.

(f) Include appropriate mitigation measures not already included in the proposed action or alternatives.

Sec. 1502.15 Affected environment.

The environmental impact statement shall succinctly describe the environment of the area(s) to be affected or created by the alternatives under consideration. The descriptions shall be no longer than is necessary to understand the effects of the alternatives. Data and analyses in a statement shall be commensurate with the importance of the impact, with less important material summarized, consolidated, or simply referenced. Agencies shall avoid useless bulk in statements and shall concentrate effort and attention on important issues. Verbose descriptions of the affected environment are themselves no measure of the adequacy of an environmental impact statement.

Sec. 1502.16 Environmental consequences.

This section forms the scientific and analytic basis for the comparisons under Sec. 1502.14. It shall consolidate the discussions of those elements required by sections 102(2)(C)(i), (ii), (iv), and (v) of NEPA which are within the scope of the statement and as much of section 102(2)(C)(iii) as is necessary to support the comparisons. The discussion will include the

environmental impacts of the alternatives including the proposed action, any adverse environmental effects which cannot be avoided should the proposal be implemented, the relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and any irreversible or irretrievable commitments of resources which would be involved in the proposal should it be implemented. This section should not duplicate discussions in Sec. 1502.14. It shall include discussions of:

(a) Direct effects and their significance (Sec. 1508.8).

(b) Indirect effects and their significance (Sec. 1508.8).

(c) Possible conflicts between the proposed action and the objectives of Federal, regional, State, and local (and in the case of a reservation, Indian tribe) land use plans, policies and controls for the area concerned. (See Sec. 1506.2(d).)

(d) The environmental effects of alternatives including the proposed action. The comparisons under Sec. 1502.14 will be based on this discussion.

(e) Energy requirements and conservation potential of various alternatives and mitigation measures.

(f) Natural or depletable resource requirements and conservation potential of various alternatives and mitigation measures.

(g) Urban quality, historic and cultural resources, and the design of the built environment, including the reuse and conservation potential of various alternatives and mitigation measures.

(h) Means to mitigate adverse environmental impacts (if not fully covered under Sec. 1502.14(f)).

[43 FR 55994, Nov. 29, 1978; 44 FR 873, Jan. 3, 1979]

Sec. 1502.17 List of preparers.

The environmental impact statement shall list the names, together with their qualifications (expertise, experience, professional disciplines), of the persons who were primarily responsible for preparing the environmental impact statement or significant background papers, including basic components of the statement (Secs. 1502.6 and 1502.8). Where possible the persons who are responsible for a particular analysis, including analyses in background papers, shall be identified. Normally the list will not exceed two pages.

Sec. 1502.18 Appendix.

If an agency prepares an appendix to an environmental impact statement the appendix shall:

(a) Consist of material prepared in connection with an environmental impact statement (as distinct from material which is not so prepared and which is incorporated by reference

(Sec. 1502.21)).

(b) Normally consist of material which substantiates any analysis fundamental to the impact statement.

(c) Normally be analytic and relevant to the decision to be made.

(d) Be circulated with the environmental impact statement or be readily available on request.

Sec. 1502.19 Circulation of the environmental impact statement.

Agencies shall circulate the entire draft and final environmental impact statements except for certain appendices as provided in Sec. 1502.18(d) and unchanged statements as provided in Sec. 1503.4(c). However, if the statement is unusually long, the agency may circulate the summary instead, except that the entire statement shall be furnished to:

(a) Any Federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved and any appropriate Federal, State or local agency authorized to develop and enforce environmental standards.

(b) The applicant, if any.

(c) Any person, organization, or agency requesting the entire environmental impact statement.

(d) In the case of a final environmental impact statement any person, organization, or agency which submitted substantive comments on the draft.

If the agency circulates the summary and thereafter receives a timely request for the entire statement and for additional time to comment, the time for that requestor only shall be extended by at least 15 days beyond the minimum period.

Sec. 1502.20 Tiering.

Agencies are encouraged to tier their environmental impact statements to eliminate repetitive discussions of the same issues and to focus on the actual issues ripe for decision at each level of environmental review (Sec. 1508.28). Whenever a broad environmental impact statement has been prepared (such as a program or policy statement) and a subsequent statement or environmental assessment is then prepared on an action included within the entire program or policy (such as a site specific action) the subsequent statement or environmental assessment need only summarize the issues discussed in the broader statement and incorporate discussions from the broader statement by reference and shall concentrate on the issues specific to the subsequent action. The subsequent document shall state where the earlier document is available. Tiering may also be appropriate for different stages of actions. (Section 1508.28).

Sec. 1502.21 Incorporation by reference.

Agencies shall incorporate material into an environmental impact statement by reference when the effect will be to cut down on bulk without impeding agency and public review of the action. The incorporated material shall be cited in the statement and its content briefly described. No material may be incorporated by reference unless it is reasonably available for inspection by potentially interested persons within the time allowed for comment. Material based on proprietary data which is itself not available for review and comment shall not be incorporated by reference.

Sec. 1502.22 Incomplete or unavailable information.

When an agency is evaluating reasonably foreseeable significant adverse effects on the human environment in an environmental impact statement and there is incomplete or unavailable information, the agency shall always make clear that such information is lacking.

(a) If the incomplete information relevant to reasonably foreseeable significant adverse impacts is essential to a reasoned choice among alternatives and the overall costs of obtaining it are not exorbitant, the agency shall include the information in the environmental impact statement.

(b) If the information relevant to reasonably foreseeable significant adverse impacts cannot be obtained because the overall costs of obtaining it are exorbitant or the means to obtain it are not known, the agency shall include within the environmental impact statement:

1. A statement that such information is incomplete or unavailable;
2. a statement of the relevance of the incomplete or unavailable information to evaluating reasonably foreseeable significant adverse impacts on the human environment;
3. a summary of existing credible scientific evidence which is relevant to evaluating the reasonably foreseeable significant adverse impacts on the human environment, and
4. the agency's evaluation of such impacts based upon theoretical approaches or research methods generally accepted in the scientific community. For the purposes of this section, "reasonably foreseeable" includes impacts which have catastrophic consequences, even if their probability of occurrence is low, provided that the analysis of the impacts is supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason.

(c) The amended regulation will be applicable to all environmental impact statements for which a Notice of Intent (40 CFR 1508.22) is published in the Federal Register on or after May 27, 1986. For environmental impact statements in progress, agencies may choose to comply with the requirements of either the original or amended regulation.

[51 FR 15625, Apr. 25, 1986]

Sec. 1502.23 Cost-benefit analysis.

If a cost-benefit analysis relevant to the choice among environmentally different alternatives is being considered for the proposed action, it shall be incorporated by reference or appended to the statement as an aid in evaluating the environmental consequences. To assess the adequacy of compliance with section 102(2)(B) of the Act the statement shall, when a cost-benefit analysis is prepared, discuss the relationship between that analysis and any analyses of unquantified environmental impacts, values, and amenities. For purposes of complying with the Act, the weighing of the merits and drawbacks of the various alternatives need not be displayed in a monetary cost-benefit analysis and should not be when there are important qualitative considerations. In any event, an environmental impact statement should at least indicate those considerations, including factors not related to environmental quality, which are likely to be relevant and important to a decision.

Sec. 1502.24 Methodology and scientific accuracy.

Agencies shall insure the professional integrity, including scientific integrity, of the discussions and analyses in environmental impact statements. They shall identify any methodologies used and shall make explicit reference by footnote to the scientific and other sources relied upon for conclusions in the statement. An agency may place discussion of methodology in an appendix.

Sec. 1502.25 Environmental review and consultation requirements.

(a) To the fullest extent possible, agencies shall prepare draft environmental impact statements concurrently with and integrated with environmental impact analyses and related surveys and studies required by the Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.), the National Historic Preservation Act of 1966 (16 U.S.C. 470 et seq.), the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.), and other environmental review laws and executive orders.

(b) The draft environmental impact statement shall list all Federal permits, licenses, and other entitlements which must be obtained in implementing the proposal. If it is uncertain whether a Federal permit, license, or other entitlement is necessary, the draft environmental impact statement shall so indicate.

PART 1503--
COMMENTING

Sec. 1503.1 Inviting comments.
1503.2 Duty to comment.
1503.3 Specificity of comments.
1503.4 Response to comments.

Authority: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 et seq.), sec. 309 of the Clean Air Act, as amended (42 U.S.C. 7609), and E.O. 11514 (Mar. 5, 1970, as amended by E.O. 11991, May 24, 1977).

Source: 43 FR 55997, Nov. 29, 1978, unless otherwise noted.

Sec. 1503.1 Inviting comments.

(a) After preparing a draft environmental impact statement and before preparing a final environmental impact statement the agency shall:

1. Obtain the comments of any Federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved or which is authorized to develop and enforce environmental standards.

2. Request the comments of:

   (i) Appropriate State and local agencies which are authorized to develop and enforce environmental standards;

   (ii) Indian tribes, when the effects may be on a reservation; and

   (iii) Any agency which has requested that it receive statements on actions of the kind proposed.

   Office of Management and Budget Circular A-95 (Revised), through its system of clearinghouses, provides a means of securing the views of State and local environmental agencies. The clearinghouses may be used, by mutual agreement of the lead agency and the clearinghouse, for securing State and local reviews of the draft environmental impact statements.

3. Request comments from the applicant, if any.

4. Request comments from the public, affirmatively soliciting comments from those persons or organizations who may be interested or affected.

(b) An agency may request comments on a final environmental impact statement before the decision is finally made. In any case other agencies or persons may make comments

before the final decision unless a different time is provided under Sec. 1506.10.

Sec. 1503.2 Duty to comment.

Federal agencies with jurisdiction by law or special expertise with respect to any environmental impact involved and agencies which are authorized to develop and enforce environmental standards shall comment on statements within their jurisdiction, expertise, or authority. Agencies shall comment within the time period specified for comment in Sec. 1506.10. A Federal agency may reply that it has no comment. If a cooperating agency is satisfied that its views are adequately reflected in the environmental impact statement, it should reply that it has no comment.

Sec. 1503.3 Specificity of comments.

(a) Comments on an environmental impact statement or on a proposed action shall be as specific as possible and may address either the adequacy of the statement or the merits of the alternatives discussed or both.

(b) When a commenting agency criticizes a lead agency's predictive methodology, the commenting agency should describe the alternative methodology which it prefers and why.

(c) A cooperating agency shall specify in its comments whether it needs additional information to fulfill other applicable environmental reviews or consultation requirements and what information it needs. In particular, it shall specify any additional information it needs to comment adequately on the draft statement's analysis of significant site-specific effects associated with the granting or approving by that cooperating agency of necessary Federal permits, licenses, or entitlements.

(d) When a cooperating agency with jurisdiction by law objects to or expresses reservations about the proposal on grounds of environmental impacts, the agency expressing the objection or reservation shall specify the mitigation measures it considers necessary to allow the agency to grant or approve applicable permit, license, or related requirements or concurrences.

Sec. 1503.4 Response to comments.

(a) An agency preparing a final environmental impact statement shall assess and consider comments both individually and collectively, and shall respond by one or more of the means listed below, stating its response in the final statement. Possible responses are to:

1. Modify alternatives including the proposed action.
2. Develop and evaluate alternatives not previously given serious consideration by the agency.

3. Supplement, improve, or modify its analyses.

4. Make factual corrections.

5. Explain why the comments do not warrant further agency response, citing the sources, authorities, or reasons which support the agency's position and, if appropriate, indicate those circumstances which would trigger agency reappraisal or further response.

(b) All substantive comments received on the draft statement (or summaries thereof where the response has been exceptionally voluminous), should be attached to the final statement whether or not the comment is thought to merit individual discussion by the agency in the text of the statement.

(c) If changes in response to comments are minor and are confined to the responses described in paragraphs (a)(4) and (5) of this section, agencies may write them on errata sheets and attach them to the statement instead of rewriting the draft statement. In such cases only the comments, the responses, and the changes and not the final statement need be circulated (Sec. 1502.19). The entire document with a new cover sheet shall be filed as the final statement (Sec. 1506.9).

PART 1504--PREDECISION REFERRALS TO THE COUNCIL OF PROPOSED FEDERAL ACTIONS DETERMINED TO BE ENVIRONMENTALLY UNSATISFACTORY

Sec. 1504.1 Purpose.
1504.2 Criteria for referral.
1504.3 Procedure for referrals and response.

Authority: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 et seq.), sec. 309 of the Clean Air Act, as amended (42 U.S.C. 7609), and E.O. 11514 (Mar. 5, 1970, as amended by E.O. 11991, May 24, 1977).

Source: 43 FR 55998, Nov. 29, 1978, unless otherwise noted.

Sec. 1504.1 Purpose.

(a) This part establishes procedures for referring to the Council Federal interagency disagreements concerning proposed major Federal actions that might cause unsatisfactory environmental effects. It provides means for early resolution of such disagreements.

(b) Under section 309 of the Clean Air Act (42 U.S.C. 7609), the Administrator of the Environmental Protection Agency is directed to review and comment publicly on the environmental impacts of Federal activities, including actions for which environmental impact statements are prepared. If after this review the Administrator determines that the matter is "unsatisfactory from the standpoint of public health or welfare or environmental quality," section 309 directs that the matter be referred to the Council (hereafter "environmental referrals").

(c) Under section 102(2)(C) of the Act other Federal agencies may make similar reviews of environmental impact statements, including judgments on the acceptability of anticipated environmental impacts. These reviews must be made available to the President, the Council and the public.

Sec. 1504.2 Criteria for referral.

Environmental referrals should be made to the Council only after concerted, timely (as early as possible in the process), but unsuccessful attempts to resolve differences with the lead agency. In determining what environmental objections to the matter are appropriate to refer to the Council, an agency should weigh potential adverse environmental impacts, considering:

(a) Possible violation of national environmental standards or policies.

(b) Severity.

(c) Geographical scope.

(d) Duration.

(e) Importance as precedents.

(f) Availability of environmentally preferable alternatives.

Sec. 1504.3 Procedure for referrals and response.

(a) A Federal agency making the referral to the Council shall:

1. Advise the lead agency at the earliest possible time that it intends to refer a matter to the Council unless a satisfactory agreement is reached.

2. Include such advice in the referring agency's comments on the draft environmental impact statement, except when the statement does not contain adequate information to permit an assessment of the matter's environmental acceptability.

3. Identify any essential information that is lacking and request that it be made available at the earliest possible time.

4. Send copies of such advice to the Council.

(b) The referring agency shall deliver its referral to the Council not later than twenty-five (25) days after the final environmental impact statement has been made available to the Environmental Protection Agency, commenting agencies, and the public. Except when an extension of this period has been granted by the lead agency, the Council will not accept a referral after that date.

(c) The referral shall consist of:

1. A copy of the letter signed by the head of the referring agency and delivered to the lead agency informing the lead agency of the referral and the reasons for it, and requesting that no action be taken to implement the matter until the Council acts upon the referral. The letter shall include a copy of the statement referred to in (c)(2) of this section.

2. A statement supported by factual evidence leading to the conclusion that the matter is unsatisfactory from the standpoint of public health or welfare or environmental quality. The statement shall:

   (i) Identify any material facts in controversy and incorporate (by reference if appropriate) agreed upon facts,

   (ii) Identify any existing environmental requirements or policies which would be violated by the matter,

   (iii) Present the reasons why the referring agency believes the matter is environmentally unsatisfactory,

   (iv) Contain a finding by the agency whether the issue raised is of national importance because of the threat to national environmental resources or policies or for some other reason,

   (v) Review the steps taken by the referring agency to bring its concerns to the attention of the lead agency at the earliest possible time, and

   (vi) Give the referring agency's recommendations as to what mitigation alternative, further study, or other course of action (including abandonment of the matter) are necessary to remedy the situation.

(d) Not later than twenty-five (25) days after the referral to the Council the lead agency may deliver a response to the Council, and the referring agency. If the lead agency requests more time and gives assurance that the matter will not go forward in the interim, the Council may grant an extension. The response shall:

1. Address fully the issues raised in the referral.

2. Be supported by evidence.

3. Give the lead agency's response to the referring agency's recommendations.

(e) Interested persons (including the applicant) may deliver their views in writing to the Council. Views in support of the referral should be delivered not later than the referral. Views in support of the response shall be delivered not later than the response. (f) Not later than twenty-five (25) days after receipt of both the referral and any response or upon being informed that there will be no response (unless the lead agency agrees to a longer time), the Council may take one or more of the following actions:

1. Conclude that the process of referral and response has successfully resolved the problem.

2. Initiate discussions with the agencies with the objective of mediation with referring and lead agencies.

3. Hold public meetings or hearings to obtain additional views and information.

4. Determine that the issue is not one of national importance and request the referring and lead agencies to pursue their decision process.

5. Determine that the issue should be further negotiated by the referring and lead agencies and is not appropriate for Council consideration until one or more heads of agencies report to the Council that the agencies' disagreements are irreconcilable.

6. Publish its findings and recommendations (including where appropriate a finding that the submitted evidence does not support the position of an agency).

7. When appropriate, submit the referral and the response together with the Council's recommendation to the President for action.

(g) The Council shall take no longer than 60 days to complete the actions specified in paragraph (f)(2), (3), or (5) of this section.

(h) When the referral involves an action required by statute to be determined on the record after opportunity for agency hearing, the referral shall be conducted in a manner consistent with 5 U.S.C. 557(d) (Administrative Procedure Act).

[43 FR 55998, Nov. 29, 1978; 44 FR 873, Jan. 3, 1979]

PART 1505--NEPA AND AGENCY DECISIONMAKING

Sec. 1505.1 Agency decisionmaking procedures.
1505.2 Record of decision in cases requiring environmental impact statements.
1505.3 Implementing the decision.

Authority: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 et seq.), sec. 309 of the Clean Air Act, as amended (42 U.S.C. 7609), and E.O. 11514 (Mar. 5, 1970, as amended by E.O. 11991, May 24, 1977).

Source: 43 FR 55999, Nov. 29, 1978, unless otherwise noted.

Sec. 1505.1 Agency decisionmaking procedures.

Agencies shall adopt procedures (Sec. 1507.3) to ensure that decisions are made in accordance with the policies and purposes of the Act. Such procedures shall include but not be limited to:

(a) Implementing procedures under section 102(2) to achieve the requirements of sections 101 and 102(1).

(b) Designating the major decision points for the agency's principal programs likely to have a significant effect on the human environment and assuring that the NEPA process corresponds with them.

(c) Requiring that relevant environmental documents, comments, and responses be part of the record in formal rulemaking or adjudicatory proceedings.

(d) Requiring that relevant environmental documents, comments, and responses accompany the proposal through existing agency review processes so that agency officials use the statement in making decisions.

(e) Requiring that the alternatives considered by the decisionmaker are encompassed by the range of alternatives discussed in the relevant environmental documents and that the decisionmaker consider the alternatives described in the environmental impact statement. If another decision document accompanies the relevant environmental documents to the decisionmaker, agencies are encouraged to make available to the public before the decision is made any part of that document that relates to the comparison of alternatives.

Sec. 1505.2 Record of decision in cases requiring environmental impact statements.

At the time of its decision (Sec. 1506.10) or, if appropriate, its recommendation to Congress, each agency shall prepare a concise public record of decision. The record, which may be integrated into any other record prepared by the agency, including that required by OMB

Circular A-95 (Revised), part I, sections 6(c) and (d), and Part II, section 5(b)(4), shall:

(a) State what the decision was.

(b) Identify all alternatives considered by the agency in reaching its decision, specifying the alternative or alternatives which were considered to be environmentally preferable. An agency may discuss preferences among alternatives based on relevant factors including economic and technical considerations and agency statutory missions. An agency shall identify and discuss all such factors including any essential considerations of national policy which were balanced by the agency in making its decision and state how those considerations entered into its decision.

(c) State whether all practicable means to avoid or minimize environmental harm from the alternative selected have been adopted, and if not, why they were not. A monitoring and enforcement program shall be adopted and summarized where applicable for any mitigation.

Sec. 1505.3 Implementing the decision.

Agencies may provide for monitoring to assure that their decisions are carried out and should do so in important cases. Mitigation (Sec. 1505.2(c)) and other conditions established in the environmental impact statement or during its review and committed as part of the decision shall be implemented by the lead agency or other appropriate consenting agency. The lead agency shall:

(a) Include appropriate conditions in grants, permits or other approvals.

(b) Condition funding of actions on mitigation.

(c) Upon request, inform cooperating or commenting agencies on progress in carrying out mitigation measures which they have proposed and which were adopted by the agency making the decision.

(d) Upon request, make available to the public the results of relevant monitoring.

PART 1506--OTHER REQUIREMENTS OF NEPA

Sec. 1506.1 Limitations on actions during NEPA process.
1506.2 Elimination of duplication with State and local procedures.
1506.3 Adoption.
1506.4 Combining documents.
1506.5 Agency responsibility.
1506.6 Public involvement.
1506.7 Further guidance.
1506.8 Proposals for legislation.
1506.9 Filing requirements.
1506.10 Timing of agency action.
1506.11 Emergencies.
1506.12 Effective date.

Authority: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 et seq.), sec. 309 of the Clean Air Act, as amended (42 U.S.C. 7609), and E.O. 11514 (Mar. 5, 1970, as amended by E.O. 11991, May 24, 1977).

Source: 43 FR 56000, Nov. 29, 1978, unless otherwise noted.

Sec. 1506.1 Limitations on actions during NEPA process.

(a) Until an agency issues a record of decision as provided in Sec. 1505.2 (except as provided in paragraph (c) of this section), no action concerning the proposal shall be taken which would:

1. Have an adverse environmental impact; or

2. Limit the choice of reasonable alternatives.

(b) If any agency is considering an application from a non-Federal entity, and is aware that the applicant is about to take an action within the agency's jurisdiction that would meet either of the criteria in paragraph (a) of this section, then the agency shall promptly notify the applicant that the agency will take appropriate action to insure that the objectives and procedures of NEPA are achieved.

(c) While work on a required program environmental impact statement is in progress and the action is not covered by an existing program statement, agencies shall not undertake in the interim any major Federal action covered by the program which may significantly affect the quality of the human environment unless such action:

1. Is justified independently of the program;

2. Is itself accompanied by an adequate environmental impact statement; and

3. Will not prejudice the ultimate decision on the program. Interim action prejudices the ultimate decision on the program when it tends to determine subsequent development or limit alternatives.

(d) This section does not preclude development by applicants of plans or designs or performance of other work necessary to support an application for Federal, State or local permits or assistance. Nothing in this section shall preclude Rural Electrification Administration approval of minimal expenditures not affecting the environment (e.g. long leadtime equipment and purchase options) made by non-governmental entities seeking loan guarantees from the Administration.

Sec. 1506.2 Elimination of duplication with State and local procedures.

(a) Agencies authorized by law to cooperate with State agencies of statewide jurisdiction pursuant to section 102(2)(D) of the Act may do so.

(b) Agencies shall cooperate with State and local agencies to the fullest extent possible to reduce duplication between NEPA and State and local requirements, unless the agencies are specifically barred from doing so by some other law. Except for cases covered by paragraph (a) of this section, such cooperation shall to the fullest extent possible include:

1. Joint planning processes.
2. Joint environmental research and studies.
3. Joint public hearings (except where otherwise provided by statute).
4. Joint environmental assessments.

(c) Agencies shall cooperate with State and local agencies to the fullest extent possible to reduce duplication between NEPA and comparable State and local requirements, unless the agencies are specifically barred from doing so by some other law. Except for cases covered by paragraph (a) of this section, such cooperation shall to the fullest extent possible include joint environmental impact statements. In such cases one or more Federal agencies and one or more State or local agencies shall be joint lead agencies. Where State laws or local ordinances have environmental impact statement requirements in addition to but not in conflict with those in NEPA, Federal agencies shall cooperate in fulfilling these requirements as well as those of Federal laws so that one document will comply with all applicable laws.

(d) To better integrate environmental impact statements into State or local planning processes, statements shall discuss any inconsistency of

a proposed action with any approved State or local plan and laws (whether or not federally sanctioned). Where an inconsistency exists, the statement should describe the extent to which the agency would reconcile its proposed action with the plan or law.

Sec. 1506.3 Adoption.

(a) An agency may adopt a Federal draft or final environmental impact statement or portion thereof provided that the statement or portion thereof meets the standards for an adequate statement under these regulations.

(b) If the actions covered by the original environmental impact statement and the proposed action are substantially the same, the agency adopting another agency's statement is not required to recirculate it except as a final statement. Otherwise the adopting agency shall treat the statement as a draft and recirculate it (except as provided in paragraph (c) of this section).

(c) A cooperating agency may adopt without recirculating the environmental impact statement of a lead agency when, after an independent review of the statement, the cooperating agency concludes that its comments and suggestions have been satisfied.

(d) When an agency adopts a statement which is not final within the agency that prepared it, or when the action it assesses is the subject of a referral under Part 1504, or when the statement's adequacy is the subject of a judicial action which is not final, the agency shall so specify.

Sec. 1506.4 Combining documents.

Any environmental document in compliance with NEPA may be combined with any other agency document to reduce duplication and paperwork.

Sec. 1506.5 Agency responsibility.

(a) Information. If an agency requires an applicant to submit environmental information for possible use by the agency in preparing an environmental impact statement, then the agency should assist the applicant by outlining the types of information required. The agency shall independently evaluate the information submitted and shall be responsible for its accuracy. If the agency chooses to use the information submitted by the applicant in the environmental impact statement, either directly or by reference, then the names of the persons responsible for the independent evaluation shall be included in

the list of preparers (Sec. 1502.17). It is the intent of this paragraph that acceptable work not be redone, but that it be verified by the agency.

(b) Environmental assessments. If an agency permits an applicant to prepare an environmental assessment, the agency, besides fulfilling the requirements of paragraph (a) of this section, shall make its own evaluation of the environmental issues and take responsibility for the scope and content of the environmental assessment.

(c) Environmental impact statements. Except as provided in Secs. 1506.2 and 1506.3 any environmental impact statement prepared pursuant to the requirements of NEPA shall be prepared directly by or by a contractor selected by the lead agency or where appropriate under Sec. 1501.6(b), a cooperating agency. It is the intent of these regulations that the contractor be chosen solely by the lead agency, or by the lead agency in cooperation with cooperating agencies, or where appropriate by a cooperating agency to avoid any conflict of interest. Contractors shall execute a disclosure statement prepared by the lead agency, or where appropriate the cooperating agency, specifying that they have no financial or other interest in the outcome of the project. If the document is prepared by contract, the responsible Federal official shall furnish guidance and participate in the preparation and shall independently evaluate the statement prior to its approval and take responsibility for its scope and contents. Nothing in this section is intended to prohibit any agency from requesting any person to submit information to it or to prohibit any person from submitting information to any agency.

Sec. 1506.6 Public involvement.

Agencies shall:

(a) Make diligent efforts to involve the public in preparing and implementing their NEPA procedures.

(b) Provide public notice of NEPA-related hearings, public meetings, and the availability of environmental documents so as to inform those persons and agencies who may be interested or affected.

5. In all cases the agency shall mail notice to those who have requested it on an individual action.

6. In the case of an action with effects of national concern notice shall include publication in the Federal Register and notice by mail to national organizations reasonably expected to be interested in the matter and may include listing in the 102 Monitor. An agency engaged in rulemaking may provide notice by mail to national organizations

who have requested that notice regularly be provided. Agencies shall maintain a list of such organizations.

7. In the case of an action with effects primarily of local concern the notice may include:

   (i) Notice to State and areawide clearinghouses pursuant to OMB Circular A- 95 (Revised).

   (ii) Notice to Indian tribes when effects may occur on reservations.

   (iii) Following the affected State's public notice procedures for comparable actions.

   (iv) Publication in local newspapers (in papers of general circulation rather than legal papers).

   (v) Notice through other local media.

   (vi) Notice to potentially interested community organizations including small business associations.

   (vii) Publication in newsletters that may be expected to reach potentially interested persons.

   (viii) Direct mailing to owners and occupants of nearby or affected property.

   (ix) Posting of notice on and off site in the area where the action is to be located.

   (c) Hold or sponsor public hearings or public meetings whenever appropriate or in accordance with statutory requirements applicable to the agency. Criteria shall include whether there is:

8. Substantial environmental controversy concerning the proposed action or substantial interest in holding the hearing.

9. A request for a hearing by another agency with jurisdiction over the action supported by reasons why a hearing will be helpful. If a draft environmental impact statement is to be considered at a public hearing, the agency should make the statement available to the public at least 15 days in advance (unless the purpose of the hearing is to provide information for the draft environmental impact statement).

   (d) Solicit appropriate information from the public.

   (e) Explain in its procedures where interested persons can get information or status reports on environmental impact statements and other elements of the NEPA process.

(f) Make environmental impact statements, the comments received, and any underlying documents available to the public pursuant to the provisions of the Freedom of Information Act (5 U.S.C. 552), without regard to the exclusion for interagency memoranda where such memoranda transmit comments of Federal agencies on the environmental impact of the proposed action. Materials to be made available to the public shall be provided to the public without charge to the extent practicable, or at a fee which is not more than the actual costs of reproducing copies required to be sent to other Federal agencies, including the Council.

Sec. 1506.7 Further guidance.

The Council may provide further guidance concerning NEPA and its procedures including:

(a) A handbook which the Council may supplement from time to time, which shall in plain language provide guidance and instructions concerning the application of NEPA and these regulations.

(b) Publication of the Council's Memoranda to Heads of Agencies.

(c) In conjunction with the Environmental Protection Agency and the publication of the 102 Monitor, notice of:

10. Research activities;

11. Meetings and conferences related to NEPA; and

12. Successful and innovative procedures used by agencies to implement NEPA.

Sec. 1506.8 Proposals for legislation.

(a) The NEPA process for proposals for legislation (Sec. 1508.17) significantly affecting the quality of the human environment shall be integrated with the legislative process of the Congress. A legislative environmental impact statement is the detailed statement required by law to be included in a recommendation or report on a legislative proposal to Congress. A legislative environmental impact statement shall be considered part of the formal transmittal of a legislative proposal to Congress; however, it may be transmitted to Congress up to 30 days later in order to allow time for completion of an accurate statement which can serve as the basis for public and Congressional debate. The statement must be available in time for Congressional hearings and deliberations.

(b) Preparation of a legislative environmental impact statement shall

conform to the requirements of these regulations except as follows:

13. There need not be a scoping process.

14. The legislative statement shall be prepared in the same manner as a draft statement, but shall be considered the "detailed statement" required by statute; Provided, That when any of the following conditions exist both the draft and final environmental impact statement on the legislative proposal shall be prepared and circulated as provided by Secs. 1503.1 and 1506.10.

    (i) A Congressional Committee with jurisdiction over the proposal has a rule requiring both draft and final environmental impact statements.
    (ii) The proposal results from a study process required by statute (such as those required by the Wild and Scenic Rivers Act (16 U.S.C. 1271 et seq.) and the Wilderness Act (16 U.S.C. 1131 et seq.)).
    (iii) Legislative approval is sought for Federal or federally assisted construction or other projects which the agency recommends be located at specific geographic locations. For proposals requiring an environmental impact statement for the acquisition of space by the General Services Administration, a draft statement shall accompany the Prospectus or the 11(b) Report of Building Project Surveys to the Congress, and a final statement shall be completed before site acquisition.
    (iv) The agency decides to prepare draft and final statements.

    (c) Comments on the legislative statement shall be given to the lead agency which shall forward them along with its own responses to the Congressional committees with jurisdiction.

Sec. 1506.9 Filing requirements.

Environmental impact statements together with comments and responses shall be filed with the Environmental Protection Agency, attention Office of Federal Activities (A-104), 401 M Street SW., Washington, DC 20460. Statements shall be filed with EPA no earlier than they are also transmitted to commenting agencies and made available to the public. EPA shall deliver one copy of each statement to the Council, which shall satisfy the requirement of availability to the President. EPA may issue guidelines to agencies to implement its responsibilities under this section and Sec. 1506.10.

Sec. 1506.10 Timing of agency action.

(a) The Environmental Protection Agency shall publish a notice in the Federal Register each week of the environmental impact statements

filed during the preceding week. The minimum time periods set forth in this section shall be calculated from the date of publication of this notice.

(b) No decision on the proposed action shall be made or recorded under Sec. 1505.2 by a Federal agency until the later of the following dates:

15. Ninety (90) days after publication of the notice described above in paragraph (a) of this section for a draft environmental impact statement.

16. Thirty (30) days after publication of the notice described above in paragraph (a) of this section for a final environmental impact statement. An exception to the rules on timing may be made in the case of an agency decision which is subject to a formal internal appeal. Some agencies have a formally established appeal process which allows other agencies or the public to take appeals on a decision and make their views known, after publication of the final environmental impact statement. In such cases, where a real opportunity exists to alter the decision, the decision may be made and recorded at the same time the environmental impact statement is published.

This means that the period for appeal of the decision and the 30-day period prescribed in paragraph (b)(2) of this section may run concurrently. In such cases the environmental impact statement shall explain the timing and the public's right of appeal. An agency engaged in rulemaking under the Administrative Procedure Act or other statute for the purpose of protecting the public health or safety, may waive the time period in paragraph (b)(2) of this section and publish a decision on the final rule simultaneously with publication of the notice of the availability of the final environmental impact statement as described in paragraph (a) of this section.

(c) If the final environmental impact statement is filed within ninety (90) days after a draft environmental impact statement is filed with the Environmental Protection Agency, the minimum thirty (30) day period and the minimum ninety (90) day period may run concurrently. However, subject to paragraph (d) of this section agencies shall allow not less than 45 days for comments on draft statements.

(d) The lead agency may extend prescribed periods. The Environmental Protection Agency may upon a showing by the lead agency of compelling reasons of national policy reduce the prescribed periods and may upon a showing by any other Federal agency of compelling reasons of national policy also extend prescribed periods, but only after consultation with the lead agency. (Also see Sec. 1507.3(d).) Failure to file timely comments shall not be a sufficient reason for extending a period. If the lead agency does not concur with the extension of time, EPA may not extend it for more than 30 days. When the Environmental Protection Agency reduces or extends any period of time it shall notify the Council.

[43 FR 56000, Nov. 29, 1978; 44 FR 874, Jan. 3, 1979]

Sec. 1506.11 Emergencies.

Where emergency circumstances make it necessary to take an action with significant environmental impact without observing the provisions of these regulations, the Federal agency taking the action should consult with the Council about alternative arrangements. Agencies and the Council will limit such arrangements to actions necessary to control the immediate impacts of the emergency. Other actions remain subject to NEPA review.

Sec. 1506.12 Effective date.

The effective date of these regulations is July 30, 1979, except that for agencies that administer programs that qualify under section 102(2)(D) of the Act or under section 104(h) of the Housing and Community Development Act of 1974 an additional four months shall be allowed for the State or local agencies to adopt their implementing procedures.

(a) These regulations shall apply to the fullest extent practicable to ongoing activities and environmental documents begun before the effective date. These regulations do not apply to an environmental impact statement or supplement if the draft statement was filed before the effective date of these regulations. No completed environmental documents need be redone by reasons of these regulations. Until these regulations are applicable, the Council's guidelines published in the Federal Register of August 1, 1973, shall continue to be applicable. In cases where these regulations are applicable the guidelines are superseded. However, nothing shall prevent an agency from proceeding under these regulations at an earlier time.

(b) NEPA shall continue to be applicable to actions begun before January 1, 1970, to the fullest extent possible.

PART 1507--AGENCY COMPLIANCE

Sec. 1507.1 Compliance.
1507.2 Agency capability to comply.
1507.3 Agency procedures.

Authority: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 et seq.), sec. 309 of the Clean Air Act, as amended (42 U.S.C. 7609), and E.O. 11514 (Mar. 5, 1970, as amended by E.O. 11991, May 24, 1977).

Source: 43 FR 56002, Nov. 29, 1978, unless otherwise noted.

Sec. 1507.1 Compliance.

All agencies of the Federal Government shall comply with these regulations. It is the intent of these regulations to allow each agency flexibility in adapting its implementing procedures authorized by Sec. 1507.3 to the requirements of other applicable laws.

Sec. 1507.2 Agency capability to comply.

Each agency shall be capable (in terms of personnel and other resources) of complying with the requirements enumerated below. Such compliance may include use of other's resources, but the using agency shall itself have sufficient capability to evaluate what others do for it. Agencies shall:

(a) Fulfill the requirements of section 102(2)(A) of the Act to utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decisionmaking which may have an impact on the human environment. Agencies shall designate a person to be responsible for overall review of agency NEPA compliance.

(b) Identify methods and procedures required by section 102(2)(B) to insure that presently unquantified environmental amenities and values may be given appropriate consideration.

(c) Prepare adequate environmental impact statements pursuant to section 102(2)(C) and comment on statements in the areas where the agency has jurisdiction by law or special expertise or is authorized to develop and enforce environmental standards.

(d) Study, develop, and describe alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources. This requirement of section 102(2)(E) extends to all such proposals, not just the more limited scope of section 102(2)(C)(iii) where the discussion of alternatives is confined to impact statements.

(e) Comply with the requirements of section 102(2)(H) that the agency initiate and utilize ecological information in the planning and development of resource-oriented projects.

(f) Fulfill the requirements of sections 102(2)(F), 102(2)(G), and 102(2)(I), of the Act and of Executive Order 11514, Protection and Enhancement of Environmental Quality, Sec. 2.

Sec. 1507.3 Agency procedures.

(a) Not later than eight months after publication of these regulations as finally adopted in the Federal Register, or five months after the establishment of an agency, whichever shall come later, each agency shall as necessary adopt procedures to supplement these regulations. When the agency is a department, major subunits are encouraged (with the consent of the department) to adopt their own procedures. Such procedures shall not paraphrase these regulations. They shall confine themselves to implementing procedures. Each agency shall consult with the Council while developing its procedures and before publishing them in the Federal Register for comment. Agencies with similar programs should consult with each other and the Council to coordinate their procedures, especially for programs requesting similar information from applicants. The procedures shall be adopted only after an opportunity for public review and after review by the Council for conformity with the Act and these regulations. The Council shall complete its review within 30 days. Once in

effect they shall be filed with the Council and made readily available to the public. Agencies are encouraged to publish explanatory guidance for these regulations and their own procedures. Agencies shall continue to review their policies and procedures and in consultation with the Council to revise them as necessary to ensure full compliance with the purposes and provisions of the Act.

(b) Agency procedures shall comply with these regulations except where compliance would be inconsistent with statutory requirements and shall include:

1. Those procedures required by Secs. 1501.2(d), 1502.9(c)(3), 1505.1, 1506.6(e), and 1508.4.

2. Specific criteria for and identification of those typical classes of action:

   (i) Which normally do require environmental impact statements.

   (ii) Which normally do not require either an environmental impact statement or an environmental assessment (categorical exclusions (Sec. 1508.4)).

   (iii) Which normally require environmental assessments but not necessarily environmental impact statements.

(c) Agency procedures may include specific criteria for providing limited exceptions to the provisions of these regulations for classified proposals. They are proposed actions which are specifically authorized under criteria established by an Executive Order or statute to be kept secret in the interest of national defense or foreign policy and are in fact properly classified pursuant to such Executive Order or statute. Environmental assessments and environmental impact statements which address classified proposals may be safeguarded and restricted from public dissemination in accordance with agencies' own regulations applicable to classified information. These documents may be organized so that classified portions can be included as annexes, in order that the unclassified portions can be made available to the public.

(d) Agency procedures may provide for periods of time other than those presented in Sec. 1506.10 when necessary

to comply with other specific statutory requirements.

(e) Agency procedures may provide that where there is a lengthy period between the agency's decision to prepare an environmental impact statement and the time of actual preparation, the notice of intent required by Sec. 1501.7 may be published at a reasonable time in advance of preparation of the draft statement.

PART 1508--TERMINOLOGY AND INDEX

Sec. 1508.1 Terminology.
1508.2 Act.
1508.3 Affecting.
1508.4 Categorical exclusion.
1508.5 Cooperating agency.
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1508.7 Cumulative impact.
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1508.25 Scope.
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1508.27 Significantly.
1508.28 Tiering.

Authority: NEPA, the Environmental Quality Improvement Act of 1970, as amended (42 U.S.C. 4371 et seq.), sec. 309 of the Clean Air Act, as amended (42 U.S.C. 7609), and E.O. 11514 (Mar. 5, 1970, as amended by E.O. 11991, May 24, 1977).

Source: 43 FR 56003, Nov. 29, 1978, unless otherwise noted.

Sec. 1508.1 Terminology.

The terminology of this part shall be uniform throughout the Federal Government.

Sec. 1508.2 Act.

"Act" means the National Environmental Policy Act, as amended (42 U.S.C. 4321, et seq.) which is also referred to as "NEPA."

Sec. 1508.3 Affecting.

"Affecting" means will or may have an effect on.

Sec. 1508.4 Categorical exclusion.

"Categorical exclusion" means a category of actions which do not individually or cumulatively have a significant effect on the human environment and which have been found to have no such effect in procedures adopted by a Federal agency in implementation of these regulations (Sec. 1507.3) and for which, therefore, neither an environmental assessment nor an environmental impact statement is required. An agency may decide in its procedures or otherwise, to prepare environmental assessments for the reasons stated in Sec. 1508.9 even though it is not required to do so. Any procedures under this section shall provide for extraordinary circumstances in which a normally excluded action may have a significant environmental effect.

Sec. 1508.5 Cooperating agency.

"Cooperating agency" means any Federal agency other than a lead agency which has jurisdiction by law or special expertise with respect to any environmental impact involved in a proposal (or a reasonable alternative) for legislation or other major Federal action significantly affecting the quality of the human environment. The selection and responsibilities of a cooperating agency are described in Sec. 1501.6. A State or local agency of similar qualifications or, when the effects are on a reservation, an Indian Tribe, may by agreement with the lead agency become a cooperating agency.

Sec. 1508.6 Council.

"Council" means the Council on Environmental Quality

established by Title II of the Act.

Sec. 1508.7 Cumulative impact.

"Cumulative impact" is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Sec. 1508.8 Effects.

"Effects" include:

(a) Direct effects, which are caused by the action and occur at the same time and place.

(b) Indirect effects, which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems.

Effects and impacts as used in these regulations are synonymous. Effects includes ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative. Effects may also include those resulting from actions which may have both beneficial and detrimental effects, even if on balance the agency believes that the effect will be beneficial.

Sec. 1508.9 Environmental assessment.

"Environmental assessment":

(a) Means a concise public document for which a Federal agency is responsible that serves to:

1. Briefly provide sufficient evidence and analysis for determining whether to prepare an

environmental impact statement or a finding of no significant impact.

2. Aid an agency's compliance with the Act when no environmental impact statement is necessary.

3. Facilitate preparation of a statement when one is necessary.

(b) Shall include brief discussions of the need for the proposal, of alternatives as required by section 102(2)(E), of the environmental impacts of the proposed action and alternatives, and a listing of agencies and persons consulted.

Sec. 1508.10 Environmental document.

"Environmental document" includes the documents specified in Sec. 1508.9 (environmental assessment), Sec. 1508.11 (environmental impact statement), Sec. 1508.13 (finding of no significant impact), and Sec. 1508.22 (notice of intent).

Sec. 1508.11 Environmental impact statement.

"Environmental impact statement" means a detailed written statement as required by section 102(2)(C) of the Act.

Sec. 1508.12 Federal agency.

"Federal agency" means all agencies of the Federal Government. It does not mean the Congress, the Judiciary, or the President, including the performance of staff functions for the President in his Executive Office. It also includes for purposes of these regulations States and units of general local government and Indian tribes assuming NEPA responsibilities under section 104(h) of the Housing and Community Development Act of 1974.

Sec. 1508.13 Finding of no significant impact.

"Finding of no significant impact" means a document by a Federal agency briefly presenting the reasons why an action, not otherwise excluded (Sec. 1508.4), will not have a significant effect on the human environment and for which an

environmental impact statement therefore will not be prepared. It shall include the environmental assessment or a summary of it and shall note any other environmental documents related to it (Sec. 1501.7(a)(5)). If the assessment is included, the finding need not repeat any of the discussion in the assessment but may incorporate it by reference.

Sec. 1508.14 Human environment.

"Human environment" shall be interpreted comprehensively to include the natural and physical environment and the relationship of people with that environment. (See the definition of "effects" (Sec. 1508.8).) This means that economic or social effects are not intended by themselves to require preparation of an environmental impact statement. When an environmental impact statement is prepared and economic or social and natural or physical environmental effects are interrelated, then the environmental impact statement will discuss all of these effects on the human environment.

Sec. 1508.15 Jurisdiction by law.

"Jurisdiction by law" means agency authority to approve, veto, or finance all or part of the proposal.

Sec. 1508.16 Lead agency.

"Lead agency" means the agency or agencies preparing or having taken primary responsibility for preparing the environmental impact statement.

Sec. 1508.17 Legislation.

"Legislation" includes a bill or legislative proposal to Congress developed by or with the significant cooperation and support of a Federal agency, but does not include requests for appropriations. The test for significant cooperation is whether the proposal is in fact predominantly that of the agency rather than another source. Drafting does not by itself constitute significant cooperation. Proposals for legislation include requests for ratification of treaties. Only the agency which has primary responsibility for the subject matter involved will prepare a legislative environmental impact

statement.

Sec. 1508.18 Major Federal action.

"Major Federal action" includes actions with effects that may be major and which are potentially subject to Federal control and responsibility. Major reinforces but does not have a meaning independent of significantly (Sec. 1508.27). Actions include the circumstance where the responsible officials fail to act and that failure to act is reviewable by courts or administrative tribunals under the Administrative Procedure Act or other applicable law as agency action.

(a) Actions include new and continuing activities, including projects and programs entirely or partly financed, assisted, conducted, regulated, or approved by federal agencies; new or revised agency rules, regulations, plans, policies, or procedures; and legislative proposals (Secs. 1506.8, 1508.17). Actions do not include funding assistance solely in the form of general revenue sharing funds, distributed under the State and Local Fiscal Assistance Act of 1972, 31 U.S.C. 1221 et seq., with no Federal agency control over the subsequent use of such funds. Actions do not include bringing judicial or administrative civil or criminal enforcement actions.

(b) Federal actions tend to fall within one of the following categories:

1. Adoption of official policy, such as rules, regulations, and interpretations adopted pursuant to the Administrative Procedure Act, 5 U.S.C. 551 et seq.; treaties and international conventions or agreements; formal documents establishing an agency's policies which will result in or substantially alter agency programs.

2. Adoption of formal plans, such as official documents prepared or approved by federal agencies which guide or prescribe alternative uses of Federal resources, upon which future agency actions will be based.

3. Adoption of programs, such as a group of concerted actions to implement a specific policy or plan; systematic and connected

agency decisions allocating agency resources to implement a specific statutory program or executive directive.

4. Approval of specific projects, such as construction or management activities located in a defined geographic area. Projects include actions approved by permit or other regulatory decision as well as federal and federally assisted activities.

Sec. 1508.19 Matter.

"Matter" includes for purposes of Part 1504: (a) With respect to the Environmental Protection Agency, any proposed legislation, project, action or regulation as those terms are used in section 309(a) of the Clean Air Act (42 U.S.C. 7609). (b) With respect to all other agencies, any proposed major federal action to which section 102(2)(C) of NEPA applies.

Sec. 1508.20 Mitigation.

"Mitigation" includes:

(a) Avoiding the impact altogether by not taking a certain action or parts of an action.

(b) Minimizing impacts by limiting the degree or magnitude of the action and its implementation.

(c) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.

(d) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.

(e) Compensating for the impact by replacing or providing substitute resources or environments.

Sec. 1508.21 NEPA process.

"NEPA process" means all measures necessary for compliance with the requirements of section 2 and Title I of NEPA.

Sec. 1508.22 Notice of intent.

"Notice of intent" means a notice that an environmental impact statement will be prepared and considered. The notice shall briefly:

(a) Describe the proposed action and possible alternatives.

(b) Describe the agency's proposed scoping process including whether, when, and where any scoping meeting will be held.

(c) State the name and address of a person within the agency who can answer questions about the proposed action and the environmental impact statement.

Sec. 1508.23 Proposal.

"Proposal" exists at that stage in the development of an action when an agency subject to the Act has a goal and is actively preparing to make a decision on one or more alternative means of accomplishing that goal and the effects can be meaningfully evaluated. Preparation of an environmental impact statement on a proposal should be timed (Sec. 1502.5) so that the final statement may be completed in time for the statement to be included in any recommendation or report on the proposal. A proposal may exist in fact as well as by agency declaration that one exists.

Sec. 1508.24 Referring agency.

"Referring agency" means the federal agency which has referred any matter to the Council after a determination that the matter is unsatisfactory from the standpoint of public health or welfare or environmental quality.

Sec. 1508.25 Scope.

Scope consists of the range of actions, alternatives, and impacts to be considered in an environmental impact statement. The scope of an individual statement may depend on its relationships to other statements (Secs.1502.20 and 1508.28). To determine the scope of environmental impact statements, agencies shall consider 3 types of actions, 3 types of alternatives, and 3 types of impacts. They include:

(a) Actions (other than unconnected single actions) which may be:

1. Connected actions, which means that they are closely related and therefore should be discussed in the same impact statement. Actions are connected if they:

   (i) Automatically trigger other actions which may require environmental impact statements.

   (ii) Cannot or will not proceed unless other actions are taken previously or simultaneously.

   (iii) Are interdependent parts of a larger action and depend on the larger action for their justification.

2. Cumulative actions, which when viewed with other proposed actions have cumulatively significant impacts and should therefore be discussed in the same impact statement.

3. Similar actions, which when viewed with other reasonably foreseeable or proposed agency actions, have similarities that provide a basis for evaluating their environmental consequencies together, such as common timing or geography. An agency may wish to analyze these actions in the same impact statement. It should do so when the best way to assess adequately the combined impacts of similar actions or reasonable alternatives to such actions is to treat them in a single impact statement.

(b) Alternatives, which include:

1. No action alternative.

2. Other reasonable courses of actions.

3. Mitigation measures (not in the proposed action).

(c) Impacts, which may be: (1) Direct; (2) indirect; (3) cumulative.

Sec. 1508.26 Special expertise.

"Special expertise" means statutory responsibility, agency mission, or related program experience.

Sec. 1508.27 Significantly.

"Significantly" as used in NEPA requires considerations of both context and intensity:

(a) Context. This means that the significance of an action must be analyzed in several contexts such as society as a whole (human, national), the affected region, the affected interests, and the locality. Significance varies with the setting of the proposed action. For instance, in the case of a site-specific action, significance would usually depend upon the effects in the locale rather than in the world as a whole. Both short- and long-term effects are relevant.

(b) Intensity. This refers to the severity of impact. Responsible officials must bear in mind that more than one agency may make decisions about partial aspects of a major action. The following should be considered in evaluating intensity:

1. Impacts that may be both beneficial and adverse. A significant effect may exist even if the Federal agency believes that on balance the effect will be beneficial.

2. The degree to which the proposed action affects public health or safety.

3. Unique characteristics of the geographic area such as proximity to historic or cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas.

4. The degree to which the effects on the quality of the human environment are likely to be highly controversial.

5. The degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks.

6. The degree to which the action may establish a

precedent for future actions with significant effects or represents a decision in principle about a future consideration.

7. Whether the action is related to other actions with individually insignificant but cumulatively significant impacts. Significance exists if it is reasonable to anticipate a cumulatively significant impact on the environment. Significance cannot be avoided by terming an action temporary or by breaking it down into small component parts.

8. The degree to which the action may adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places or may cause loss or destruction of significant scientific, cultural, or historical resources.

9. The degree to which the action may adversely affect an endangered or threatened species or its habitat that has been determined to be critical under the Endangered Species Act of 1973.

10. Whether the action threatens a violation of Federal, State, or local law or requirements imposed for the protection of the environment.

[43 FR 56003, Nov. 29, 1978; 44 FR 874, Jan. 3, 1979]

Sec. 1508.28 Tiering.

"Tiering" refers to the coverage of general matters in broader environmental impact statements (such as national program or policy statements) with subsequent narrower statements or environmental analyses (such as regional or basinwide program statements or ultimately site-specific statements) incorporating by reference the general discussions and concentrating solely on the issues specific to the statement subsequently prepared. Tiering is appropriate when the sequence of statements or analyses is:

(a) From a program, plan, or policy environmental impact statement to a program, plan, or policy statement or analysis of lesser scope or to a site- specific statement or

analysis.

(b) From an environmental impact statement on a specific action at an early stage (such as need and site selection) to a supplement (which is preferred) or a subsequent statement or analysis at a later stage (such as environmental mitigation). Tiering in such cases is appropriate when it helps the lead agency to focus on the issues which are ripe for decision and exclude from consideration issues already decided or not yet ripe.

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NEPA's Forty Most Asked Questions

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1a. **Range of Alternatives.** What is meant by "range of alternatives" as referred to in Sec. 1505.1(e)?

A. The phrase "range of alternatives" refers to the alternatives discussed in environmental documents. It includes all reasonable alternatives, which must be rigorously explored and objectively evaluated, as well as those other alternatives, which are eliminated from detailed study with a brief discussion of the reasons for eliminating them. Section 1502.14. A decisionmaker must not consider alternatives beyond the range of alternatives discussed in the relevant environmental documents. Moreover, a decisionmaker must, in fact, consider all the alternatives discussed in an EIS. Section 1505.1(e).

1b. **How many alternatives** have to be discussed when there is an infinite number of possible alternatives?

A. For some proposals there may exist a very large or even an infinite number of possible reasonable alternatives. For example, a proposal to designate wilderness areas within a National Forest could be said to involve an infinite number of alternatives from 0 to 100 percent of the forest. When there are potentially a very large number of alternatives, only a reasonable number of examples, covering the full spectrum of alternatives, must be analyzed and compared in the EIS. An appropriate series of alternatives might include dedicating 0, 10, 30, 50, 70, 90, or 100 percent of the Forest to wilderness. What constitutes a reasonable range of alternatives depends on the nature of the proposal and the facts in each case.

2a. **Alternatives Outside the Capability of Applicant or Jurisdiction of Agency.** If an EIS is prepared in connection with an application for a permit or other federal approval, must the EIS rigorously analyze and discuss alternatives that are outside the capability of the applicant or can it be limited to reasonable alternatives that can be carried out by the applicant?

A. Section 1502.14 requires the EIS to examine all reasonable alternatives to the proposal. In determining the scope of alternatives to be considered, the emphasis is on what is "reasonable" rather than on whether the proponent or applicant likes or is itself capable of carrying out a particular alternative. Reasonable alternatives include those that are practical or feasible from the technical and economic standpoint and using common sense, rather than simply desirable from the standpoint of the applicant.

2b. Must the EIS analyze **alternatives outside the jurisdiction** or capability of the agency or beyond what Congress has authorized?

A. An alternative that is outside the legal jurisdiction of the lead agency must still be analyzed in the EIS if it is reasonable. A potential conflict with local or federal law does not necessarily render an alternative unreasonable, although such conflicts must be considered. Section 1506.2(d). Alternatives that are outside the scope of what Congress has approved or funded must still be evaluated in the EIS if they are reasonable, because the EIS may serve as the basis for modifying the Congressional approval or funding in light of NEPA's goals and policies. Section 1500.1(a).

3. **No-Action Alternative.** What does the "no action" alternative include? If an agency is under a court order or legislative command to act, must the EIS address the "no action" alternative?

A. Section 1502.14(d) requires the alternatives analysis in the EIS to "include the alternative of no action." There are two distinct interpretations of "no action" that must be considered, depending on the nature of the proposal being evaluated. The first situation might involve an action such as updating a land management plan where ongoing programs initiated under existing legislation and regulations will continue, even as new plans are developed. In these cases "no action" is "no change" from current management direction or level of management intensity. To construct an alternative that is based on no management at all would be a useless academic exercise. Therefore, the "no action" alternative may be thought of in terms of continuing with the present course of action until that action is changed. Consequently, projected impacts of alternative management schemes would be compared in the EIS to those impacts projected for the existing plan. In this case, alternatives would include management plans of both greater and lesser intensity, especially greater and lesser levels of resource development.

The second interpretation of "no action" is illustrated in instances involving federal decisions on proposals for projects. "No action" in such cases would mean the proposed activity would not take place, and the resulting environmental effects from taking no action would be compared with the effects of permitting the proposed activity or an alternative activity to go forward.

Where a choice of "no action" by the agency would result in predictable actions by others, this consequence of the "no action" alternative should be included in the analysis. For example, if denial of permission to build a railroad to a facility would lead to construction of a road and increased truck traffic, the EIS should analyze this consequence of the "no action" alternative.

In light of the above, it is difficult to think of a situation where it would not be appropriate to address a "no action" alternative. Accordingly, the regulations require the analysis of the no action alternative even if the agency is under a court order or legislative command to act. This analysis provides a benchmark, enabling decisionmakers to compare the magnitude of environmental effects of the action alternatives. It is also an example of a reasonable alternative outside the jurisdiction of the agency which must be analyzed. Section 1502.14(c). See Question 2 above. Inclusion of such an analysis in the EIS is necessary to inform the Congress, the public, and the President as intended by NEPA. Section 1500.1(a).

4a. **Agency's Preferred Alternative.** What is the "agency's preferred alternative"?

A. The "agency's preferred alternative" is the alternative which the agency believes would fulfill its statutory mission and responsibilities, giving consideration to economic, environmental, technical and other factors. The concept of the "agency's preferred alternative" is different from the "environmentally preferable alternative," although in some cases one alternative may be both. See Question 6 below. It is identified so that agencies and the public can understand the lead agency's orientation.

4b. Does the **"preferred alternative"** have to be identified in the Draft EIS **and** the Final EIS or just in the Final EIS?

A. Section 1502.14(e) requires the section of the EIS on alternatives to "identify the agency's preferred alternative if one or more exists, in the draft statement, and identify such alternative in the final statement . . ." This means that if the agency has a preferred alternative at the Draft EIS stage, that alternative must be labeled or identified as such in the Draft EIS. If the responsible federal official in fact has no preferred alternative at the Draft EIS stage, a preferred alternative need not be identified there. By the time the Final EIS is filed, Section 1502.14(e) presumes the existence of a preferred alternative and requires its identification in the Final EIS "unless another law prohibits the expression of such a preference."

4c. Who recommends or determines the **"preferred alternative?"**

A. The lead agency's official with line responsibility for preparing the EIS and assuring its adequacy is responsible for identifying the agency's preferred alternative(s). The NEPA regulations do not dictate which official in an agency shall be responsible for preparation of EISs, but agencies can identify this official in their implementing procedures, pursuant to Section 1507.3.

Even though the agency's preferred alternative is identified by the EIS preparer in the EIS, the statement must be objectively prepared and not slanted to support the choice of the agency's preferred alternative over the other reasonable and feasible alternatives.

5a. **Proposed Action v. Preferred Alternative.** Is the "proposed action" the same thing as the "preferred alternative"?

A. The "proposed action" may be, but is not necessarily, the agency's "preferred alternative." The proposed action may be a proposal in its initial form before undergoing analysis in the EIS process. If the proposed action is [46 FR 18028] internally generated, such as preparing a land management plan, the proposed action might end up as the agency's preferred alternative. On the other hand the proposed action may be granting an application to a non-federal entity for a permit. The agency may or may not have a "preferred alternative" at the Draft EIS stage (see Question 4 above). In that case the agency may decide at the Final EIS stage, on the basis of the Draft EIS and the public and agency comments, that an alternative other than the proposed action is the agency's "preferred alternative."

5b. Is the analysis of the **"proposed action"** in an EIS to be treated differently from the analysis of alternatives?

A. The degree of analysis devoted to each alternative in the EIS is to be substantially similar to that devoted to the "proposed action." Section 1502.14 is titled "Alternatives including the proposed action" to reflect such comparable treatment. Section 1502.14(b) specifically requires "substantial treatment" in the EIS of each alternative including the proposed action. This regulation does not dictate an amount of information to be provided, but rather, prescribes a level of treatment, which may in turn require varying amounts of information, to enable a reviewer to evaluate and compare alternatives.

6a. **Environmentally Preferable Alternative.** What is the meaning of the term "environmentally preferable alternative" as used in the regulations with reference to Records of Decision? How is the term "environment" used in the phrase?

A. Section 1505.2(b) requires that, in cases where an EIS has been prepared, the Record of Decision (ROD) must identify all alternatives that were considered, ". . . specifying the alternative or alternatives which were considered to be environmentally preferable." The environmentally preferable alternative is the alternative that will promote the national environmental policy as expressed in NEPA's Section 101. Ordinarily, this means the alternative that causes the least damage to the biological and physical environment; it also means the alternative which best protects, preserves, and enhances historic, cultural, and natural resources.

The Council recognizes that the identification of the environmentally preferable alternative may involve difficult judgments, particularly when one environmental value must be balanced against another. The public and other agencies reviewing a Draft EIS can assist the lead agency to develop and determine environmentally preferable alternatives by providing their views in comments on the Draft EIS. Through the identification of the environmentally preferable alternative, the decisionmaker is clearly faced with a choice between that alternative and others, and must consider whether the decision accords with the Congressionally declared policies of the Act.

6b. **Who recommends or determines** what is environmentally preferable?

A. The agency EIS staff is encouraged to make recommendations of the environmentally preferable alternative(s) during EIS preparation. In any event the lead agency official responsible for the EIS is encouraged to identify the environmentally preferable alternative(s) in the EIS. In all cases, commentors from other agencies and the public are also encouraged to address this question. The agency must identify the environmentally preferable alternative in the ROD.

7. **Difference Between Sections of EIS on Alternatives and Environmental Consequences.** What is the difference between the sections in the EIS on "alternatives" and "environmental consequences"? How do you avoid duplicating the discussion of alternatives in preparing these two sections?

A. The "alternatives" section is the heart of the EIS. This section rigorously explores and objectively evaluates all reasonable alternatives including the proposed action. Section 1502.14. It should include relevant comparisons on environmental and other grounds. The "environmental consequences" section of the EIS discusses the specific environmental impacts or effects of each of the alternatives including the proposed action. Section 1502.16. In order to avoid duplication between these two sections, most of the "alternatives" section should be devoted to describing and comparing the alternatives. Discussion of the environmental impacts of these alternatives should be limited to a concise descriptive summary of such impacts in a comparative form, including charts or tables, thus sharply defining the issues and providing a clear basis for choice among options. Section 1502.14.

The "environmental consequences" section should be devoted largely to a scientific analysis of the direct and indirect environmental effects of the proposed action and of each of the alternatives. It forms the analytic basis for the concise comparison in the "alternatives" section.

8. **Early Application of NEPA.** Section 1501.2(d) of the NEPA regulations requires agencies to provide for the early application of NEPA to cases where actions are planned by **private applicants** or **non-Federal entities** and are, at some stage, subject to federal approval of permits, loans, loan guarantees, insurance or other actions. What must and can agencies do to apply NEPA early in these cases?

A. Section 1501.2(d) requires federal agencies to take steps toward ensuring that private parties and state and local entities initiate environmental studies as soon as federal involvement in their proposals can be foreseen. This section is intended to ensure that environmental factors are considered at an early stage in the planning process and to avoid the situation where the applicant for a federal permit or approval has completed planning and eliminated all alternatives to the proposed action by the time the EIS process commences or before the EIS process has been completed.

Through early consultation, business applicants and approving agencies may gain better appreciation of each other's needs and foster a decisionmaking process which avoids later unexpected confrontations.

Federal agencies are required by Section 1507.3(b) to develop procedures to carry out Section 1501.2(d). The procedures should include an "outreach program", such as a means for prospective applicants to conduct pre-application consultations with the lead and cooperating agencies. Applicants need to find out, in advance of project planning, what environmental studies or other information will be required, and what mitigation requirements are likely, in connecton with the later federal NEPA process. Agencies should designate staff to advise potential applicants of the agency's NEPA information requirements and should publicize their pre-application procedures and information requirements in newsletters or other media used by potential applicants.

Complementing Section 1501.2(d), Section 1506.5(a) requires agencies to assist applicants by outlining the types of information required in those cases where the agency requires the applicant to submit environmental data for possible use by the agency in preparing an EIS.

Section 1506.5(b) allows agencies to authorize preparation of environmental assessments by applicants. Thus, the procedures should also include a means for anticipating and utilizing applicants' environmental studies or "early corporate environmental assessments" to fulfill some of the federal agency's NEPA obligations. However, in such cases the agency must still evaluate independently the environmental issues [46 FR 18029] and take responsibility for the environmental assessment.

These provisions are intended to encourage and enable private and other non-federal entities to build environmental considerations into their own planning processes in a way that facilitates the application of NEPA and avoids delay.

9. **Applicant Who Needs Other Permits.** To what extent must an agency inquire into whether an applicant for a federal permit, funding or other approval of a proposal will also need approval from another agency for the same proposal or some other related aspect of it?

A. Agencies must integrate the NEPA process into other planning at the earliest possible time to insure that planning and decisions reflect environmental values, to avoid delays later in the process, and to head off potential conflicts. Specifically, the agency must "provide for cases where actions are planned by . . . applicants," so that designated staff are available to advise potential applicants of studies or other information that will foreseeably be required for the later federal action; the agency shall consult with the applicant if the agency foresees its own involvement in the proposal; and it shall insure that the NEPA process commences at the earliest possible time. Section 1501.2(d). (See Question 8.)

The regulations emphasize agency cooperation early in the NEPA process. Section 1501.6. Section 1501.7 on "scoping" also provides that all affected Federal agencies are to be invited to participate in scoping the environmental issues and to identify the various environmental review and consultation requirements that may apply to the proposed action. Further, Section 1502.25(b) requires that the draft EIS list all the federal permits, licenses and other entitlements that are needed to implement the proposal.

• These provisions create an affirmative obligation on federal agencies to inquire early, and to the maximum degree possible, to ascertain whether an applicant is or will be seeking other federal assistance or approval, or whether the applicant is waiting until a proposal has been substantially developed before requesting federal aid or approval.

Thus, a federal agency receiving a request for approval or assistance should determine whether the applicant has filed separate requests for federal approval or assistance with other federal agencies. Other federal agencies that are likely to become involved should then be contacted, and the NEPA process coordinated, to insure an early and comprehensive analysis of the direct and indirect effects of the proposal and any related actions. The agency should inform the applicant that action on its application may be delayed unless it submits all other federal applications (where feasible to do so), so that all the relevant agencies can work together on the scoping process and preparation of the EIS.

10a. **Limitations on Action During 30-Day Review Period for Final EIS.** What actions by agencies and/or applicants are allowed during EIS preparation and during the 30-day review period after publication of a final EIS?

A. No federal decision on the proposed action shall be made or recorded until at least 30 days after the publication by EPA of notice that the particular EIS has been filed with EPA. Sections 1505.2 and 1506.10. Section 1505.2 requires this decision to be stated in a public Record of Decision.

Until the agency issues its Record of Decision, no action by an agency or an applicant concerning the proposal shall be taken which would have an adverse environmental impact or limit the choice of reasonable alternatives. Section 1506.1(a). But this does not preclude

preliminary planning or design work which is needed to support an application for permits or assistance. Section 1506.1(d).

When the impact statement in question is a program EIS, no major action concerning the program may be taken which may significantly affect the quality of the human environment, unless the particular action is justified independently of the program, is accompanied by its own adequate environmental impact statement and will not prejudice the ultimate decision on the program. Section 1506.1(c).

10b. Do these **limitations on action** (described in Question 10a) apply to **state or local agencies** that have statutorily delegated responsibility for preparation of environmental documents required by NEPA, for example, under the HUD Block Grant program?

A. Yes, these limitations do apply, without any variation from their application to federal agencies.

11. **Limitations on Actions by an Applicant During EIS Process.** What actions must a lead agency take during the NEPA process when it becomes aware that a non-federal applicant is about to take an action within the agency's jurisdiction that would either have an adverse environmental impact or limit the choice of reasonable alternatives (e.g., prematurely commit money or other resources towards the completion of the proposal)?

A. The federal agency must notify the applicant that the agency will take strong affirmative steps to insure that the objectives and procedures of NEPA are fulfilled. Section 1506.1(b). These steps could include seeking injunctive measures under NEPA, or the use of sanctions available under either the agency's permitting authority or statutes setting forth the agency's statutory mission. For example, the agency might advise an applicant that if it takes such action the agency will not process its application.

12a. **Effective Date and Enforceability of the Regulations.** What actions are subject to the Council's new regulations, and what actions are grandfathered under the old guidelines?

A. The effective date of the Council's regulations was July 30, 1979 (except for certain HUD programs under the Housing and Community Development Act, 42 U.S.C. 5304(h), and certain state highway programs that qualify under Section 102(2)(D) of NEPA for which the regulations became effective on November 30, 1979). All the provisions of the regulations are binding as of that date, including those covering decisionmaking, public participation, referrals, limitations on actions, EIS supplements, etc. For example, a Record of Decision would be prepared even for decisions where the draft EIS was filed before July 30, 1979.

But in determining whether or not the new regulations apply to the preparation of a particular environmental document, the relevant factor is the date of filing of the draft of that document. Thus, the new regulations do not require the redrafting of an EIS or supplement if the draft EIS or supplement was filed before July 30, 1979. However, a supplement prepared after the effective date of the regulations for an EIS issued in final before the effective date of the regulations would be controlled by the regulations.

Even though agencies are not required to apply the regulations to an EIS or other document for which the draft was filed prior to July 30, 1979, the regulations encourage agencies to follow the regulations "to the fullest extent practicable," i.e., if it is feasible to do so, in preparing the final document. Section 1506.12(a).

12b. Are **projects authorized by Congress before** the effective date of the Council's regulations grandfathered?

A. No. The date of Congressional authorization for a project is not determinative of whether the Council's regulations or former Guidelines apply to the particular proposal. No incomplete projects or proposals of any kind are grandfathered in whole or in part. Only certain environmental documents, for which the draft was issued before the effective date of the regulations, are grandfathered and [46 FR 18030] subject to the Council's former Guidelines.

12c. **Can a violation of the regulations give rise to a cause of action?**

A. While a trivial violation of the regulations would not give rise to an independent cause of action, such a cause of action would arise from a substantial violation of the regulations. Section 1500.3.

13. **Use of Scoping Before Notice of Intent to Prepare EIS.** Can the scoping process be used in connection with preparation of an **environmental assessment,** i.e., before both the decision to proceed with an EIS and publication of a notice of intent?

A. Yes. Scoping can be a useful tool for discovering alternatives to a proposal, or significant impacts that may have been overlooked. In cases where an environmental assessment is being prepared to help an agency decide whether to prepare an EIS, useful information might result from early participation by other agencies and the public in a scoping process.

The regulations state that the scoping process is to be preceded by a Notice of Intent (NOI) to prepare an EIS. But that is only the minimum requirement. Scoping may be initiated earlier, as long as there is appropriate public notice and enough information available on the proposal so that the public and relevant agencies can participate effectively.

However, scoping that is done before the assessment, and in aid of its preparation, cannot substitute for the normal scoping process after publication of the NOI, unless the earlier public notice stated clearly that this possibility was under consideration, and the NOI expressly provides that written comments on the scope of alternatives and impacts will still be considered.

14a. **Rights and Responsibilities of Lead and Cooperating Agencies.** What are the respective rights and responsibilities of lead and cooperating agencies? What letters and memoranda must be prepared?

A. After a lead agency has been designated (Sec. 1501.5), that agency has the responsibility to solicit cooperation from other federal agencies that have jurisdiction by law or special expertise on any environmental issue that should be addressed in the EIS being prepared. Where appropriate, the lead agency should seek the cooperation of state or local agencies of similar qualifications. When the proposal may affect an Indian reservation, the agency should consult with the Indian tribe. Section 1508.5. The request for cooperation should come at the earliest possible time in the NEPA process.

After discussions with the candidate cooperating agencies, the lead agency and the cooperating agencies are to determine by letter or by memorandum which agencies will undertake cooperating responsibilities. To the extent possible at this stage, responsibilities for specific issues should be assigned. The allocation of responsibilities will be completed during scoping. Section 1501.7(a)(4).

Cooperating agencies must assume responsibility for the development of information and the preparation of environmental analyses at the request of the lead agency. Section 1501.6(b)(3). Cooperating agencies are now required by Section 1501.6 to devote staff resources that were normally primarily used to critique or comment on the Draft EIS after its

preparation, much earlier in the NEPA process -- primarily at the scoping and Draft EIS preparation stages. If a cooperating agency determines that its resource limitations preclude any involvement, or the degree of involvement (amount of work) requested by the lead agency, it must so inform the lead agency in writing and submit a copy of this correspondence to the Council. Section 1501.6(c).

In other words, the potential cooperating agency must decide early if it is able to devote any of its resources to a particular proposal. For this reason the regulation states that an agency may reply to a request for cooperation that "other program commitments preclude any involvement or the degree of involvement requested in the action that is the subject of the environmental impact statement." (Emphasis added). The regulation refers to the "action," rather than to the EIS, to clarify that the agency is taking itself out of all phases of the federal action, not just draft EIS preparation. This means that the agency has determined that it cannot be involved in the later stages of EIS review and comment, as well as decisionmaking on the proposed action. For this reason, cooperating agencies with jurisdiction by law (those which have permitting or other approval authority) cannot opt out entirely of the duty to cooperate on the EIS. See also Question 15, relating specifically to the responsibility of EPA.

14b. How are **disputes resolved between lead and cooperating agencies** concerning the scope and level of detail of analysis and the quality of data in impact statements?

A. Such disputes are resolved by the agencies themselves. A lead agency, of course, has the ultimate responsibility for the content of an EIS. But it is supposed to use the environmental analysis and recommendations of cooperating agencies with jurisdiction by law or special expertise to the maximum extent possible, consistent with its own responsibilities as lead agency. Section 1501.6(a)(2).

If the lead agency leaves out a significant issue or ignores the advice and expertise of the cooperating agency, the EIS may be found later to be inadequate. Similarly, where cooperating agencies have their own decisions to make and they intend to adopt the environmental impact statement and base their decisions on it, one document should include all of the information necessary for the decisions by the cooperating agencies. Otherwise they may be forced to duplicate the EIS process by issuing a new, more complete EIS or Supplemental EIS, even though the original EIS could have sufficed if it had been properly done at the outset. Thus, both lead and cooperating agencies have a stake in producing a document of good quality. Cooperating agencies also have a duty to participate fully in the scoping process to ensure that the appropriate range of issues is determined early in the EIS process.

Because the EIS is not the Record of Decision, but instead constitutes the information and analysis on which to base a decision, disagreements about conclusions to be drawn from the EIS need not inhibit agencies from issuing a joint document, or adopting another agency's EIS, if the analysis is adequate. Thus, if each agency has its own "preferred alternative," both can be identified in the EIS. Similarly, a cooperating agency with jurisdiction by law may determine in its own ROD that alternative A is the environmentally preferable action, even though the lead agency has decided in its separate ROD that Alternative B is environmentally preferable.

14c. What are the specific responsibilities of federal and state **cooperating agencies to review draft EISs**?

A. Cooperating agencies (i.e., agencies with jurisdiction by law or special expertise) and agencies that are authorized to develop or enforce environmental standards, must comment on environmental impact statements within their jurisdiction, expertise or authority. Sections 1503.2, 1508.5. If a cooperating agency is satisfied that its views are adequately reflected in the environmental impact statement, it should simply comment accordingly. Conversely, if the cooperating agency determines that a draft EIS is incomplete, inadequate or inaccurate, or it has other comments, it should promptly make such comments, conforming to the requirements of specificity in section 1503.3.

14d. How is the lead agency to treat the comments of another agency with jurisdiction by law or special expertise which has **failed or refused to cooperate or participate in scoping or EIS preparation**?

A. A lead agency has the responsibility to respond to all substantive comments raising significant issues regarding a draft EIS. Section 1503.4. However, cooperating agencies are generally under an obligation to raise issues or otherwise participate in the EIS process during scoping and EIS preparation if they reasonably can do so. In practical terms, if a cooperating agency fails to cooperate at the outset, such as during scoping, it will find that its comments at a later stage will not be as persuasive to the lead agency.

15. **Commenting Responsibilities of EPA.** Are EPA's responsibilities to review and comment on the environmental effects of agency proposals under **Section 309 of the Clean Air Act** independent of its responsibility as a cooperating agency?

A. Yes. EPA has an obligation under Section 309 of the Clean Air Act to review and comment in writing on the environmental impact of any matter relating to the authority of the Administrator contained in proposed legislation, federal construction projects, other federal actions requiring EISs, and new regulations. 42 U.S.C. Sec. 7609. This obligation is independent of its role as a cooperating agency under the NEPA regulations.

16. **Third Party Contracts.** What is meant by the term "third party contracts" in connection with the preparation of an EIS? See Section 1506.5(c). When can "third party contracts" be used?

A. As used by EPA and other agencies, the term "third party contract" refers to the preparation of EISs by contractors paid by the applicant. In the case of an EIS for a National Pollution Discharge Elimination System (NPDES) permit, the applicant, aware in the early planning stages of the proposed project of the need for an EIS, contracts directly with a consulting firm for its preparation. See 40 C.F.R. 6.604(g). The "third party" is EPA which, under Section 1506.5(c), must select the consulting firm, even though the applicant pays for the cost of preparing the EIS. The consulting firm is responsible to EPA for preparing an EIS that meets the requirements of the NEPA regulations and EPA's NEPA procedures. It is in the applicant's interest that the EIS comply with the law so that EPA can take prompt action

on the NPDES permit application. The "third party contract" method under EPA's NEPA procedures is purely voluntary, though most applicants have found it helpful in expediting compliance with NEPA.

If a federal agency uses "third party contracting," the applicant may undertake the necessary paperwork for the solicitation of a field of candidates under the agency's direction, so long as the agency complies with Section 1506.5(c). Federal procurement requirements do not apply to the agency because it incurs no obligations or costs under the contract, nor does the agency procure anything under the contract.

17a. **Disclosure Statement to Avoid Conflict of Interest.** If an EIS is prepared with the assistance of a consulting firm, the firm must execute a disclosure statement. What criteria must the firm follow in determining whether it has any "financial or other interest in the outcome of the project" which would cause a conflict of interest?

A. Section 1506.5(c), which specifies that a consulting firm preparing an EIS must execute a disclosure statement, does not define "financial or other interest in the outcome of the project." The Council interprets this term broadly to cover any known benefits other than general enhancement of professional reputation. This includes any financial benefit such as a promise of future construction or design work on the project, as well as indirect benefits the consultant is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients). For example, completion of a highway project may encourage construction of a shopping center or industrial park from which the consultant stands to benefit. If a consulting firm is aware that it has such an interest in the decision on the proposal, it should be disqualified from preparing the EIS, to preserve the objectivity and integrity of the NEPA process.

When a consulting firm has been involved in developing initial data and plans for the project, but does not have any financial or other interest in the outcome of the decision, it need not be disqualified from preparing the EIS. However, a disclosure statement in the draft EIS should clearly state the scope and extent of the firm's prior involvement to expose any potential conflicts of interest that may exist.

17b. If the firm in fact has no promise of future work or other interest in the outcome of the proposal, **may the firm later bid** in competition with others for future work on the project if the proposed action is approved?

A. Yes.

18. **Uncertainties About Indirect Effects of A Proposal.** How should uncertainties about indirect effects of a proposal be addressed, for example, in cases of disposal of federal lands, when the identity or plans of future landowners is unknown?

A. The EIS must identify all the indirect effects that are known, and make a good faith effort to explain the effects that are not known but are "reasonably foreseeable." Section 1508.8(b). In the example, if there is total uncertainty about the identity of future land owners or the nature of future land uses, then of course, the agency is not required to engage in speculation

or contemplation about their future plans. But, in the ordinary course of business, people do make judgments based upon reasonably foreseeable occurrences. It will often be possible to consider the likely purchasers and the development trends in that area or similar areas in recent years; or the likelihood that the land will be used for an energy project, shopping center, subdivision, farm or factory. The agency has the responsibility to make an informed judgment, and to estimate future impacts on that basis, especially if trends are ascertainable or potential purchasers have made themselves known. The agency cannot ignore these uncertain, but probable, effects of its decisions.

19a. **Mitigation Measures.** What is the scope of mitigation measures that must be discussed?

A. The mitigation measures discussed in an EIS must cover the range of impacts of the proposal. The measures must include such things as design alternatives that would decrease pollution emissions, construction impacts, esthetic intrusion, as well as relocation assistance, possible land use controls that could be enacted, and other possible efforts. Mitigation measures must be considered even for impacts that by themselves would not be considered "significant." Once the proposal itself is considered as a whole to have significant effects, all of its specific effects on the environment (whether or not "significant") must be considered, and mitigation measures must be developed where it is feasible to do so. Sections 1502.14(f), 1502.16(h), 1508.14.

19b. How should an EIS treat the subject of available mitigation measures that are (1) **outside the jurisdiction** of the lead or cooperating agencies, or (2) **unlikely** to be adopted or enforced by the responsible agency?

A. All relevant, reasonable mitigation measures that could improve the project are to be identified, even if they are outside the jurisdiction of the lead agency or the cooperating agencies, and thus would not be committed as part of the RODs of these agencies. Sections 1502.16(h), 1505.2(c). This will serve to [46 FR 18032] alert agencies or officials who can implement these extra measures, and will encourage them to do so. Because the EIS is the most comprehensive environmental document, it is an ideal vehicle in which to lay out not only the full range of environmental impacts but also the full spectrum of appropriate mitigation.

However, to ensure that environmental effects of a proposed action are fairly assessed, the probability of the mitigation measures being implemented must also be discussed. Thus the EIS and the Record of Decision should indicate the likelihood that such measures will be adopted or enforced by the responsible agencies. Sections 1502.16(h), 1505.2. If there is a history of nonenforcement or opposition to such measures, the EIS and Record of Decision should acknowledge such opposition or nonenforcement. If the necessary mitigation measures will not be ready for a long period of time, this fact, of course, should also be recognized.

20. Worst Case Analysis. [Withdrawn.]

21. **Combining Environmental and Planning Documents.** Where an EIS or an EA is combined with another project planning document (sometimes called **"piggybacking"**), to what degree may the EIS or EA refer to and rely upon information in the project document to satisfy NEPA's requirements?

A. Section 1502.25 of the regulations requires that draft EISs be prepared concurrently and integrated with environmental analyses and related surveys and studies required by other federal statutes. In addition, Section 1506.4 allows any environmental document prepared in compliance with NEPA to be combined with any other agency document to reduce duplication and paperwork. However, these provisions were not intended to authorize the preparation of a short summary or outline EIS, attached to a detailed project report or land use plan containing the required environmental impact data. In such circumstances, the reader would have to refer constantly to the detailed report to understand the environmental impacts and alternatives which should have been found in the EIS itself.

The EIS must stand on its own as an analytical document which fully informs decisionmakers and the public of the environmental effects of the proposal and those of the reasonable alternatives. Section 1502.1. But, as long as the EIS is clearly identified and is self-supporting, it can be physically included in or attached to the project report or land use plan, and may use attached report material as technical backup.

Forest Service environmental impact statements for forest management plans are handled in this manner. The EIS identifies the agency's preferred alternative, which is developed in detail as the proposed management plan. The detailed proposed plan accompanies the EIS through the review process, and the documents are appropriately cross-referenced. The proposed plan is useful for EIS readers as an example, to show how one choice of management options translates into effects on natural resources. This procedure permits initiation of the 90-day public review of proposed forest plans, which is required by the National Forest Management Act.

All the alternatives are discussed in the EIS, which can be read as an independent document. The details of the management plan are not repeated in the EIS, and vice versa. This is a reasonable functional separation of the documents: the EIS contains information relevant to the choice among alternatives; the plan is a detailed description of proposed management activities suitable for use by the land managers. This procedure provides for concurrent compliance with the public review requirements of both NEPA and the National Forest Management Act.

Under some circumstances, a project report or management plan may be totally merged with the EIS, and the one document labeled as both "EIS" and "management plan" or "project report." This may be reasonable where the documents are short, or where the EIS format and the regulations for clear, analytical EISs also satisfy the requirements for a project report.

22. **State and Federal Agencies as Joint Lead Agencies.** May state and federal agencies

serve as joint lead agencies? If so, how do they resolve law, policy and resource conflicts under NEPA and the relevant state environmental policy act? How do they resolve differences in perspective where, for example, national and local needs may differ?

A. Under Section 1501.5(b), federal, state or local agencies, as long as they include at least one federal agency, may act as joint lead agencies to prepare an EIS. Section 1506.2 also strongly urges state and local agencies and the relevant federal agencies to cooperate fully with each other. This should cover joint research and studies, planning activities, public hearings, environmental assessments and the preparation of joint EISs under NEPA and the relevant "little NEPA" state laws, so that one document will satisfy both laws.

The regulations also recognize that certain inconsistencies may exist between the proposed federal action and any approved state or local plan or law. The joint document should discuss the extent to which the federal agency would reconcile its proposed action with such plan or law. Section 1506.2(d). (See Question 23).

Because there may be differences in perspective as well as conflicts among [46 FR 18033] federal, state and local goals for resources management, the Council has advised participating agencies to adopt a flexible, cooperative approach. The joint EIS should reflect all of their interests and missions, clearly identified as such. The final document would then indicate how state and local interests have been accommodated, or would identify conflicts in goals (e.g., how a hydroelectric project, which might induce second home development, would require new land use controls). The EIS must contain a complete discussion of scope and purpose of the proposal, alternatives, and impacts so that the discussion is adequate to meet the needs of local, state and federal decisionmakers.

23a. **Conflicts of Federal Proposal With Land Use Plans, Policies or Controls.** How should an agency handle potential **conflicts** between a proposal and the objectives of Federal, state or local land use plans, policies and controls for the area concerned? See Sec. 1502.16(c).

A. The agency should first inquire of other agencies whether there are any potential conflicts. If there would be immediate conflicts, or if conflicts could arise in the future when the plans are finished (see Question 23(b) below), the EIS must acknowledge and describe the extent of those conflicts. If there are any possibilities of resolving the conflicts, these should be explained as well. The EIS should also evaluate the seriousness of the impact of the proposal on the land use plans and policies, and whether, or how much, the proposal will impair the effectiveness of land use control mechanisms for the area. Comments from officials of the affected area should be solicited early and should be carefully acknowleged and answered in the EIS.

23b. What constitutes a **"land use plan or policy"** for purposes of this discussion?

A. The term "land use plans," includes all types of formally adopted documents for land use planning, zoning and related regulatory requirements. Local general plans are included, even though they are subject to future change. Proposed plans should also be addressed if they have been formally proposed by the appropriate government body in a written form, and are

being actively pursued by officials of the jurisdiction. Staged plans, which must go through phases of development such as the Water Resources Council's Level A, B and C planning process should also be included even though they are incomplete.

The term "policies" includes formally adopted statements of land use policy as embodied in laws or regulations. It also includes proposals for action such as the initiation of a planning process, or a formally adopted policy statement of the local, regional or state executive branch, even if it has not yet been formally adopted by the local, regional or state legislative body.

23c. What options are available for the decisionmaker when **conflicts with such plans** or policies are identified?

A. After identifying any potential land use conflicts, the decisionmaker must weigh the significance of the conflicts, among all the other environmental and non-environmental factors that must be considered in reaching a rational and balanced decision. Unless precluded by other law from causing or contributing to any inconsistency with the land use plans, policies or controls, the decisionmaker retains the authority to go forward with the proposal, despite the potential conflict. In the Record of Decision, the decisionmaker must explain what the decision was, how it was made, and what mitigation measures are being imposed to lessen adverse environmental impacts of the proposal, among the other requirements of Section 1505.2. This provision would require the decisionmaker to explain any decision to override land use plans, policies or controls for the area.

24a. **Environmental Impact Statements on Policies, Plans or Programs.** When are EISs required on policies, plans or programs?

A. An EIS must be prepared if an agency proposes to implement a specific policy, to adopt a plan for a group of related actions, or to implement a specific statutory program or executive directive. Section 1508.18. In addition, the adoption of official policy in the form of rules, regulations and interpretations pursuant to the Administrative Procedure Act, treaties, conventions, or other formal documents establishing governmental or agency policy which will substantially alter agency programs, could require an EIS. Section 1508.18. In all cases, the policy, plan, or program must have the potential for significantly affecting the quality of the human environment in order to require an EIS. It should be noted that a proposal "may exist in fact as well as by agency declaration that one exists." Section 1508.23.

24b. When is an **area-wide or overview EIS** appropriate?

A. The preparation of an area-wide or overview EIS may be particularly useful when similar actions, viewed with other reasonably foreseeable or proposed agency actions, share common timing or geography. For example, when a variety of energy projects may be located in a single watershed, or when a series of new energy technologies may be developed through federal funding, the overview or area-wide EIS would serve as a valuable and necessary analysis of the affected environment and the potential cumulative impacts of the reasonably foreseeable actions under that program or within that geographical area.

24c. What is the function of **tiering** in such cases?

A. Tiering is a procedure which allows an agency to avoid duplication of paperwork through the incorporation by reference of the general discussions and relevant specific discussions from an environmental impact statement of broader scope into one of lesser scope or vice versa. In the example given in Question 24b, this would mean that an overview EIS would be prepared for all of the energy activities reasonably foreseeable in a particular geographic area or resulting from a particular development program. This impact statement would be followed by site-specific or project-specific EISs. The tiering process would make each EIS of greater use and meaning to the public as the plan or program develops, without duplication of the analysis prepared for the previous impact statement.

25a. **Appendices and Incorporation by Reference.** When is it appropriate to use appendices instead of including information in the body of an EIS?

A. The body of the EIS should be a succinct statement of all the information on environmental impacts and alternatives that the decisionmaker and the public need, in order to make the decision and to ascertain that every significant factor has been examined. The EIS must explain or summarize methodologies of research and modeling, and the results of research that may have been conducted to analyze impacts and alternatives.

Lengthy technical discussions of modeling methodology, baseline studies, or other work are best reserved for the appendix. In other words, if only technically trained individuals are likely to understand a particular discussion then it should go in the appendix, and a plain language summary of the analysis and conclusions of that technical discussion should go in the text of the EIS.

The final statement must also contain the agency's responses to comments on the draft EIS. These responses will be primarily in the form of changes in the document itself, but specific answers to each significant comment should also be included. These specific responses may be placed in an appendix. If the comments are especially voluminous, summaries of the comments and responses will suffice. (See Question 29 regarding the level of detail required for responses to comments.)

25b. How does an **appendix** differ from **incorporation by reference?**

A. First, if at all possible, the appendix accompanies the EIS, whereas the material which is incorporated by reference does not accompany the EIS. Thus the appendix should contain information that reviewers will be likely to want to examine. The appendix should include material that pertains to preparation of a particular EIS. Research papers directly relevant to the proposal, lists of affected species, discussion of the methodology of models used in the analysis of impacts, extremely detailed responses to comments, or other information, would be placed in the appendix.

The appendix must be complete and available at the time the EIS is filed. Five copies of the appendix must be sent to EPA with five copies of the EIS for filing. If the appendix is too bulky to be circulated, it instead must be placed in conveniently accessible locations or

furnished directly to commentors upon request. If it is not circulated with the EIS, the Notice of Availability published by EPA must so state, giving a telephone number to enable potential commentors to locate or request copies of the appendix promptly.

Material that is not directly related to preparation of the EIS should be incorporated by reference. This would include other EISs, research papers in the general literature, technical background papers or other material that someone with technical training could use to evaluate the analysis of the proposal. These must be made available, either by citing the literature, furnishing copies to central locations, or sending copies directly to commentors upon request.

Care must be taken in all cases to ensure that material incorporated by reference, and the occasional appendix that does not accompany the EIS, are in fact available for the full minimum public comment period.

26a. **Index and Keyword Index in EISs.** How detailed must an EIS index be?

A. The EIS index should have a level of detail sufficient to focus on areas of the EIS of reasonable interest to any reader. It cannot be restricted to the most important topics. On the other hand, it need not identify every conceivable term or phrase in the EIS. If an agency believes that the reader is reasonably likely to be interested in a topic, it should be included.

26b. Is a **keyword index** required?

A. No. A keyword index is a relatively short list of descriptive terms that identifies the key concepts or subject areas in a document. For example it could consist of 20 terms which describe the most significant aspects of an EIS that a future researcher would need: type of proposal, type of impacts, type of environment, geographical area, sampling or modelling methodologies used. This technique permits the compilation of EIS data banks, by facilitating quick and inexpensive access to stored materials. While a keyword index is not required by the regulations, it could be a useful addition for several reasons. First, it can be useful as a quick index for reviewers of the EIS, helping to focus on areas of interest. Second, if an agency keeps a listing of the keyword indexes of the EISs it produces, the EIS preparers themselves will have quick access to similar research data and methodologies to aid their future EIS work. Third, a keyword index will be needed to make an EIS available to future researchers using EIS data banks that are being developed. Preparation of such an index now when the document is produced will save a later effort when the data banks become operational.

27a. **List of Preparers.** If a consultant is used in preparing an EIS, must the list of preparers identify members of the consulting firm as well as the agency NEPA staff who were primarily responsible?

A. Section 1502.17 requires identification of the names and qualifications of persons who were primarily responsible for preparing the EIS or significant background papers, including basic components of the statement. This means that members of a consulting firm preparing material that is to become part of the EIS must be identified. The EIS should identify these

individuals even though the consultant's contribution may have been modified by the agency.

27b. Should agency staff involved in reviewing and editing the EIS also be included in the **list of preparers?**

A. Agency personnel who wrote basic components of the EIS or significant background papers must, of course, be identified. The EIS should also list the technical editors who reviewed or edited the statements.

27c. How much information should be included on each person listed?

A. The list of preparers should normally not exceed two pages. Therefore, agencies must determine which individuals had primary responsibility and need not identify individuals with minor involvement. The list of preparers should include a very brief identification of the individuals involved, their qualifications (expertise, professional disciplines) and the specific portion of the EIS for which they are responsible. This may be done in tabular form to cut down on length. A line or two for each person's qualifications should be sufficient.

28. **Advance or Xerox Copies of EIS.** May an agency file xerox copies of an EIS with EPA pending the completion of printing the document?

A. Xerox copies of an EIS may be filed with EPA prior to printing only if the xerox copies are simultaneously made available to other agencies and the public. Section 1506.9 of the regulations, which governs EIS filing, specifically requires Federal agencies to file EISs with EPA no earlier than the EIS is distributed to the public. However, this section does not prohibit xeroxing as a form of reproduction and distribution. When an agency chooses xeroxing as the reproduction method, the EIS must be clear and legible to permit ease of reading and ultimate microfiching of the EIS. Where color graphs are important to the EIS, they should be reproduced and circulated with the xeroxed copy.

29a. **Responses to Comments.** What response must an agency provide to a comment on a draft EIS which states that the EIS's methodology is inadequate or inadequately explained? For example, what level of detail must an agency include in its response to a simple postcard comment making such an allegation?

A. Appropriate responses to comments are described in Section 1503.4. Normally the responses should result in changes in the text of the EIS, not simply a separate answer at the back of the document. But, in addition, the agency must state what its response was, and if the agency decides that no substantive response to a comment is necessary, it must explain briefly why.

An agency is not under an obligation to issue a lengthy reiteration of its methodology for any portion of an EIS if the only comment addressing the methodology is a simple complaint that the EIS methodology is inadequate. But agencies must respond to comments, however brief, which are specific in their criticism of agency methodology. For example, if a commentor on an EIS said that an agency's air quality dispersion analysis or methodology was inadequate, and the agency had included a discussion of that analysis in the EIS, little if anything need be

added in response to such a comment. However, if the commentor said that the dispersion analysis was inadequate because of its use of a certain computational technique, or that a dispersion analysis was inadequately explained because computational techniques were not included or referenced, then the agency would have to respond in a substantive and meaningful way to such a comment.

If a number of comments are identical or very similar, agencies may group the comments and prepare a single answer for each group. Comments may be summarized if they are especially voluminous. The comments or summaries must be attached to the EIS regardless of whether the agency believes they merit individual discussion in the body of the final EIS.

29b. How must an agency respond to a comment on a draft EIS that raises a **new alternative not previously considered** in the draft EIS?

A. This question might arise in several possible situations. First, a commentor on a draft EIS may indicate that there is a possible alternative which, in the agency's view, is not a reasonable alternative. Section 1502.14(a). If that is the case, the agency must explain why the comment does not warrant further agency response, citing authorities or reasons that support the agency's position and, if appropriate, indicate those circumstances which would trigger agency reappraisal or further response. Section 1503.4(a). For example, a commentor on a draft EIS on a coal fired power plant may suggest the alternative of using synthetic fuel. The agency may reject the alternative with a brief discussion (with authorities) of the unavailability of synthetic fuel within the time frame necessary to meet the need and purpose of the proposed facility.

A second possibility is that an agency may receive a comment indicating that a particular alternative, while reasonable, should be modified somewhat, for example, to achieve certain mitigation benefits, or for other reasons. If the modification is reasonable, the agency should include a discussion of it in the final EIS. For example, a commentor on a draft EIS on a proposal for a pumped storage power facility might suggest that the applicant's proposed alternative should be enhanced by the addition of certain reasonable mitigation measures, including the purchase and setaside of a wildlife preserve to substitute for the tract to be destroyed by the project. The modified alternative including the additional mitigation measures should be discussed by the agency in the final EIS.

A third slightly different possibility is that a comment on a draft EIS will raise an alternative which is a minor variation of one of the alternatives discussed in the draft EIS, but this variation was not given any consideration by the agency. In such a case, the agency should develop and evaluate the new alternative, if it is reasonable, in the final EIS. If it is qualitatively within the spectrum of alternatives that were discussed in the draft, a supplemental draft will not be needed. For example, a commentor on a draft EIS to designate a wilderness area within a National Forest might reasonably identify a specific tract of the forest, and urge that it be considered for designation. If the draft EIS considered designation of a range of alternative tracts which encompassed forest area of similar quality and quantity, no supplemental EIS would have to be prepared. The agency could fulfill its obligation by addressing that specific alternative in the final EIS.

As another example, an EIS on an urban housing project may analyze the alternatives of

constructing 2,000, 4,000, or 6,000 units. A commentor on the draft EIS might urge the consideration of constructing 5,000 units utilizing a different configuration of buildings. This alternative is within the spectrum of alternatives already considered, and, therefore, could be addressed in the final EIS.

A fourth possibility is that a commentor points out an alternative which is not a variation of the proposal or of any alternative discussed in the draft impact statement, and is a reasonable alternative that warrants serious agency response. In such a case, the agency must issue a supplement to the draft EIS that discusses this new alternative. For example, a commentor on a draft EIS on a nuclear power plant might suggest that a reasonable alternative for meeting the projected need for power would be through peak load management and energy conservation programs. If the permitting agency has failed to consider that approach in the Draft EIS, and the approach cannot be dismissed by the agency as unreasonable, a supplement to the Draft EIS, which discusses that alternative, must be prepared. (If necessary, the same supplement should also discuss substantial changes in the proposed action or significant new circumstances or information, as required by Section 1502.9(c)(1) of the Council's regulations.)

If the new alternative was not raised by the commentor during scoping, but could have been, commentors may find that they are unpersuasive in their efforts to have their suggested alternative analyzed in detail by the agency. However, if the new alternative is discovered or developed later, and it could not reasonably have been raised during the scoping process, then the agency must address it in a supplemental draft EIS. The agency is, in any case, ultimately responsible for preparing an adequate EIS that considers all alternatives.

30. **Adoption of EISs.** When a cooperating agency with jurisdiction by law intends to adopt a lead agency's EIS and it is not satisfied with the adequacy of the document, may the cooperating agency adopt only the part of the EIS with which it is satisfied? If so, would a cooperating agency with jurisdiction by law have to prepare a separate EIS or EIS supplement covering the areas of disagreement with the lead agency?

A. Generally, a cooperating agency may adopt a lead agency's EIS without recirculating it if it concludes that its NEPA requirements and its comments and suggestions have been satisfied. Section 1506.3(a), (c). If necessary, a cooperating agency may adopt only a portion of the lead agency's EIS and may reject that part of the EIS with which it disagrees, stating publicly why it did so. Section 1506.3(a).

A cooperating agency with jurisidiction by law (e.g., an agency with independent legal responsibilities with respect to the proposal) has an independent legal obligation to comply with NEPA. Therefore, if the cooperating agency determines that the EIS is wrong or inadequate, it must prepare a supplement to the EIS, replacing or adding any needed information, and must circulate the supplement as a draft for public and agency review and comment. A final supplemental EIS would be required before the agency could take action. The adopted portions of the lead agency EIS should be circulated with the supplement. Section 1506.3(b). A cooperating agency with jurisdiction by law will have to prepare its own Record of Decision for its action, in which it must explain how it reached its conclusions. Each agency should explain how and why its conclusions differ, if that is the case, from those of other agencies which issued their Records of Decision earlier.

An agency that did not cooperate in preparation of an EIS may also adopt an EIS or portion thereof. But this would arise only in rare instances, because an agency adopting an EIS for use in its own decision normally would have been a cooperating agency. If the proposed action for which the EIS was prepared is substantially the same as the proposed action of the adopting agency, the EIS may be adopted as long as it is recirculated as a final EIS and the agency announces what it is doing. This would be followed by the 30-day review period and issuance of a Record of Decision by the adopting agency. If the proposed action by the adopting agency is not substantially the same as that in [46 FR 18036] the EIS (i.e., if an EIS on one action is being adapted for use in a decision on another action), the EIS would be treated as a draft and circulated for the normal public comment period and other procedures. Section 1506.3(b).

31a. **Application of Regulations to Independent Regulatory Agencies.** Do the Council's NEPA regulations apply to independent regulatory agencies like the Federal Energy Regulatory Commission (FERC) and the Nuclear Regulatory Commission?

A. The statutory requirements of NEPA's Section 102 apply to "all agencies of the federal government." The NEPA regulations implement the procedural provisions of NEPA as set forth in NEPA's Section 102(2) for all agencies of the federal government. The NEPA regulations apply to independent regulatory agencies, however, they do not direct independent regulatory agencies or other agencies to make decisions in any particular way or in a way inconsistent with an agency's statutory charter. Sections 1500.3, 1500.6, 1507.1, and

1507.3.

31b. Can an Executive Branch agency like the Department of the Interior **adopt an EIS** prepared by an independent regulatory agency such as FERC?

A. If an independent regulatory agency such as FERC has prepared an EIS in connection with its approval of a proposed project, an Executive Branch agency (e.g., the Bureau of Land Management in the Department of the Interior) may, in accordance with Section 1506.3, adopt the EIS or a portion thereof for its use in considering the same proposal. In such a case the EIS must, to the satisfaction of the adopting agency, meet the standards for an adequate statement under the NEPA regulations (including scope and quality of analysis of alternatives) and must satisfy the adopting agency's comments and suggestions. If the independent regulatory agency fails to comply with the NEPA regulations, the cooperating or adopting agency may find that it is unable to adopt the EIS, thus forcing the preparation of a new EIS or EIS Supplement for the same action. The NEPA regulations were made applicable to all federal agencies in order to avoid this result, and to achieve uniform application and efficiency of the NEPA process.

32. **Supplements to Old EISs.** Under what circumstances do old EISs have to be supplemented before taking action on a proposal?

A. As a rule of thumb, if the proposal has not yet been implemented, or if the EIS concerns an ongoing program, EISs that are more than 5 years old should be carefully reexamined to determine if the criteria in Section 1502.9 compel preparation of an EIS supplement.

If an agency has made a substantial change in a proposed action that is relevant to environmental concerns, or if there are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts, a supplemental EIS must be prepared for an old EIS so that the agency has the best possible information to make any necessary substantive changes in its decisions regarding the proposal. Section 1502.9(c).

33a. **Referrals.** When must a referral of an interagency disagreement be made to the Council?

A. The Council's referral procedure is a pre-decision referral process for interagency disagreements. Hence, Section 1504.3 requires that a referring agency must deliver its referral to the Council not later than 25 days after publication by EPA of notice that the final EIS is available (unless the lead agency grants an extension of time under Section 1504.3(b)).

33b. May a **referral** be made after this issuance of a Record of Decision?

A. No, except for cases where agencies provide an internal appeal procedure which permits simultaneous filing of the final EIS and the record of decision (ROD). Section 1506.10(b)(2). Otherwise, as stated above, the process is a pre-decision referral process. Referrals must be made within 25 days after the notice of availability of the final EIS, whereas the final decision (ROD) may not be made or filed until after 30 days from the notice of availability of

the EIS. Sections 1504.3(b), 1506.10(b). If a lead agency has granted an extension of time for another agency to take action on a referral, the ROD may not be issued until the extension has expired.

34a. **Records of Decision.** Must Records of Decision (RODs) be made public? How should they be made available?

A. Under the regulations, agencies must prepare a "concise public record of decision," which contains the elements specified in Section 1505.2. This public record may be integrated into any other decision record prepared by the agency, or it may be separate if decision documents are not normally made public. The Record of Decision is intended by the Council to be an environmental document (even though it is not explicitly mentioned in the definition of "environmental document" in Section 1508.10). Therefore, it must be made available to the public through appropriate public notice as required by Section 1506.6(b). However, there is no specific requirement for publication of the ROD itself, either in the Federal Register or elsewhere.

34b. May the **summary section** in the final Environmental Impact Statement substitute for or constitute an agency's Record of Decision?

A. No. An environmental impact statement is supposed to inform the decisionmaker before the decision is made. Sections 1502.1, 1505.2. The Council's regulations provide for a 30-day period after notice is published that the final EIS has been filed with EPA before the agency may take final action. During that period, in addition to the agency's own internal final review, the public and other agencies can comment on the final EIS prior to the agency's final action on the proposal. In addition, the Council's regulations make clear that the requirements for the summary in an EIS are not the same as the requirements for a ROD. Sections 1502.12 and 1505.2.

34c. What provisions should **Records of Decision** contain pertaining to **mitigation and monitoring**?

A. Lead agencies "shall include appropriate conditions [including mitigation measures and monitoring and enforcement programs] in grants, permits or other approvals" and shall "condition funding of actions on mitigation." Section 1505.3. Any such measures that are adopted must be explained and committed in the ROD.

The reasonable alternative mitigation measures and monitoring programs should have been addressed in the draft and final EIS. The discussion of mitigation and monitoring in a Record of Decision must be more detailed than a general statement that mitigation is being required, but not so detailed as to duplicate discussion of mitigation in the EIS. The Record of Decision should contain a concise summary identification of the mitigation measures which the agency has committed itself to adopt.

The Record of Decision must also state whether all practicable mitigation measures have been adopted, and if not, why not. Section 1505.2(c). The Record of Decision must identify the mitigation measures and monitoring and enforcement programs that have been selected and plainly indicate that they are adopted as part of the agency's decision. If the proposed

action is the issuance of a permit or other approval, the specific details of the mitigation measures shall then be included as appropriate conditions in whatever grants, permits, funding or other approvals are being made by the federal agency. Section 1505.3 (a), (b). If the proposal is to be carried out by the [46 FR 18037] federal agency itself, the Record of Decision should delineate the mitigation and monitoring measures in sufficient detail to constitute an enforceable commitment, or incorporate by reference the portions of the EIS that do so.

34d. What is the **enforceability of a Record of Decision?**

A. Pursuant to generally recognized principles of federal administrative law, agencies will be held accountable for preparing Records of Decision that conform to the decisions actually made and for carrying out the actions set forth in the Records of Decision. This is based on the principle that an agency must comply with its own decisons and regulations once they are adopted. Thus, the terms of a Record of Decision are enforceable by agencies and private parties. A Record of Decision can be used to compel compliance with or execution of the mitigation measures identified therein.

35. **Time Required for the NEPA Process.** How long should the NEPA process take to complete?

A. When an EIS is required, the process obviously will take longer than when an EA is the only document prepared. But the Council's NEPA regulations encourage streamlined review, adoption of deadlines, elimination of duplicative work, eliciting suggested alternatives and other comments early through scoping, cooperation among agencies, and consultation with applicants during project planning. The Council has advised agencies that under the new NEPA regulations even large complex energy projects would require only about 12 months for the completion of the entire EIS process. For most major actions, this period is well within the planning time that is needed in any event, apart from NEPA.

The time required for the preparation of program EISs may be greater. The Council also recognizes that some projects will entail difficult long-term planning and/or the acquisition of certain data which of necessity will require more time for the preparation of the EIS. Indeed, some proposals should be given more time for the thoughtful preparation of an EIS and development of a decision which fulfills NEPA's substantive goals.

For cases in which only an environmental assessment will be prepared, the NEPA process should take no more than 3 months, and in many cases substantially less, as part of the normal analysis and approval process for the action.

36a. **Environmental Assessments (EA).** How long and detailed must an environmental assessment (EA) be?

A. The environmental assessment is a concise public document which has three defined functions. (1) It briefly provides sufficient evidence and analysis for determining whether to prepare an EIS; (2) it aids an agency's compliance with NEPA when no EIS is necessary, i.e., it helps to identify better alternatives and mitigation measures; and (3) it facilitates

preparation of an EIS when one is necessary. Section 1508.9(a).

Since the EA is a concise document, it should not contain long descriptions or detailed data which the agency may have gathered. Rather, it should contain a brief discussion of the need for the proposal, alternatives to the proposal, the environmental impacts of the proposed action and alternatives, and a list of agencies and persons consulted. Section 1508.9(b).

While the regulations do not contain page limits for EA's, the Council has generally advised agencies to keep the length of EAs to not more than approximately 10-15 pages. Some agencies expressly provide page guidelines (e.g., 10-15 pages in the case of the Army Corps). To avoid undue length, the EA may incorporate by reference background data to support its concise discussion of the proposal and relevant issues.

36b. Under what circumstances is a **lengthy EA** appropriate?

A. Agencies should avoid preparing lengthy EAs except in unusual cases, where a proposal is so complex that a concise document cannot meet the goals of Section 1508.9 and where it is extremely difficult to determine whether the proposal could have significant environmental effects. In most cases, however, a lengthy EA indicates that an EIS is needed.

37a. **Findings of No Significant Impact (FONSI).** What is the level of detail of information that must be included in a finding of no significant impact (FONSI)?

A. The FONSI is a document in which the agency briefly explains the reasons why an action will not have a significant effect on the human environment and, therefore, why an EIS will not be prepared. Section 1508.13. The finding itself need not be detailed, but must succinctly state the reasons for deciding that the action will have no significant environmental effects, and, if relevant, must show which factors were weighted most heavily in the determination. In addition to this statement, the FONSI must include, summarize, or attach and incorporate by reference, the environmental assessment.

37b. What are the criteria for deciding whether a **FONSI** should be made available for **public review** for 30 days before the agency's final determination whether to prepare an EIS?

A. Public review is necessary, for example, (a) if the proposal is a borderline case, i.e., when there is a reasonable argument for preparation of an EIS; (b) if it is an unusual case, a new kind of action, or a precedent setting case such as a first intrusion of even a minor development into a pristine area; (c) when there is either scientific or public controversy over the proposal; or (d) when it involves a proposal which is or is closely similar to one which normally requires preparation of an EIS. Sections 1501.4(e)(2), 1508.27. Agencies also must allow a period of public review of the FONSI if the proposed action would be located in a floodplain or wetland. E.O. 11988, Sec. 2(a)(4); E.O. 11990, Sec. 2(b).

38. **Public Availability of EAs v. FONSIs.** Must (EAs) and FONSIs be made public? If so, how should this be done?

A. Yes, they must be available to the public. Section 1506.6 requires agencies to involve the public in implementing their NEPA procedures, and this includes public involvement in the preparation of EAs and FONSIs. These are public "environmental documents" under Section 1506.6(b), and, therefore, agencies must give public notice of their availability. A combination of methods may be used to give notice, and the methods should be tailored to the needs of particular cases. Thus, a Federal Register notice of availability of the documents, coupled with notices in national publications and mailed to interested national groups might be appropriate for proposals that are national in scope. Local newspaper notices may be more appropriate for regional or site-specific proposals.

The objective, however, is to notify all interested or affected parties. If this is not being achieved, then the methods should be reevaluated and changed. Repeated failure to reach the interested or affected public would be interpreted as a violation of the regulations.

39. **Mitigation Measures Imposed in EAs and FONSIs.** Can an EA and FONSI be used to impose enforceable mitigation measures, monitoring programs, or other requirements, even though there is no requirement in the regulations in such cases for a formal Record of Decision?

A. Yes. In cases where an environmental assessment is the appropriate environmental document, there still may be mitigation measures or alternatives that would be desirable to consider and adopt even though the impacts of the proposal will not be "significant." In such cases, the EA should include a discussion of these measures or alternatives to "assist [46 FR 18038] agency planning and decisionmaking" and to "aid an agency's compliance with [NEPA] when no environmental impact statement is necessary." Section 1501.3(b), 1508.9(a)(2). The appropriate mitigation measures can be imposed as enforceable permit conditions, or adopted as part of the agency final decision in the same manner mitigation measures are adopted in the formal Record of Decision that is required in EIS cases.

40. **Propriety of Issuing EA When Mitigation Reduces Impacts.** If an environmental assessment indicates that the environmental effects of a proposal are significant but that, with mitigation, those effects may be reduced to less than significant levels, may the agency make a finding of no significant impact rather than prepare an EIS? Is that a legitimate function of an EA and scoping?

[**N.B.:** Courts have disagreed with CEQ's position in Question 40. The 1987-88 CEQ Annual Report stated that CEQ intended to issue additional guidance on this topic. Ed. note.]

A. Mitigation measures may be relied upon to make a finding of no significant impact only if they are imposed by statute or regulation, or submitted by an applicant or agency as part of the original proposal. As a general rule, the regulations contemplate that agencies should use a broad approach in defining significance and should not rely on the possibility of mitigation as an excuse to avoid the EIS requirement. Sections 1508.8, 1508.27.

If a proposal appears to have adverse effects which would be significant, and certain mitigation measures are then developed during the scoping or EA stages, the existence of

such possible mitigation does not obviate the need for an EIS. Therefore, if scoping or the EA identifies certain mitigation possibilities without altering the nature of the overall proposal itself, the agency should continue the EIS process and submit the proposal, and the potential mitigation, for public and agency review and comment. This is essential to ensure that the final decision is based on all the relevant factors and that the full NEPA process will result in enforceable mitigation measures through the Record of Decision.

In some instances, where the proposal itself so integrates mitigation from the beginning that it is impossible to define the proposal without including the mitigation, the agency may then rely on the mitigation measures in determining that the overall effects would not be significant (e.g., where an application for a permit for a small hydro dam is based on a binding commitment to build fish ladders, to permit adequate down stream flow, and to replace any lost wetlands, wildlife habitat and recreational potential). In those instances, agencies should make the FONSI and EA available for 30 days of public comment before taking action. Section 1501.4(e)(2).

Similarly, scoping may result in a redefinition of the entire project, as a result of mitigation proposals. In that case, the agency may alter its previous decision to do an EIS, as long as the agency or applicant resubmits the entire proposal and the EA and FONSI are available for 30 days of review and comment. One example of this would be where the size and location of a proposed industrial park are changed to avoid affecting a nearby wetland area.

[This memorandum was published in the Federal Register and appears at 48 Fed. Reg. 34263 (1983). Ed. Note]

GUIDANCE REGARDING NEPA REGULATIONS

40 CFR Part 1500

MEMORANDUM

For: Heads of Federal Agencies

From: A. Alan Hill, Chairman, Council on Environmental Quality

Re: Guidance Regarding NEPA Regulations

The Council on Environmental Quality (CEQ) regulations implementing the National Environmental Policy Act (NEPA) were issued on November 29, 1978. These regulations became effective for, and binding upon, most federal agencies on July 30, 1979, and for all remaining federal agencies on November 30, 1979.

As part of the Council's NEPA oversight responsibilities it solicited through an August 14, 1981, notice in the Federal Register public and agency comments regarding a series of questions that were developed to provide information on the manner in which federal agencies were implementing the CEQ regulations. On July 12, 1982, the Council announced the availability of a document summarizing the comments received from the public and other agencies and also identifying issue areas which the Council intended to review. On August 12, 1982, the Council held a public meeting to address those issues and hear any other comments which the public or other interested agencies might have about the NEPA process. The issues addressed in this guidance were identified during this process.

There are many ways in which agencies can meet their responsibilities under NEPA and the 1978 regulations. The purpose of this document is to provide the Council's guidance on various ways to carry out activities under the regulations.

Scoping

The Council on Environmental Quality (CEQ) regulations direct federal agencies which have made a decision to prepare an environmental impact statement to engage in a public scoping process. Public hearings or meetings, although often held, are not required; instead the manner in which public input will be sought is left to the discretion of the agency.

The purpose of this process is to determine the scope of the EIS so that preparation of the document can be effectively managed. Scoping is intended to ensure that problems are identified early and properly studied, that issues of little significance do not consume time and effort, that the draft EIS is thorough and balanced, and that delays occasioned by an inadequate draft EIS are avoided. The scoping process should identify the public and agency concerns; clearly define the environmental issues and

alternatives to be examined in the EIS including the elimination of nonsignificant issues; identify related issues which originate from separate legislation, regulation, or Executive Order (e.g. historic preservation or endangered species concerns); and identify state and local agency requirements which must be addressed. An effective scoping process can help reduce unnecessary paperwork and time delays in preparing and processing the EIS by clearly identifying all relevant procedural requirements.

In April 1981, the Council issued a "Memorandum for General Counsels, NEPA Liaisons and Participants in Scoping" on the subject of Scoping Guidance. The purpose of this guidance was to give agencies suggestions as to how to more effectively carry out the CEQ scoping requirement. The availability of this document was announced in the Federal Register at 46 FR 25461. It is still available upon request from the CEQ General Counsel's office.

The concept of lead agency (§1508.16) and cooperating agency (§1508.5) can be used effectively to help manage the scoping process and prepare the environmental impact statement. The lead agency should identify the potential cooperating agencies. It is incumbent upon the lead agency to identify any agency which may ultimately be involved in the proposed action, including any subsequent permitting [48 FR 34264]a actions. Once cooperating agencies have been identified they have specific responsibility under the NEPA regulations (40 CFR 1501.6). Among other things cooperating agencies have responsibilities to participate in the scoping process and to help identify issues which are germane to any subsequent action it must take on the proposed action. The ultimate goal of this combined agency effort is to produce an EIS which in addition to fulfilling the basic intent of NEPA, also encompasses to the maximum extent possible all the environmental and public involvement requirements of state and federal laws, Executive Orders, and administrative policies of the involved agencies. Examples of these requirements include the Fish and Wildlife Coordination Act, the Clean Air Act, the Endangered Species Act, the National Historic Preservation Act, the Wild and Scenic Rivers Act, the Farmland Protection Policy Act, Executive Order 11990 (Protection of Wetlands), and Executive Order 11998 (Floodplain Management).

It is emphasized that cooperating agencies have the responsibility and obligation under the CEQ regulations to participate in the scoping process. Early involvement leads to early identification of significant issues, better decisionmaking, and avoidance of possible legal challenges. Agencies with "jurisdiction by law" must accept designation as a cooperating agency if requested (40 CFR 1501.6).

One of the functions of scoping is to identify the public involvement/public hearing procedures of all appropriate state and federal agencies that will ultimately act upon the proposed action. To the maximum extent possible, such procedures should be integrated into the EIS process so that joint public meetings and hearings can be conducted. Conducting joint meetings and hearings eliminates duplication and should significantly reduce the time and cost of processing an EIS and any subsequent approvals. The end result will be a more informed public cognizant of all facets of the proposed action.

It is important that the lead agency establish a process to properly manage scoping. In

appropriate situations the lead agency should consider designating a project coordinator and forming an interagency project review team. The project coordinator would be the key person in monitoring time schedules and responding to any problems which may arise in both scoping and preparing the EIS. The project review team would be established early in scoping and maintained throughout the process of preparing the EIS. This review team would include state and local agency representatives. The review team would meet periodically to ensure that the EIS is complete, concise, and prepared in a timely manner.

A project review team has been used effectively on many projects. Some of the more important functions this review team can serve include: (1) A source of information, (2) a coordination mechanism, and (3) a professional review group. As an information source, the review team can identify all federal, state, and local environmental requirements, agency public meeting and hearing procedures, concerned citizen groups, data needs and sources of existing information, and the significant issues and reasonable alternatives for detailed analysis, excluding the non-significant issues. As a coordination mechanism, the team can ensure the rapid distribution of appropriate information or environmental studies, and can reduce the time required for formal consultation on a number of issues (e.g., endangered species or historic preservation). As a professional review group the team can assist in establishing and monitoring a tight time schedule for preparing the EIS by identifying critical points in the process, discussing and recommending solutions to the lead agency as problems arise, advising whether a requested analysis or information item is relevant to the issues under consideration, and providing timely and substantive review comments on any preliminary reports or analyses that may be prepared during the process. The presence of professionals from all scientific disciplines which have a significant role in the proposed action could greatly enhance the value of the team.

The Council recognizes that there may be some problems with the review team concept such as limited agency travel funds and the amount of work necessary to coordinate and prepare for the periodic team meetings. However, the potential benefits of the team concept are significant and the Council encourages agencies to consider utilizing interdisciplinary project review teams to aid in EIS preparation. A regularly scheduled meeting time and location should reduce coordination problems. In some instances, meetings can be arranged so that many projects are discussed at each session. The benefits of the concept are obvious: timely and effective preparation of the EIS, early identification and resolution of any problems which may arise, and elimination, or at least reduction of, the need for additional environmental studies subsequent to the approval of the EIS.

Since the key purpose of scoping is to identify the issues and alternatives for consideration, the scoping process should "end" once the issues and alternatives to be addressed in the EIS have been clearly identified. Normally this would occur during the final stages of preparing the draft EIS and before it is officially circulated for public and agency review.

The Council encourages the lead agency to notify the public of the results of the scoping process to ensure that all issues have been identified. The lead agency should document

the results of the scoping process in its administrative record.

The NEPA regulations place a new and significant responsibility on agencies and the public alike during the scoping process to identify all significant issues and reasonable alternatives to be addressed in the EIS. Most significantly, the Council has found that scoping is an extremely valuable aid to better decisionmaking. Thorough scoping may also have the effect of reducing the frequency with which proposed actions are challenged in court on the basis of an inadequate EIS. Through the techniques identified in this guidance, the lead agency will be able to document that an open public involvement process was conducted, that all reasonable alternatives were identified, that significant issues were identified and non-significant issues eliminated, and that the environmental public involvement requirements of all agencies were met, to the extent possible, in a single "one-stop" process.

Categorical Exclusions

Section 1507 of the CEQ regulations directs federal agencies when establishing implementing procedures to identify those actions which experience has indicated will not have a significant environmental effect and to categorically exclude them from NEPA review. In our August 1981 request for public comments, we asked the question "Have categorical exclusions been adequately identified and defined?".

The responses the Council received indicated that there was considerable belief that categorical exclusions were not adequately identified and defined. A number of commentators indicated that agencies had not identified all categories of actions that meet the categorical exclusion definition (§1508.4) or that agencies were overly restrictive in their interpretations of categorical exclusions. Concerns were expressed that agencies were requiring [48 FR 34265] too much documentation for projects that were not major federal actions with significant effects and also that agency procedures to add categories of actions to their existing lists of categorical exclusions were too cumbersome.

The National Environmental Policy Act and the CEQ regulations are concerned primarily with those "major federal actions signficantly affecting the quality of the human environment" (42 U.S.C. 4332). Accordingly, agency procedures, resources, and efforts should focus on determining whether the proposed federal action is a major federal action significantly affecting the quality of the human environment. If the answer to this question is yes, an environmental impact statement must be prepared. If there is insufficient information to answer the question, an environmental assessment is needed to assist the agency in determining if the environmental impacts are significant and require an EIS. If the assessment shows that the impacts are not significant, the agency must prepare a finding of no significant impact. Further stages of this federal action may be excluded from requirements to prepare NEPA documents.

The CEQ regulations were issued in 1978 and most agency implementing regulations and procedures were issued shortly thereafter. In recognition of the experience with the NEPA process that agencies have had since the CEQ regulations were issued, the

Council believes that it is appropriate for agencies to examine their procedures to insure that the NEPA process utilizes this additional knowledge and experience. Accordingly, the Council strongly encourages agencies to re-examine their environmental procedures and specifically those portions of the procedures where "categorical exclusions" are discussed to determine if revisions are appropriate. The specific issues which the Council is concerned about are (1) the use of detailed lists of specific activities for categorical exclusions, (2) the excessive use of environmental assessments/findings of no significant impact and (3) excessive documentation.

The Council has noted some agencies have developed lists of specific activities which qualify as categorical exclusions. The Council believes that if this approach is applied narrowly it will not provide the agency with sufficient flexibility to make decisions on a project-by-project basis with full consideration to the issues and impacts that are unique to a specific project. The Council encourages the agencies to consider broadly defined criteria which characterize types of actions that, based on the agency's experience, do not cause significant environmental effects. If this technique is adopted, it would be helpful for the agency to offer several examples of activities frequently performed by that agency's personnel which would normally fall in these categories. Agencies also need to consider whether the cumulative effects of several small actions would cause sufficient environmental impact to take the actions out of the categorically excluded class.

The Council also encourages agencies to examine the manner in which they use the environmental assessment process in relation to their process for identifying projects that meet the categorical exclusion definition. A report(1) to the Council indicated that some agencies have a very high ratio of findings of no significant impact to environmental assessments each year while producing only a handful of EIS's. Agencies should examine their decisionmaking process to ascertain if some of these actions do not, in fact, fall within the categorical exclusion definition, or, conversely, if they deserve full EIS treatment.

As previously noted, the Council received a number of comments that agencies require an excessive amount of environmental documentation for projects that meet the categorical exclusion definition. The Council believes that sufficient information will usually be available during the course of normal project development to determine the need for an EIS and further that the agency's administrative record will clearly document the basis for its decision. Accordingly, the Council strongly discourages procedures that would require the preparation of additional paperwork to document that an activity has been categorically excluded.

Categorical exclusions promulgated by an agency should be reviewed by the Council at the draft stage. After reviewing comments received during the review period and prior to publication in final form, the Council will determine whether the categorical exclusions are consistent with the NEPA regulations.

Adoption Procedures

During the recent effort undertaken by the Council to review the current NEPA regulations, several participants indicated federal agencies were not utilizing the adoption procedures as authorized by the CEQ regulations. The concept of adoption was incorporated into the Council's NEPA Regulations (40 CFR 1506.3) to reduce duplicative EISs prepared by Federal agencies. The experiences gained during the 1970's revealed situations in which two or more agencies had an action relating to the same project; however, the timing of the actions was different. In the early years of NEPA implementation, agencies independently approached their activities and decisions. This procedure lent itself to two or even three EISs on the same project. In response to this situation the CEQ regulations authorized agencies, in certain instances, to adopt environmental impact statements prepared by other agencies.

In general terms, the regulations recognize three possible situations in which adoption is appropriate. One is where the federal agency participated in the process as a cooperating agency. (40 CFR 1506.3(c)). In this case, the cooperating agency may adopt a final EIS and simply issue its record of decision.(2) However, the cooperating agency must independently review the EIS and determine that its own NEPA procedures have been satisfied.

A second case concerns the federal agency which was not a cooperating agency, but is, nevertheless, undertaking an activity which was the subject of an EIS. (40 CFR 1506.3(b)). This situation would arise because an agency did not anticipate that it would be involved in a project which was the subject of another agency's EIS. In this instance where the proposed action is substantially the same as that action described in the EIS, the agency may adopt the EIS and recirculate (file with EPA and distribute to agencies and the public) it as a final EIS. However, the agency must independently review the EIS to determine that it is current and that its own NEPA procedures have been satisfied. When recirculating the final EIS the agency should provide information which identifies what federal action is involved.

The third situation is one in which the proposed action is not substantially the same as that covered by the EIS. In this case, any agency may adopt an EIS or a portion thereof by circulating the EIS as a draft or as a portion of the agency's draft and preparing a final EIS. (40 CFR 1506.3(a)). Repetitious analysis and time consuming data collection can be easily eliminated utilizing this procedure.

The CEQ regulations specifically address the question of adoption only in terms of preparing EIS's. However, the objectives that underlie this portion of the regulations -- i.e., reducing delays and eliminating duplication -- apply with equal force to the issue of adopting other environmental documents. Consequently, the Council encourages agencies to put in place a mechanism for [48 FR 34266] adopting environmental assessments prepared by other agencies. Under such procedures the agency could adopt the environmental assessment and prepare a Finding of No Significant Impact based on that assessment. In doing so, the agency should be guided by several principles:

- **First, when an agency adopts such an analysis it must independently evaluate the information contained therein and take full responsibility for its scope and**

content.

- **Second, if the proposed action meets the criteria set out in 40 CFR 1501.4(e)(2), a Finding of No Significant Impact would be published for 30 days of public review before a final determination is made by the agency on whether to prepare an environmental impact statement.**

Contracting Provisions

Section 1506.5(c) of the NEPA regulations contains the basic rules for agencies which choose to have an environmental impact statement prepared by a contractor. That section requires the lead or cooperating agency to select the contractor, to furnish guidance and to participate in the preparation of the environmental impact statement. The regulation requires contractors who are employed to prepare an environmental impact statement to sign a disclosure statement stating that they have no financial or other interest in the outcome of the project. The responsible federal official must independently evaluate the statement prior to its approval and take responsibility for its scope and contents.

During the recent evaluation of comments regarding agency implementation of the NEPA process, the Council became aware of confusion and criticism about the provisions of Section 1506.5(c). It appears that a great deal of misunderstanding exists regarding the interpretation of the conflict of interest provision. There is also some feeling that the conflict of interest provision should be completely eliminated.(3)

Applicability of §1506.5(c)

This provision is only applicable when a federal lead agency determines that it needs contractor assistance in preparing an EIS. Under such circumstances, the lead agency or a cooperating agency should select the contractor to prepare the EIS.(4)

This provision does not apply when the lead agency is preparing the EIS based on information provided by a private applicant. In this situation, the private applicant can obtain its information from any source. Such sources could include a contractor hired by the private applicant to do environmental, engineering, or other studies necessary to provide sufficient information to the lead agency to prepare an EIS. The agency must independently evaluate the information and is responsible for its accuracy.

Conflict of Interest Provisions

The purpose of the disclosure statement requirement is to avoid situations in which the contractor preparing the environmental impact statement has an interest in the outcome of the proposal. Avoidance of this situation should, in the Council's opinion, ensure a better and more defensible statement for the federal agencies. This requirement also serves to assure the public that the analysis in the environmental impact statement has been prepared free of subjective, self-serving research and analysis.

Some persons believe these restrictions are motivated by undue and unwarranted suspicion about the bias of contractors. The Council is aware that many contractors would conduct their studies in a professional and unbiased manner. However, the Council has the responsibility of overseeing the administration of the National Environmental Policy Act in a manner most consistent with the statute's directives and the public's expectations of sound government. The legal responsibilities for carrying out NEPA's objectives rest solely with federal agencies. Thus, if any delegation of work is to occur, it should be arranged to be performed in as objective a manner as possible.

Preparation of environmental impact statements by parties who would suffer financial losses if, for example, a "no action" alternative were selected, could easily lead to a public perception of bias. It is important to maintain the public's faith in the integrity of the EIS process, and avoidance of conflicts in the preparation of environmental impact statements is an important means of achieving this goal.

The Council has discovered that some agencies have been interpreting the conflicts provision in an overly burdensome manner. In some instances, multidisciplinary firms are being excluded from environmental impact statements preparation contracts because of links to a parent company which has design and/or construction capabilities. Some qualified contractors are not bidding on environmental impact statement contracts because of fears that their firm may be excluded from future design or construction contracts. Agencies have also applied the selection and disclosure provisions to project proponents who wish to have their own contractor for providing environmental information. The result of these misunderstandings has been reduced competition in bidding for EIS preparation contracts, unnecessary delays in selecting a contractor and preparing the EIS, and confusion and resentment about the requirement. The Council believes that a better understanding of the scope of §1506.5(c) by agencies, contractors and project proponents will eliminate these problems.

Section 1506.5(c) prohibits a person or entity entering into a contract with a federal agency to prepare an EIS when that party has at that time and during the life of the contract pecuniary or other interests in the outcomes of the proposal. Thus, a firm which has an agreement to prepare an EIS for a construction project cannot, at the same time, have an agreement to perform the construction, nor could it be the owner of the construction site. However, if there are no such separate interests or arrangements, and if the contract for EIS preparation does not contain any incentive clauses or guarantees of any future work on the project, it is doubtful that an inherent conflict of interest will exist. Further, §1506.5(c) does not prevent an applicant from submitting information to an agency. The lead federal agency should evaluate potential conflicts of interest prior to entering into any contract for the preparation of environmental documents.

Selection of Alternatives in Licensing and Permitting Situations

Numerous comments have been received questioning an agency's obligation, under the

National Environmental Policy Act, to evaluate alternatives to a proposed action developed by an applicant for a federal permit or license. This concern arises from a belief that projects conceived and developed by private parties should not be questioned or second-guessed by the government. There has been discussion of developing two standards to determining the range of alternatives to be evaluated: The "traditional" standard for projects which are initiated and developed by a Federal agency, and a second standard of evaluating only those alternatives presented by an applicant for a permit or license.

Neither NEPA nor the CEQ regulations make a distinction between actions initiated by a Federal agency and by applicants. Early NEPA case law, while emphasizing the need for a rigorous examination of alternatives, did [48 FR 34267] not specifically address this issue. In 1981, the Council addressed the question in its document, "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations".(5) The answer indicated that the emphasis in determining the scope of alternatives should be on what is "reasonable". The Council said that, "Reasonable alternatives include those that are practical or feasible from the technical and economic standpoint and using common sense rather than simply desirable from the standpoint of the applicant."

Since issuance of that guidance, the Council has continued to receive requests for further clarification of this question. Additional interest has been generated by a recent appellate court decision. Roosevelt Campobello International Park Commission v. E.P.A. (6) dealt with EPA's decision of whether to grant a permit under the National Pollutant Discharge Elimination System to a company proposing a refinery and deep-water terminal in Maine. The court discussed both the criteria used by EPA in its selecting of alternative sites to evaluate, and the substantive standard used to evaluate the sites. The court determined that EPA's choice of alternative sites was "focused by the primary objectives of the permit applicant . . ." and that EPA had limited its consideration of sites to only those sites which were considered feasible, given the applicant's stated goals. The court found that EPA's criteria for selection of alternative sites was sufficient to meet its NEPA responsibilities.

This decision is in keeping with the concept that an agency's responsibilities to examine alternative sites has always been "bounded by some notion of feasibility" to avoid NEPA from becoming "an exercise in frivolous boilerplate".(7) NEPA has never been interpreted to require examination of purely conjectural possibilities whose implementation is deemed remote and speculative. Rather, the agency's duty is to consider "alternatives as they exist and are likely to exist."(8) In the Roosevelt Campobello case, for example, EPA examined three alternative sites and two alternative modifications of the project at the preferred alternative site. Other factors to be developed during the scoping process -- comments received from the public, other government agencies and institutions, and development of the agency's own environmental data -- should certainly be incorporated into the decision of which alternatives to seriously evaluate in the EIS. There is, however, no need to disregard the applicant's purposes and needs and the common sense realities of a given situation in the development of alternatives.

Tiering

Tiering of environmental impact statements refers to the process of addressing a broad, general program, policy or proposal in an initial environmental impact statement (EIS), and analyzing a narrower site-specific proposal, related to the initial program, plan or policy in a subsequent EIS. The concept of tiering was promulgated in the 1978 CEQ regulations; the preceding CEQ guidelines had not addressed the concept. The Council's intent in formalizing the tiering concept was to encourage agencies, "to eliminate repetitive discussions and to focus on the actual issues ripe for decisions at each level of environmental review."(9)

Despite these intentions, the Council perceives that the concept of tiering has caused a certain amount of confusion and uncertainty among individuals involved in the NEPA process. This confusion is by no means universal; indeed, approximately half of those commenting in response to our question about tiering (10) indicated that tiering is effective and should be used more frequently. Approximately one-third of the commentators responded that they had no experience with tiering upon which to base their comments. The remaining commentators were critical of tiering. Some commentators believed that tiering added an additional layer of paperwork to the process and encouraged, rather than discouraged, duplication. Some commentators thought that the inclusion of tiering in the CEQ regulations added an extra legal requirement to the NEPA process. Other commentators said that an initial EIS could be prepared when issues were too broad to analyze properly for any meaningful consideration. Some commentators believed that the concept was simply not applicable to the types of projects with which they worked; others were concerned about the need to supplement a tiered EIS. Finally, some who responded to our inquiry questioned the courts' acceptance of tiered EISs.

The Council believes that misunderstanding of tiering and its place in the NEPA process is the cause of much of this criticism. Tiering, of course, is by no means the best way to handle all proposals which are subject to NEPA analysis and documentation. The regulations do not require tiering; rather, they authorize its use when an agency determines it is appropriate. It is an option for an agency to use when the nature of the proposal lends itself to tiered EIS(s).

Tiering does not add an additional legal requirement to the NEPA process. An environmental impact statement is required for proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. In the context of NEPA, "major Federal actions" include adoption of official policy, formal plans, and programs as well as approval of specific projects, such as construction activities in a particular location or approval of permits to an outside applicant. Thus, where a Federal agency adopts a formal plan which will be executed throughout a particular region, and later proposes a specific activity to implement that plan in the same region, both actions need to be analyzed under NEPA to determine whether they are major actions which will significantly affect the environment. If the answer is yes in both cases, both actions will be subject to the EIS requirement, whether

tiering is used or not. The agency then has one of two alternatives: Either preparation of two environmental impact statements, with the second repeating much of the analysis and information found in the first environmental impact statement, or tiering the two documents. If tiering is utilized, the site-specific EIS contains a summary of the issues discussed in the first statement and the agency will incorporate by reference discussions from the first statement. Thus, the second, or site-specific statement, would focus primarily on the issues relevant to the specific proposal, and would not duplicate material found in the first EIS. It is difficult to understand, given this scenario, how tiering can be criticized for adding an unnecessary layer to the NEPA process; rather, it is intended to streamline the existing process.

The Council agrees with commentators who stated that there are stages in the development of a proposal for a program, plan or policy when the issues are too broad to lend themselves to meaningful analysis in the framework of an EIS. The CEQ regulations specifically define a "proposal" as existing at, "that stage in the development of an action when an agency subject to [NEPA] has a goal and is actively preparing to make a decision on one or more alternative means of accomplishing the goal and the effects can be meaningfully evaluated." (11) Tiering is not intended to force an agency to prepare an EIS before this stage is reached; rather, it is a technique to be used once meaningful analysis can [48 FR 34268] be performed. An EIS is not required before that stage in the development of a proposal, whether tiering is used or not.

The Council also realizes that tiering is not well suited to all agency programs. Again, this is why tiering has been established as an option for the agency to use, as opposed to a requirement.

A supplemental EIS is required when an agency makes substantial changes in the proposed action relevant to environmental concerns, or when there are signifcant new circumstances or information relevant to environmental concerns bearing on the proposed action, and is optional when an agency otherwise determines to supplement an EIS.(12) The standard for supplementing an EIS is not changed by the use of tiering; there will no doubt be occasions when a supplement is needed, but the use of tiering should reduce the number of those occasions.

Finally, some commentators raised the question of courts' acceptability of tiering. This concern is understandable, given several cases which have reversed agency decisions in regard to a particular programmatic EIS. However, these decisions have never invalidated the concept of tiering, as stated in the CEQ regulations and discussed above. Indeed, the courts recognized the usefulness of the tiering approach in case law before the promulgation of the tiering regulation. Rather, the problems appear when an agency determines not to prepare a site-specific EIS based on the fact that a programmatic EIS was prepared. In this situation, the courts carefully examine the analysis contained in the programmatic EIS. A court may or may not find that the programmatic EIS contains appropriate analysis of impacts and alternatives to meet the adequacy test for the site-specific proposal. A recent decision by the Ninth Circuit Court of Appeals (13) invalidated an attempt by the Forest Service to make a determination regarding wilderness and non-wilderness designations on the basis of a

programmatic EIS for this reason. However, it should be stressed that this and other decisions are not a repudiation of the tiering concept. In these instances, in fact, tiering has not been used; rather, the agencies have attempted to rely exclusively on programmatic or "first level" EISs which did not have site-specific information. No court has found that the tiering process as provided for in the CEQ regulations is an improper manner of implementing the NEPA process.

In summary, the Council believes that tiering can be a useful method of reducing paperwork and duplication when used carefully for appropriate types of plans, programs and policies which will later be translated into site-specific projects. Tiering should not be viewed as an additional substantive requirement, but rather a means of accomplishing the NEPA requirements in an efficient manner as possible.

Footnotes

1. **Environmental Law Institute, NEPA In Action Environmental Offices in Nineteen Federal Agencies, A Report To the Council on Environmental Quality, October 1981.**
2. **Records of decision must be prepared by each agency responsible for making a decision, and cannot be adopted by another agency.**
3. **The Council also received requests for guidance on effective management of the third-party environmental impact statement approach. However, the Council determined that further study regarding the policies behind this technique is warranted, and plans to undertake that task in the future.**
4. **There is no bar against the agency considering candidates suggested by the applicant, although the Federal agency must retain its independence. If the applicant is seen as having a major role in the selection of the contractor, contractors may feel the need to please both the agency and the applicant. An applicant's suggestion, if any, to the agency regarding the choice of contractors should be one of many factors involved in the selection process.**
5. **46 FR 18026 (1981).**
6. **684 F.2d 1041 (1st Cir. 1982).**
7. **Vermont Yankee Nuclear Power Corp. v. NRDC, 435 U.S. 519, 551 (1978).**
8. **Monarch Chemical Works, Inc. v. Exon, 466 F.Supp. 639, 650 (1979), quoting Carolina Environmental Study Group v. U.S., 510 F.2d 796, 801 (1975).**
9. **Preamble, FR, Vol. 43, No. 230, p. 55984, 11/29/78.**
10. **"Is tiering being used to minimizes repetition in an environmental assessment and in environmental impact statements?", 46 FR 41131, August 14, 1981.**
11. **40 CFR 1508.23 (emphasis added).**

12. 40 CFR 1502.9(c).

13. California v. Block, 18 ERC 1149 (1982).

a[48 FR 34264] indicates that the subsequent text may be cited to 48 Fed. Reg. 34264 (1983). Ed. Note.

EXECUTIVE OFFICE OF THE PRESIDENT
COUNCIL ON ENVIRONMENTAL QUALITY
WASHINGTON, D.C. 20503

July 28, 1999

MEMORANDUM FOR HEADS OF FEDERAL AGENCIES

FROM: GEORGE T. FRAMPTON, JR. GTF Jr.
Acting Chair

SUBJECT: DESIGNATION OF NON-FEDERAL AGENCIES TO BE COOPERATING AGENCIES IN IMPLEMENTING THE PROCEDURAL REQUIREMENTS OF THE NATIONAL ENVIRONMENTAL POLICY ACT

The purpose of this Memorandum is to urge agencies to more actively solicit in the future the participation of state, tribal and local governments as "cooperating agencies" in implementing the environmental impact statement process under the National Environmental Policy Act (NEPA). 40 C.F.R. §1508.5. As soon as practicable, but no later than the scoping process, federal agency officials should identify state, tribal and local government agencies which have jurisdiction by law and or special expertise with respect to reasonable alternatives or significant environmental, social or economic impacts association with a proposed action that requires the preparation of an environmental impact statement[1]. The federal agency should then determine whether such non-federal agencies are interested in assuming the responsibilities of becoming a cooperating agency under 40 C.F.R. §1501.6. Where invited tribal, state, or local agencies choose not to become cooperators in the NEPA process, they may still be identified as an internal party on the distribution list, if they so desire.

[1] While CEQ has not attempted to identify every state, tribal and local government agencies with jurisdiction by law or special expertise (nor do we propose to do so), agencies may wish to refer to Appendix II to the CEQ regulations, "Federal and Federal-State Agencies with Jurisdiction by Law or Special Expertise on Environmental Quality Issues", Vol. 49 *Federal Register*,. No. 247, 49754-49778 (December 21, 1984), for guidance as to the types of actions and expertise that are relevant in determining appropriate cooperating agencies. Please contact CEQ for copies, if needed.

Recycled Paper

The benefits of granting cooperating agency status include disclosure of relevant information early in the analytical process, receipt of technical expertise and staff support, avoidance of duplication with state, tribal and local procedures, and establishment of a mechanism for addressing intergovernmental issues. If a non-federal agency agrees to become a cooperating agency, agencies are encouraged to document (e.g., in a memorandum of agreement) their specific expectations, roles and responsibilities, including such issues as preparation of analysis, schedules, availability of pre-decisional information and other issues. Cooperating agencies are normally expected to use their own funds for routine activities, but to the extent available funds permit, the lead agency should fund or include in its budget requests funding for major activities or analyses that it requests from cooperating agencies. 40 C.F.R. §1501.6(b)(5).

Agencies are reminded that cooperating agency status neither enlarges nor diminishes the decisionmaking authority of either federal or non-federal entities. However, cooperating agency relationships with state, tribal and local agencies help to achieve the direction set forth in NEPA to work with other levels of government "to promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans." Considering NEPA's mandate and the authority granted in federal regulation to allow for cooperating agency status for state, tribal and local agencies, cooperator status for appropriate non-federal agencies should be routinely solicited.

Recycled Paper

EXECUTIVE OFFICE OF THE PRESIDENT
COUNCIL ON ENVIRONMENTAL QUALITY
WASHINGTON, D.C. 20503

January 30, 2002

MEMORANDUM FOR THE HEADS OF FEDERAL AGENCIES

FROM: JAMES CONNAUGHTON
Chair

SUBJECT: COOPERATING AGENCIES IN IMPLEMENTING THE PROCEDURAL REQUIREMENTS OF THE NATIONAL ENVIRONMENTAL POLICY ACT

The purpose of this Memorandum is to ensure that all Federal agencies are actively considering designation of Federal and non-federal cooperating agencies in the preparation of analyses and documentation required by the National Environmental Policy Act (NEPA), and to ensure that Federal agencies actively participate as cooperating agencies in other agency's NEPA processes.[1] The CEQ regulations addressing cooperating agencies status (40 C.F.R. §§ 1501.6 & 1508.5) implement the NEPA mandate that Federal agencies responsible for preparing NEPA analyses and documentation do so "in cooperation with State and local governments" and other agencies with jurisdiction by law or special expertise. (42 U.S.C. §§ 4331(a), 4332(2)). Despite previous memoranda and guidance from CEQ, some agencies remain reluctant to engage other Federal and non-federal agencies as a cooperating agency.[2] In addition, some Federal agencies remain reluctant to assume the role of a cooperating agency, resulting in an inconsistent implementation of NEPA.

Studies regarding the efficiency, effectiveness, and value of NEPA analyses conclude that stakeholder involvement is important in ensuring decisionmakers have the environmental information necessary to make informed and timely decisions efficiently.[3] Cooperating agency status is a major component of agency stakeholder involvement that neither enlarges nor diminishes the decisionmaking authority of any agency involved in the NEPA process. This

[1] Cooperating agency status under NEPA is not equivalent to other requirements calling for an agency to engage another governmental entity in a consultation or coordination process (e.g., Endangered Species Act section 7, National Historic Preservation Act section 106). Agencies are urged to integrate NEPA requirements with other environmental review and consultation requirements (40 C.F.R. § 1500.2(c)); and reminded that not establishing or ending cooperating agency status does not satisfy or end those other requirements.

[2] Memorandum for Heads of Federal Agencies, Subject: Designation of Non-Federal Agencies to be Cooperating Agencies in Implementing the Procedural Requirements of the National Environmental Policy Act, dated July 28, 1999; Memorandum for Federal NEPA Liaisons, Federal, State, and Local Officials and Other Persons Involved in the NEPA Process, Subject: Questions and Answers About the NEPA Regulations (NEPA's Forty Most Asked Questions), dated March 16, 1981, published at 46 Fed. Reg. 18026 (Mar. 23, 1981), as amended.

[3] E.g., *The National Environmental Policy Act – A Study of its Effectiveness After Twenty-Five Years*, CEQ, January 1997

memo does not expand requirements or responsibilities beyond those found in current laws and regulations, nor does it require an agency to provide financial assistance to a cooperating agency.

The benefits of enhanced cooperating agency participation in the preparation of NEPA analyses include: disclosing relevant information early in the analytical process; applying available technical expertise and staff support; avoiding duplication with other Federal, State, Tribal and local procedures; and establishing a mechanism for addressing intergovernmental issues. Other benefits of enhanced cooperating agency participation include fostering intra- and intergovernmental trust (e.g., partnerships at the community level) and a common understanding and appreciation for various governmental roles in the NEPA process, as well as enhancing agencies' ability to adopt environmental documents. It is incumbent on Federal agency officials to identify as early as practicable in the environmental planning process those Federal, State, Tribal and local government agencies that have jurisdiction by law and special expertise with respect to all reasonable alternatives or significant environmental, social or economic impacts associated with a proposed action that requires NEPA analysis.

The Federal agency responsible for the NEPA analysis should determine whether such agencies are interested and appear capable of assuming the responsibilities of becoming a cooperating agency under 40 C.F.R. § 1501.6. Whenever invited Federal, State, Tribal and local agencies elect not to become cooperating agencies, they should still be considered for inclusion in interdisciplinary teams engaged in the NEPA process and on distribution lists for review and comment on the NEPA documents. Federal agencies declining to accept cooperating agency status in whole or in part are obligated to respond to the request and provide a copy of their response to the Council. (40 C.F.R. § 1501.6(c)).

In order to assure that the NEPA process proceeds efficiently, agencies responsible for NEPA analysis are urged to set time limits, identify milestones, assign responsibilities for analysis and documentation, specify the scope and detail of the cooperating agency's contribution, and establish other appropriate ground-rules addressing issues such as availability of pre-decisional information. Agencies are encouraged in appropriate cases to consider documenting their expectations, roles and responsibilities (e.g., Memorandum of Agreement or correspondence). Establishing such a relationship neither creates a requirement nor constitutes a presumption that a lead agency provides financial assistance to a cooperating agency.

Once cooperating agency status has been extended and accepted, circumstances may arise when it is appropriate for either the lead or cooperating agency to consider ending cooperating agency status. This Memorandum provides factors to consider when deciding whether to invite, accept or end cooperating agency status. These factors are neither intended to be all-inclusive nor a rote test. Each determination should be made on a case-by-case basis considering all relevant information and factors, including requirements imposed on State, Tribal and local governments by their governing statutes and authorities. We rely upon you to ensure the reasoned use of agency discretion and to articulate and document the bases for extending, declining or ending cooperating agency status. The basis and determination should be included in the administrative record.

CEQ regulations do not explicitly discuss cooperating agencies in the context of Environmental Assessments (EAs) because of the expectation that EAs will normally be brief, concise documents that would not warrant use of formal cooperating agency status. However, agencies do at times – particularly in the context of integrating compliance with other environmental review laws – develop EAs of greater length and complexity than those required under the CEQ regulations. While we continue to be concerned about needlessly lengthy EAs (that may, at times, indicate the need to prepare an Environmental Impact Statement (EIS)), we recognize that there are times when cooperating agencies will be useful in the context of EAs. For this reason, this guidance is recommended for preparing EAs. However, this guidance does not change the basic distinction between EISs and EAs set forth in the regulations or prior guidance.

To measure our progress in addressing the issue of cooperating agency status, by October 31, 2002 agencies of the Federal government responsible for preparing NEPA analyses (e.g., the lead agency) shall provide the first bi-annual report regarding all EISs and EAs begun during the six-month period between March 1, 2002 and August 31, 2002. This is a periodic reporting requirement with the next report covering the September 2002 – February 2003 period due on April 30, 2003. For EISs, the report shall identify: the title; potential cooperating agencies; agencies invited to participate as cooperating agencies; agencies that requested cooperating agency status; agencies which accepted cooperating agency status; agencies whose cooperating agency status ended; and the current status of the EIS. A sample reporting form is at attachment 2. For EAs, the report shall provide the number of EAs and those involving cooperating agency(s) as described in attachment 2. States, Tribes, and units of local governments that have received authority by Federal law to assume the responsibilities for preparing NEPA analyses are encouraged to comply with these reporting requirements.

If you have any questions concerning this memorandum, please contact Horst G. Greczmiel, Associate Director for NEPA Oversight at 202-395-5750, Horst_Greczmiel@ceq.eop.gov, or 202-456-0753 (fax).

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Factors for Determining Whether to Invite, Decline or End Cooperating Agency Status

1. Jurisdiction by law (40 C.F.R. § 1508.15) – for example, agencies with the authority to grant permits for implementing the action [federal agencies shall be a cooperating agency (1501.6); non-federal agencies may be invited (40 C.F.R. § 1508.5)]:

- Does the agency have the authority to approve a proposal or a portion of a proposal?
- Does the agency have the authority to veto a proposal or a portion of a proposal?
- Does the agency have the authority to finance a proposal or a portion of a proposal?

2. Special expertise (40 C.F.R. § 1508.26) – cooperating agency status for specific purposes linked to special expertise requires more than an interest in a proposed action [federal and non-federal agencies may be requested (40 C.F.R. §§ 1501.6 & 1508.5)]:

- Does the cooperating agency have the expertise needed to help the lead agency meet a statutory responsibility?
- Does the cooperating agency have the expertise developed to carry out an agency mission?
- Does the cooperating agency have the related program expertise or experience?
- Does the cooperating agency have the expertise regarding the proposed actions' relationship to the objectives of regional, State and local land use plans, policies and controls (1502.16(c))?

3. Do the agencies understand what cooperating agency status means and can they legally enter into an agreement to be a cooperating agency?

4. Can the cooperating agency participate during scoping and/or throughout the preparation of the analysis and documentation as necessary and meet milestones established for completing the process?

5. Can the cooperating agency, in a timely manner, aid in:

- identifying significant environmental issues [including aspects of the human environment (40 C.F.R. § 1508.14), including natural, social, economic, energy, urban quality, historic and cultural issues (40 C.F.R. § 1502.16)]?
- eliminating minor issues from further study?
- identifying issues previously the subject of environmental review or study?
- identifying the proposed actions' relationship to the objectives of regional, State and local land use plans, policies and controls (1502.16(c))?

(40 C.F.R. §§ 1501.1(d) and 1501.7)

6. Can the cooperating agency assist in preparing portions of the review and analysis and resolving significant environmental issues to support scheduling and critical milestones?

8. CA unwilling or unable to accept the lead agency's decisionmaking authority regarding the scope of the analysis, including authority to define the purpose and need for the proposed action or to develop information/analysis of alternatives they favor and disfavor.
9. Agency unable or unwilling to provide data and rationale underlying the analyses or assessment of alternatives.
10. Agency releases predecisional information (including working drafts) in a manner that undermines or circumvents the agreement to work cooperatively before publishing draft or final analyses and documents.
11. Agency consistently misrepresents the process or the findings presented in the analysis and documentation.
12. Other. Identify the other:

Environmental Assessments:

	Total
Number of EAs started during the reporting period	
Number of EAs involving potential CAs	
Number of EAs where agencies were invited to participate	
Number of EAs where agencies requested CA status	
Number of EAs where a CA status was not initiated or was ended for the reasons identified	
Number of EAs involving CAs begun and ongoing during the reporting period	
Number of EAs involving CAs begun and completed during the reporting period	

Sample Report to the Council on Environmental Quality
on Cooperating Agency (CA) Status
March 1, 2002 to August 31, 2002

I. Environmental Impact Statements:

	1.	2.	etc.
EIS	**(Title of EIS)**		
Potential CA	**(Name of potential CA)**		
Invited CA	**(Name of potential CA and basis – identify the jurisdiction by law or special expertise)**		
Agency Requesting CA Status	**(Name of potential CA and basis – identify the jurisdiction by law or special expertise)**		
CAs	**(Name of CA engaged in the EIS)**		
CA Status not Initiated or Ended	**(e.g., name of agency – reason status was not initiated or was ended – see examples listed below**		
Status of EIS	**(e.g., begun on mm/dd/yy; DEIS published mm/dd/yy; FEIS published mm/dd/yy; ROD published mm/dd/yy)**		

Examples of reasons CA status was not initiated or why it ended:

1. Lack of special expertise – identify the expertise sought by the lead agency and/or offered by the potential cooperating agency).
2. State, Tribal or local entity lacks authority to enter into an agreement to be a CA.
3. Potential CA unable to agree to participate during scoping and/or throughout the preparation of the analysis and documentation as necessary and meet milestones established for completing the process.
4. Potential or active CA unable or unwilling to identify significant issues, eliminate minor issues, identify issues previously studied, or identify conflicts with the objectives of regional, State and local land use plans, policies and controls in a timely manner.
5. Potential or active CA unable or unwilling to assist in preparing portions of the review and analysis and resolving significant environmental issues in a timely manner.
6. Potential or active CA unable or unwilling to provide resources to support scheduling and critical milestones.
7. Agency unable or unwilling to consistently participate in meetings or respond in a timely fashion after adequate time for review of documents, issues and analyses.

7. Can the cooperating agency provide resources to support scheduling and critical milestones such as:

- personnel? Consider all forms of assistance (e.g., data gathering; surveying; compilation; research.
- expertise? This includes technical or subject matter expertise.
- funding? Examples include funding for personnel, travel and studies. Normally, the cooperating agency will provide the funding; to the extent available funds permit, the lead agency shall fund or include in budget requests funding for an analyses the lead agency requests from cooperating agencies. Alternatives to travel, such as telephonic or video conferencing, should be considered especially when funding constrains participation.
- models and databases? Consider consistency and compatibility with lead and other cooperating agencies' methodologies.
- facilities, equipment and other services? This type of support is especially relevant for smaller governmental entities with limited budgets.

8. Does the agency provide adequate lead-time for review and do the other agencies provide adequate time for review of documents, issues and analyses? For example, are either the lead or cooperating agencies unable or unwilling to consistently participate in meetings in a timely fashion after adequate time for review of documents, issues and analyses?

9. Can the cooperating agency(s) accept the lead agency's final decisionmaking authority regarding the scope of the analysis, including authority to define the purpose and need for the proposed action? For example, is an agency unable or unwilling to develop information/analysis of alternatives they favor and disfavor?

10. Are the agency(s) able and willing to provide data and rationale underlying the analyses or assessment of alternatives?

11. Does the agency release predecisional information (including working drafts) in a manner that undermines or circumvents the agreement to work cooperatively before publishing draft or final analyses and documents? Disagreeing with the published draft or final analysis should not be a ground for ending cooperating status. Agencies must be alert to situations where state law requires release of information.

12. Does the agency consistently misrepresent the process or the findings presented in the analysis and documentation?

The factors provided for extending cooperating agency status are not intended to be all-inclusive. Moreover, satisfying all the factors is not required and satisfying one may be sufficient. Each determination should be made on a case-by-case basis considering all relevant information and factors.

Index to 516 DM 1-7

Chapter 1 Protection and Enhancement of Environmental Quality
Chapter 2 Initiating the NEPA Process
Chapter 3 Environmental Assessments
Chapter 4 Environmental Impact Statements
Chapter 5 Relationship to Decisionmaking
Chapter 6 Managing the NEPA Process
Chapter 7 Review of Environmental Statements Prepared by Other Federal Agencies

1.1 Purpose. This Chapter establishes the Department's policies complying with Title 1 of the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321-4347) (NEPA); Section 2 of Executive Order 11514, Protection and Enhancement of Environmental Quality, as amended by Executive Order 11991; and the regulations of the Council on Environmental Quality (CEQ) implementing the procedural provisions of NEPA (40 CFR 1500-1508).

1.2 Policy. It is the policy of the Department:

A. To provide leadership in protecting and enhancing those aspects of the quality of the Nation's environment which relate to or may be affected by the Department's policies, goals, programs, plans, or functions in furtherance of national environmental policy;

B. To use all practicable means, consistent with other essential considerations of national policy, to improve, coordinate, and direct its policies, plans, functions, programs, and resources in furtherance of national environmental goals;

C. To interpret and administer, to the fullest extent possible, the policies, regulations, and public laws of the United States administered by the Department in accordance with the policies of NEPA;

D. To consider and give important weight to environmental factors, along with other essential considerations, in developing proposals and making decisions in order to achieve a proper balance between the development and utilization of natural, cultural, and human resources and the protection and enhancement of environmental quality;

E. To consult, coordinate, and cooperate with other Federal agencies and State, local, and Indian tribal governments in the development and implementation of the Department's plans and programs affecting environmental quality and, in turn, to provide to the fullest extent practicable, these entities with information concerning the environmental impacts of their own plans and programs;

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F. To provide, to the fullest extent practicable, timely information to the public to better assist in understanding Departmental plans and programs affecting environmental quality and to facilitate their involvement in the development of such plans and programs; and

G. To cooperate with and assist the CEQ.

1.3 General Responsibilities. The following responsibilities reflect the Secretary's decision that the officials responsible for making program decisions are also responsible for taking the requirements of NEPA into account in those decisions and will be held accountable for that responsibility:

A. Assistant Secretary--Policy, Budget and Administration.
(1) Is the Department's focal point on NEPA matters and is responsible for overseeing the Department's implementation of NEPA.
(2) Serves as the Department's principal contact with the CEQ.
(3) Assigns to the Director, Office of Environmental Project Review, the responsibilities outlined for that Office in this Part.

B. Solicitor. Is responsible for providing legal advice in the Department's compliance with NEPA.

C. Assistant Secretaries.
(1) Are responsible for compliance with NEPA, E.O. 11514, as amended, the CEQ regulations, and this Part for bureaus and offices under their jurisdiction.
(2) Will insure that, to the fullest extent possible, the policies, regulations, and public laws of the United States administered under their jurisdiction are interpreted and administered in accordance with the policies of NEPA.

C. Heads of Bureaus and Offices.

(1) Must comply with the provisions of NEPA, E.O. 11514, as amended, the CEQ regulations and this Part.

(2) Will interpret and administer, to the fullest extent possible, the policies, regulations, and public laws of the United States administered under their jurisdiction in accordance with the policies of NEPA.

(3) Will continue to review their statutory authorities, administrative regulations, policies, programs, and procedures, including those related to loans, grants, contracts, leases, licenses, or permits, in order to identify any deficiencies or inconsistencies therein which prohibit or limit full compliance with the intent, purpose, and provisions of NEPA and, in consultation with the Solicitor and the Legislative Counsel, shall take or recommend, as appropriate, corrective actions as may be necessary to bring these authorities and policies into conformance with the intent, purpose, and procedures of NEPA.

(4) Will monitor, evaluate, and control on a continuing basis their activities so as to protect and enhance the quality of the environment. Such activities will include those directed to controlling pollution and enhancing the environment and designed to accomplish other program objectives which may affect the quality of the environment. They will develop programs and measures to protect and enhance environmental quality and assess progress in meeting the specific objectives of such activities as they affect the quality of the environment.

1.4 Consideration of Environmental Values.

A. In Departmental Management.

(1) In the management of the natural, cultural, and human resources under its jurisdiction, the Department must consider and balance a wide range of economic, environmental, and social objectives at the local, regional, national, and international levels, not all of which are quantifiable in comparable terms. In considering and balancing these objectives, Departmental plans, proposals, and decisions often require recognition of complements and resolution of conflicts among interrelated uses of these natural, cultural, and human resources within technological, budgetary, and legal constraints.

(2) Departmental project reports, program proposals, issue papers, and other decision documents must carefully analyze the various objectives, resources, and constraints, and comprehensively and objectively evaluate the advantages and disadvantages of the proposed actions and their reasonable alternatives. Where appropriate, these documents will utilize and reference supporting and underlying economic, environmental, and other analyses,

(3) The underlying environmental analyses will factually, objectively, and comprehensively analyze the environmental effects of proposed actions and their reasonable alternatives. They will systematically analyze the environmental impacts of alternatives, and particularly those alternatives and measures which would reduce, mitigate or prevent adverse environmental impacts or which would enhance environmental quality. However, such an environmental analysis is not, in and of itself, a program proposal or the decision document, is not a justification of a proposal, and will not support or deprecate the overall merits of a proposal or its various alternatives.

B. In Internally Initiated Proposals. Officials responsible for development or conduct of planning and decision making systems within the Department shall incorporate to the maximum extent necessary environmental planning as an integral part of these systems in order to insure that environmental values and impacts are fully considered and in order to facilitate any necessary documentation of those considerations.

C. In Externally Initiated Proposals. Officials responsible for development or conduct of loan, grant, contract, lease, license, permit, or other externally initiated activities shall require applicants, to the extent necessary and practicable, to provide environmental information, analyses, and reports as an integral part of their applications. This will serve to encourage applicants to incorporate environmental considerations into their planning processes as well as provide the Department with necessary information to meet its own environmental responsibilities.

1.5 Consultation, Coordination, and Cooperation with Other Agencies and Organizations.

A. Departmental Plans and Programs.

(1) Officials responsible for planning or implementing Departmental plans and programs will develop and utilize procedures to consult, coordinate, and cooperate with relevant State, local, and Indian tribal governments; other bureaus and Federal agencies; and public and private organizations and individuals concerning the environmental effects of these plans and programs on their jurisdictions or interests.

(2) Bureaus and offices will utilize, to the maximum extent possible, existing notification, coordination and review mechanisms established by the Office of Management and Budget, the Water Resources Council, and CEQ. However, use of these mechanisms must not be a substitute for early and positive consultation, coordination, and cooperation with others, especially State, local, and Indian tribal governments.

B. Other Departmental Activities.

(1) Technical assistance, advice, data, and information useful in restoring, maintaining, and enhancing the quality of the environment will be made

available to other Federal agencies, State, local, and Indian tribal governments, institutions, and individuals as appropriate.

(2) Information regarding existing or potential environmental problems and control methods developed as a part of research, development, demonstration, test, or evaluation activities will be made available to other Federal agencies, State, local, and Indian tribal governments, institutions and other entities as appropriate.

(3) Recognizing the worldwide and long-range character of environmental problems, where consistent with the foreign policy of the United States appropriate support will be made available to initiatives, resolutions, and programs designed to maximize international cooperation in anticipating and preventing a decline in the quality of the world environment.

C. Plans and Programs of Other Agencies and Organizations

(1) Officials responsible for protecting, conserving, developing, or managing resources under the Department's jurisdiction shall coordinate and cooperate with State, local, and Indian tribal governments, other bureaus and Federal agencies, and public and private organizations and individuals, and provide them with timely information concerning the environmental effects of these entities' plans and programs.

(2) Bureaus and offices are encouraged to participate early in the planning processes of other agencies and organizations in order to insure full cooperation with and understanding of the Department's programs and interests in natural, cultural, and human resources.

(3) Bureaus and offices will utilize to the fullest extent possible, existing Departmental review mechanisms to avoid unnecessary duplication of effort and to avoid confusion by other organizations.

1.6 Public Involvement. Bureaus and offices, in consultation with the Office of Public Affairs, will develop and utilize procedures to insure the fullest practicable provision of timely public information and understanding of their plans and programs with environmental impact including information on the environmental impacts of alternative courses of action. These procedures will include, wherever appropriate, provision for public meetings or hearings in order to obtain the views of interested parties. Bureaus and offices will also encourage State and local agencies and Indian tribal governments to adopt similar procedures for informing the public concerning their activities affecting the quality of the environment. (See also 301 DM 2.)

1.7 Mandate.

A. This Part provides Department-wide instructions for complying with NEPA and Executive Orders 11514, as amended by 11991 (Protection and Enhancement of Environmental Quality) and 12114 (Environmental Effects Abroad of Major Federal Actions).

B. The Department hereby adopts the regulations of the CEQ implementing the procedural provisions of NEPA (Sec. 102(2)(C) except where compliance would be inconsistent with other statutory requirements. In the

case of any apparent discrepancies between these procedures and the mandatory provisions of the CEQ regulations the regulations shall govern.

C. Instructions supplementing the CEQ regulations are provided in Chapters 2-7 of this Part. Citations in brackets refer to the CEQ regulations. Instructions specific to each bureau are appended to Chapter 6. In addition, bureaus may prepare a handbook(s) or other technical guidance for their personnel on how to apply this Part to principal programs.

D. Instructions implementing Executive Order 12114 will be provided in Chapter 8.

2.1 Purpose. This Chapter provides supplementary instructions for implementing those portions of the CEQ regulations pertaining to initiating the NEPA process.

2.2 Apply NEPA Early (1501.2).

A. Bureaus will initiate early consultation and coordination with other bureaus and any Federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved, and with appropriate Federal, State, local and Indian tribal agencies authorized to develop and enforce environmental standards.

B. Bureaus will also consult early with interested private parties and organizations, including when the Bureau's own involvement is reasonably foreseeable in a private or non-Federal application.

C. Bureaus will revise or amend program regulations or directives to insure that private or non-Federal applicants are informed of any environmental information required to be included in their applications and of any consultation with other Federal agencies, and State, local or Indian tribal governments required prior to making the application. A list of these regulations or directives will be included in each Bureau Appendix to Chapter 6.

2.3 Whether to Prepare an EIS (1501.4).

A. Categorical Exclusions (CX) (1508.4).

(1) The following criteria will be used to determine actions to be categorically excluded from the NEPA process: (a) The action or group of actions would have no significant effect on the quality of the human environment; and (b) The action or group of actions would not involve unresolved conflicts concerning alternative uses of available resources.

(2) Based on the above criteria, the classes of actions listed in Appendix 1 to this Chapter are categorically excluded, Department-wide, from the NEPA process. A list of CX specific to Bureau programs will be included in each Bureau Appendix to Chapter 6.

(3) The exceptions listed in Appendix 2 to this Chapter apply to individual actions within CX. Environmental documents must be prepared for any actions involving these exceptions.

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(4) Notwithstanding the criteria, exclusions and exceptions above, extraordinary circumstances may dictate or a responsible Departmental or Bureau official may decide to prepare an environmental document.

B. Environmental Assessment (EA) (1508.9). See 516 DM 3.

C. Finding of No Significant Impact (FONSI) (1508.13). A FONSI will be prepared as separate covering document based upon a review of an EA. Accordingly, the words include(d) in Section 1508.13 should be interpreted as attach(ed).

D. Notice of Intent (NOI) (1508.22)'. A NOI will be prepared as soon as practicable after a decision to prepare an environmental impact statement and shall be published in the Federal Register, with a copy to the Office of Environmental Project Review, and made available to the affected public in accordance with Section 1506.6. Publication of a NOI may be delayed if there is proposed to be more than three (3) months between the decision to prepare an environmental impact statement and the time preparation is actually initiated. The Office of Environmental Project Review will periodically publish a consolidated list of these notices in the Federal Register.

E. Environmental impact Statement (EIS) (1508.11). See 516 DM 4. Decisions/actions which would normally require the preparation of an EIS will be identified in each Bureau Appendix to Chapter 6.

2.4 Lead Agencies (1501.5).

A. The Assistant Secretary-Policy, Budget and Administration will designate lead Bureaus within the Department when Bureaus under more than one Assistant Secretary are involved and will represent the Department in consultations with CEQ or other Federal agencies in the resolution of lead agency determinations.

B. Bureaus will inform the Office of Environmental Project Review of any agreements to assume lead agency status.

C. A non-Federal agency will not be designated as a joint lead agency unless it has a duty to comply with a local or State EIS requirement that is comparable to a NEPA statement. Any non-Federal agency may be a cooperating agency by agreement. Bureaus will consult with the Solicitor's Office in cases where such non-Federal agencies are also applicants before the Department to determine relative lead/cooperating agency responsibilities.

2.5 Cooperating Agencies (1501.6).

A. The Office of Environmental Project Review will assist Bureaus and coordinate requests from non-Interior agencies in determining cooperating agencies.

B. Bureaus will inform the Office of Environmental Project Review of any agreements to assume cooperating agency status or any declinations pursuant to Section 1501.6(c).

2.6 Scoping (1501.7).

A. The invitation requirement in Section 1501.7(a)(1) may be satisfied by including such an invitation in the NOI.
B. If a scoping meeting is held, consensus is desirable; however, the lead agency is ultimately responsible for the scope of an EIS.

2.7 Time Limits (1501.8). When time limits are established they should reflect the availability of personnel and funds.

3.1 Purpose. This Chapter provides supplementary instructions for implementing those portions of the CEQ regulations pertaining to environmental assessments (EA).

3.2 When to Prepare (1501.3).

A. An EA will be prepared for all actions, except those covered by a categorical exclusion, covered sufficiently by an earlier environmental document, or for those actions for which a decision has already been made to prepare an EIS. The purpose of such an EA is to allow the responsible official to determine whether to prepare an EIS.
B. In addition, an EA may be prepared on any action at any time in order to assist in planning and decision making.

3.3 Public Involvement.

A. Public notification must be provided and, where appropriate, the public involved in the EA process (1506.6).
B. The scoping process may be applied to an EA (1501.7).

3.4 Content.

A. At a minimum, an EA will include brief discussions of the need for the proposal, of alternatives as required by Section 102(2)(E) of NEPA, of the environmental impacts of the proposed action and such alternatives, and a listing of agencies and persons consulted (1508.9(b)).
B. In addition, an EA may be expanded to describe the proposal, a broader range of alternatives, and proposed mitigation measures if this facilitates planning and decision making.
C. The level of detail and depth of impact analysis should normally be limited to that needed to determine whether there are significant environmental effects.
D. An EA will contain objective analyses which support its environmental impact conclusions. It will not, in and of itself, conclude whether or not an EIS will be prepared. This conclusion will be made upon review of the EA by the responsible official and documented in either a NOI or FONSI.

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3.5 Format.

A. An EA may be prepared in any format useful to facilitate planning and decision making.
B. An EA may be combined with any other planning or decision making document; however, that portion which analyzes the environmental impacts of the proposal and alternatives will be clearly and separately identified and not spread throughout or interwoven into other sections of the document.

3.6 Adoption.

A. An EA prepared for a proposal before the Department by another agency, entity or person, including an applicant, may be adopted if, upon independent evaluation by the responsible official, it is found to comply with this Chapter and relevant provisions of the CEQ regulations.
B. When appropriate and efficient, a responsible official may augment such an EA when it is essentially but not entirely in compliance in order to make it so.
C. If such an EA or augmented EA is adopted, the responsible official must prepare his/her own N01 or FONSI which also acknowledges the origin of the EA and takes full responsibility for its scope and content.

4.1 Purpose. This Chapter provides supplementary instructions for implementing those portions of the CEQ regulations pertaining to environmental impact statements (EIS).

4.2 Statutory Requirements (1502.3). NEPA requires that an EIS be prepared by the responsible Federal official. This official is normally the lowest-level official who has overall responsibility for formulating, reviewing, or proposing an action or, alternatively, has been delegated the authority or responsibility to develop, approve, or adopt a proposal or action. Preparation at this level will insure that the NEPA process will be incorporated into the planning process and that the EIS will accompany the proposal through existing review processes.

4.3 Timing (1502.5).

A. The feasibility analysis (go/no-go) stage, at which time an EIS is to be completed, is to be interpreted as the stage prior to the first point of major commitment to the proposal. For example, this would normally be at the authorization stage for proposals requiring Congressional authorization, the location or corridor stage for transportation, transmission, and communication projects, and the leasing stage for mineral resources proposals.
B. An EIS need not be commenced until an application is essentially complete; e.g., any required environmental information is submitted, any consultation required with other agencies has been conducted, and any required advance funding is paid by the applicant.

4.4 Page Limits (1502.7). Where the text of an EIS for a complex proposal or group of proposals appears to require more than the normally prescribed limit of 300 pages, bureaus will insure that the length of such statements is no greater than necessary to comply with NEPA, the CEQ regulations, and this Chapter.

4.5 Supplemental Statements (1502.9).

A. Supplements are only required if such changes in the proposed action or alternatives, new circumstances, or resultant significant effects are not adequately analyzed in the previously prepared EIS.
B. A bureau and/or the appropriate program Assistant Secretary will consult with the Office of Environmental Project Review and the Office of the Solicitor

prior to proposing to CEQ to prepare a final supplement without preparing an intervening draft.

C. If, after a decision has been made based on a final EIS, a described proposal is further defined or modified and if its changed effects are minor or still within the scope of the earlier EIS, an EA and FONSI may be prepared for subsequent decisions rather than a supplement.

4.6 Format (1502.10).

A. Proposed departures from the standard format described in the CEQ regulations and this Chapter must be approved by the Office of Environmental Project Review.

B. The section listing the preparers of the EIS will also include other sources of information, including a bibliography or list of cited references, when appropriate.

C. The section listing the distribution of the EIS will also briefly describe the consultation and public involvement processes utilized in planning the proposal and in preparing the EIS, if this information is not discussed elsewhere in the document.

D. If CEQ's standard format is not used or if the EIS is combined with another planning or decision making document, the section which analyzes the environmental consequences of the proposal and its alternatives will be clearly and separately identified and not interwoven into other portions of or spread throughout the document.

4.7 Cover Sheet (1502.11). The cover sheet will also indicate whether the EIS is intended to serve any other environmental review or consultation requirements pursuant to Section 1502.25.

4.8 Summary (1502. 12). The emphasis in the summary should be on those considerations, controversies, and issues which significantly affect the quality of the human environment.

4.9 Purpose and Need (1502.13). This section may introduce a number of factors, including economic and technical considerations and Departmental or bureau statutory missions, which may be beyond the scope of the EIS. Care should be taken to insure an objective presentation and not a justification.

4.10 Alternatives Including the Proposed Action (1502.14).

A. As a general rule, the following guidance will apply:

(1) For internally initiated proposals; i.e., for those cases where the Department conducts or controls the planning process, both the draft and final EIS shall identify the bureaus' proposed action.

(2) For externally initiated proposals; i.e., for those cases where the Department is reacting to an application or similar request, the draft and final EIS shall identify the applicant's proposed action and the bureau's preferred alternative unless another law prohibits such an

expression (3) Proposed departures from this guidance must be approved by the Office of Environmental Project Review and the Office of the Solicitor.

B. Mitigation measures are not necessarily independent of the proposed action and its alternatives and should be incorporated into and analyzed as a part of the proposal and appropriate alternatives. Where appropriate, major mitigation measures may be identified and analyzed as separate alternatives in and of themselves where the environmental consequences are distinct and significant enough to warrant separate evaluation.

4.11 Appendix (1502.18). If an EIS is intended to serve other environmental review or consultation requirements pursuant to Section 1502.25, any more detailed information needed to comply with these requirements may be included as an appendix.

4.12 Incorporation by Reference (1502.21). Citations of specific topics will include the pertinent page numbers. All literature references win be listed in the bibliography.

4.13 Incomplete or Unavailable Information (1502.22). The references to overall costs in this section are not limited to market costs, but include other costs to society such as social costs due to delay.

4.14 Methodology and Scientific Accuracy (1502.24). Conclusions about environmental effects will be preceded by an analysis that supports that conclusion unless explicit reference by footnote is made to other supporting documentation that is readily available to the public.

4.15 Environmental Review and Consultation Requirements (1502.25).

A. A list of related environmental review and consultation requirements is available from the Office of Environmental Project Review.
B. If the EIS is intended to serve as the vehicle to fully or partially comply with any of these requirements, the associated analyses, studies, or surveys will be identified as such and discussed in the text of the EIS and the cover sheet will so indicate. Any supporting analyses or reports will be referenced or included as an appendix and shall be sent to reviewing agencies as appropriate in accordance with applicable regulations or procedures.

4.16 Inviting Comments (1503.1).

A. Comments from State agencies will be requested through procedures established by the Governor pursuant to Executive Order 12372, and may be requested from local agencies through these procedures to the extent that they include the affected local jurisdictions. See 511DM.
B. When the proposed action may affect the environment of an Indian reservation, comments will be requested from the Indian tribe through the tribal governing body, unless the tribal governing body has designated an alternate review process.

4.17 Response to Comments (1503.4).

A. Preparation of a final EIS need not be delayed in those cases where a Federal agency, from which comments are required to be obtained (1503.1(a)(1)), does not comment within the prescribed time period. Informal attempts will be made to determine the status of any such comments and every reasonable attempt should be made to include the comments and a response in the final EIS.
B. When other commentary are late, their comments should be included in the final EIS to the extent practicable.
C. For those ElSs requiring the approval of the Assistant Secretary - Policy, Budget and Administration pursuant to 516 DM 6.3, bureaus will consult with the Office of Environmental Project Review when they propose to prepare an abbreviated final EIS (1503.4(c)).

4.18 Elimination of Duplication with State and Local Procedures (1506.2). Bureaus will incorporate in their appropriate program regulations provisions for the preparation of an EIS by a State agency to the extent authorized in Section 102(2XD) of NEPA. Eligible programs are listed in Appendix I to this Chapter.

4.19 Combining Documents (1506.4). See 516 DM 4.6D.

4.20 Departmental Responsibility (1506.5). Following the responsible official's preparation or independent evaluation of and assumption of responsibility for an environmental document, an applicant may print it provided the applicant is bearing the cost of the document pursuant to other laws.

4.21 Public Involvement (1506.6). See 516 DM 1.6 and 301 DM 2.

4.22 Further Guidance (1506.7). The Office of Environmental Project Review may provide further guidance concerning NEPA pursuant to its organizational responsibilities (110 DM 22) and through supplemental directives (381 DM 4.5B).

4.23 Proposals for Legislation (1506.8). The Legislative Counsel in consultation with the Office of Environmental Project Review, shall:

A. Identify in the annual submittal to OMB of the Department's proposed legislative program any requirements for and the status of any environmental
B. When required, insure that a legislative EIS is included as a part of the formal transmittal of a legislative proposal to the Congress.

4.24 Time Periods (1506.10).

A. The minimum review period for a draft EIS will be sixty (60) days from the date of transmittal to the Environmental Protection Agency.

For those EISs requiring the approval of the Assistant Secretary - Policy, Budget and Administration pursuant to 516 DM 6.3, the Office of Environmental Project Review will be responsible for consulting with the Environmental Protection Agency and/or CEQ about any proposed reductions in time periods or any extensions of time periods proposed by those agencies

5.1 Purpose. This Chapter provides supplementary instructions for implementing those portions of the CEQ regulations pertaining to decision making..

5.2 Predecision Referrals to CEQ (1504.3).

A. Upon receipt of advice that another Federal agency intends to refer a Departmental matter to CEQ, the lead bureau will immediately meet with that Federal agency to attempt to resolve the issues raised and expeditiously notify its Assistant Secretary and the Office of Environmental Project Review.
B. Upon any referral of a Departmental matter to CEQ by another Federal agency, the Office of Environmental Project Review will be responsible for coordinating the Department's position.

5.3 Decision making Procedures (1505.1).

A. Procedures for decisions by the Secretary/Under Secretary are specified in 301 DM 1. Assistant Secretaries should follow a similar process when an environmental document accompanies a proposal for their decision.
B. Bureaus will incorporate in their formal decision making procedures and NEPA handbooks provisions for consideration of environmental factors and relevant environmental documents. The major decision points for principal programs likely to have significant environmental effects will be identified in the Bureau Appendix to Chapter 6.
C. Relevant environmental documents including supplements, will be included as part of the record in formal rulemaking or adjudicatory proceedings.
D. Relevant environmental documents comments, and responses will accompany proposals through existing review processes so that Departmental officials use them in making decisions.
E. The decision maker will consider the environmental impacts of the alternatives described in any relevant environmental document and the range of these alternatives must encompass the alternatives considered by the decision maker.

5.4 Record of Decision (1505-2).

A. Any decision documents prepared pursuant to 301 DM 1 for proposals

involving an EIS may incorporate all appropriate provisions of Section 1505.2(b) and (c).

B. If a decision document incorporating these provisions is made available to the public following a-decision, it will serve the purpose of a record of decision.

5.5 implementing the Decision (1505.3). The terms 11monitoring" and "conditions" will be interpreted as being related to factors affecting the quality of the human environment.

5.6 Limitations on Actions (1506.1). A bureau will notify its Assistant secretary, the Solicitor, and the Office of Environmental Project Review of any situations described in Section 1506.1(b).

5.7 Timing of Actions (1506.10). For those EISs requiring the approval of the Assistant Secretary--Policy, Budget and Administration pursuant to 516 DM 6.3, the responsible official will consult with the Office of Environmental Project Review before making any request for reducing the time period before a decision or action.

5.8 Emergencies (1506.11). In the event of an unanticipated emergency situation, a bureau will immediately take any necessary action to prevent or reduce risks to public health or safety or serious resource losses and then expeditiously consult with its Assistant Secretary, the Solicitor, and the Office of Environmental Project Review about compliance with NEPA. The Office of Environmental Project Review and the bureau will jointly be responsible for consulting with CEQ.

6.1 Purpose. This Chapter provides supplementary instructions for implementing those provisions of the CEQ regulations pertaining to procedures for implementing and managing the NEPA process.

6.2 Organization for Environmental Quality.

A. Office of Environmental Project Review. The Director, Office of Environmental Project Review, reporting to the Assistant Secretary--Policy, Budget and Administration (PBA), is responsible for providing advice and assistance to the Department on matters pertaining to environmental quality and for overseeing and coordinating the Departments compliance with NEPA, E.O. 11514, the CEQ regulations, and this Part. (See also 110 DM 22.)

B. Bureaus and Offices. Heads of bureaus and offices will designate organizational elements or individuals, as appropriate, at headquarters and regional levels to be responsible for overseeing matters pertaining to the environmental effects of the bureaus plans and programs. The individuals assigned these responsibilities should have management experience or potential, understand the bureau's planning and decision making processes, and be well trained in environmental matters, including the Department's policies and procedures so that their advice has significance in the bureau's planning and decisions. These organizational elements will be identified in the Bureau Appendix to this Chapter.

6.3 Approval of EISs.

A. A program Assistant Secretary is authorized to approve an EIS in those cases where the responsibility for the decision for which the EIS has been prepared rests with the Assistant Secretary or below. The Assistant Secretary may further assign the authority to approve the EIS if he or she chooses. The Assistant Secretary--PBA will make certain that each program Assistant Secretary has adequate safeguards to assure that the EISs comply with NEPA, the CEQ regulations, and the Departmental Manual.

B. The Assistant Secretary--PBA is authorized to approve an EIS in those cases where the decision-for which the EIS has been prepared will occur at a level in the Department above an individual program Assistant Secretary.

6.4 List of Specific Compliance Responsibilities.

3/18/80 #2244
Replaces 9/17/70 #1222 and 9/27/71 #1341

A. Bureaus and offices shall:
   (1) Prepare NEPA handbooks providing guidance on how to implement NEPA in principal program areas.
   (2) Prepare program regulations or directives for applicants.
   (3) Propose categorical exclusions.
   (4) Prepare and approve EAs.
   (5) Decide whether to prepare an EIS.
   (6) Prepare and publish NOIs and FONSI.
   (7) Prepare and, when assigned, approve EISs.

B. Assistant Secretaries shall:
   (1) Approve bureau handbooks.
   (2) Approve regulations or directives for applicants.
   (3) Approve categorical exclusions.
   (4) Approve EISs pursuant to 516 DM 6.3.

C. The Assistant Secretary--Policies Budget and Administration shall:
   (1) Concur with regulations or directives for applicants.
   (2) Concur with categorical exclusions.
   (3) Approve EISs pursuant to 516 DM 6.3.

6.5 Bureau Requirements.

A. Requirements specific to bureaus appear as appendices to this Chapter and include the following:
   (1) Identification of officials and organizational elements responsible for NEPA compliance (516 DM 6.2B).
   (2) List of program regulations or directives which provide information to applicants (516 DM 2.2B).
   (3) Identification of major decision points in principal programs (516 DM 5.3B) for which an EIS is normally prepared (516 DM 2.3E).
   (4) List of categorical exclusions (516 DM 2.3A).

B. Appendices are attached for the following bureaus:
   (1) Fish and Wildlife Service (Appendix 1).
   (2) Geological Survey (Appendix 2).
   (3) Heritage Conservation and Recreation Service (Appendix 3).
   (4) Bureau of Indian Affairs (Appendix 4).
   (5) Bureau of Land Management (Appendix 5).
   (6) Bureau of Mines (Appendix 6).
   (7) National Park Service (Appendix 7)
   (8) Office of Surface Mining (Appendix 8).
   (9) Water and Power Resources Service (Appendix 9).

C. The Office of the Secretary and other Departmental Offices do not have separate appendices, but must comply with this Part and will consult with the Office of Environmental Project Review about compliance activities

6.6 Information About the NEPA Process. The Office of Environmental Project Review

will publish periodically a Departmental list of contacts where information about the NEPA process and the status of EISs may be obtained.

7.1 Purpose. These procedures are to implement the policy and directives of Section 102(2)(C) of the National Environmental Policy Act of 1969 (P.L. 91-190, 83 Stat. 852, January 1, 1970); Section 2(f) of Executive Order No. 11514 (March 5, 1970); the Guidelines issued by the Council on Environmental Quality (36 F.R. 7724, April 23, 1971); Bulletin No. 72-6 of the Office of Management and Budget (September 14, 1971);.and provide guidance to bureaus and offices of the Department in the review of environmental statements prepared by and for other Federal agencies.

7.2 Policy. The Department considers it a priority responsibility to provide competent and timely review comments on environmental statements prepared by other Federal agencies for their major actions which significantly affect the quality of the human environment. These reviews are predicated on the Department's jurisdiction by law or special expertise with respect to the environmental impact involved and shall provide constructive comments to other Federal agencies to assist them in meeting their environmental responsibilities.

7.3 Responsibilities.

A. The Assistant Secretary - Program Policy:

(1) Shall be the Department's contact point for the receipt of requests for reviews of draft and final environmental statements prepared by or for other Federal agencies;

(2) Shall determine whether such review requests are to be answered by a Secretarial officer or by a Field Representative, and determine which bureaus and/or offices shall perform such reviews;

(3) Shall prepare, or where appropriate, shall designate a lead bureau responsible for preparing the Department's review comments. The lead bureau may be a bureau, Secretarial office, other Departmental office, or task force and shall be that organizational entity with the most significant jurisdiction or environmental expertise in regard to the requested review;

(4) Shall set review schedules and target dates for responding to review requests and monitor their compliance;

(5) Shall Review, sign, and transmit the Department's Review comments to the requesting agency and to the Council on Environmental Quality, unless he designates otherwise;

(6) Shall follow through on the Department is Review comments transmitted to the requesting agency to ensure resolution of the Department's concerns, unless he designates otherwise; and

(7) Shall consult with the Legislative Counsel and the Solicitor when environmental reviews pertain to legislative or legal matters, respectively.

B. The Legislative Counsel:

(1) Shall ensure that requests for reviews of environmental statements prepared by other Federal agencies that accompany or pertain to legislative proposals are immediately referred to the Assistant Secretary - Program Policy.

C. Field Representatives:

(1) When designated by the Assistant Secretary Program Policy, shall Review, sign, and transmit the Department's Review comments to the requesting agency and to the Council on Environmental Quality.

C. Assistant Secretaries andHeads of Bureaus and Offices:

(1) Shall designate officials and organizational elements responsible for the coordination and conduct of environmental reviews and report this information to the Assistant Secretary - Program Policy;

(2) Shall provide the Assistant Secretary - Program Policy with appropriate information and material concerning their delegated jurisdiction and special environmental expertise in order to assist him in assigning Review responsibilities;

(3) Shall conduct reviews based upon their areas of jurisdiction or special environmental expertise and provide comments to designated lead bureaus assigned responsibilities for preparing Departmental comments;

(4) When designated lead bureau by the Assistant Secretary - Program Policy, shall prepare and forward the Department's Review comments as instructed; and

(5) Shall assure that Review schedules for discharging assigned responsibilities are met, and promptly inform other concerned offices if established target dates cannot be met and when they will be met.

7.4 Types of Reviews

A. Descriptions of Proposed Actions:

(1) Descriptions of proposed actions are not substitutes for environmental statements. Federal agencies and applicants for Federal assistance may circulate such descriptions, for the purpose of soliciting information concerning environmental impact in order to determine whether or not to prepare environmental statements.

(2) Requests for reviews of descriptions of proposed actions are not required to be processed through the Assistant Secretary - Program Policy. Review comments may be handled independently by bureaus and offices, with the Field Representative and Assistant Secretary - Program Policy being advised of significant or highly controversial issues. Review

comments are for the purpose of providing technical assistance to the requesting agency and should reflect this fact.

B. Environmental Assessments or Reports:

(1) Environmental assessments or reports are not substitutes for environmental statements. These assessments or reports may be prepared by Federal agencies, their consultants, or applicants for Federal assistance. They are prepared either to provide information in order to determine whether or not an environmental statement should be prepared, or to provide input into an environmental statement. If they are separately circulated, it is generally for the purpose of soliciting additional information concerning environmental impact.

(2) Requests for reviews of environmental assessments or reports are not required to be processed through the Assistant Secretary - Program Policy. Review comments may be handled independently by bureaus and offices, with the Field Representative and Assistant Secretary - Program Policy being advised of significant or highly controversial issues. Review comments are for the purpose of providing technical assistance to the requesting agency and should reflect this fact.

C. Negative Declarations:

(1) Negative declarations are prepared in lieu of environmental statements by Federal agencies and, in some cases, by applicants for Federal assistance. A negative declaration is a statement for the record by the proponent Federal agency that it has reviewed the environmental impact of its proposed action, that it determines that the action will not significantly affect the quality of the human environment, and that an environmental statement is not required. Such declarations are not normally circulated.

(2) Requests for reviews of negative declarations are not required to be processed through the Assistant Secretary - Program Policy. Review comments may be handled independently by bureaus and offices and shall concur or not concur with the requesting agency. If a bureau or office does not concur, the Field Representative and Assistant Secretary - Program Policy will be advised promptly by copy of the comments with a copy of the negative declaration attached.

D. Preliminary, Proposed, or Working Draft Environmental Statements:

(1) Preliminary, proposed, or working draft environmental statements are sometimes prepared and circulated by Federal agencies and applicants for Federal assistance for consultative purposes.

(2) Requests for reviews of these types of draft environmental statements are not required to be processed through the Assistant Secretary - Program Policy. Review comments may be handled independently by bureaus and offices with the Field Representative and Assistant Secretary - Program Policy being advised of significant or highly controversial issues. Review comments are for the purpose of providing informal technical assistance to the requesting agency and

should state that they do not represent the Review comments of the Department on the draft environmental statement.

E. Draft Environmental Statements

(1) Draft environmental statements are prepared by Federal agencies under the provisions of Section 102(2)(C) of the National Environmental Policy Act and provisions of the Guidelines of the Council on Environmental Quality. They are officially circulated to other Federal agencies for Review from their Jurisdiction by law or special environmental expertise.

(2) All requests from other Federal agencies for' Review of draft environmental statements shall be made through the Assistant Secretary - Program Policy. Review comments shall be handled in accordance with his instructions and the provisions of this chapter.

F. Final Environmental Statements:

(1) Final environmental statements are prepared by Federal agencies following receipt and consideration of Review comments. They are filed with the Council on Environmental Quality and are generally circulated for information purposes and sometimes for comment.

(2) The Assistant Secretary - Program Policy shall Review final environmental statements to determine whether they reflect adequate consideration of the Department's comments. Bureaus and offices shall not comment independently on final environmental statements, but shall inform the Assistant Secretary - Program Policy of their views. Any Review comments shall be handled in accordance with his instructions.

7.5 Content of Review Comments on Draft Environmental Statements

A. Departmental Comments:

(1) Departmental comments on draft environmental statements prepared by other Federal agencies shall be based upon the Department's jurisdiction by law or special expertise with respect to the environmental impact of the proposed action or alternatives to the action. The adequacy of the statement in regard to the Act and the Council on Environmental Quality's Guidelines is the responsibility of the Federal agency that prepared the statement and any comments on its adequacy shall be limited to the Department's jurisdiction or environmental expertise.

(2) Reviews shall be conducted in sufficient detail to insure that both potentially beneficial and adverse environmental effects of the proposed action, including cumulative and secondary effects, are adequately identified. Wherever possible, and within the Department's competence and resources, other agencies will be advised on ways to avoid or minimize adverse impacts of the proposed action and on alternatives to the proposed action that may-have been overlooked or inadequately treated.

(3) Review comments should not capsulize or restate the environmental statement, but should provide clear, concise, substantive, and complete comments on the stated or unstated environmental impacts of the proposed action and, if appropriate, on alternatives to the action. Comments, either positive or negative, shall be objective and constructive.

(4) Departmental Review comments shall be organized as follows:

(a) Control Number The Departmental Review control number shall be typed in the upper lefthand corner below the Departmental seal on the letterhead page of the comments.

(b) Introduction The introductory paragraph shall reference the other Federal agency's Review request, including the date, the type of Review requested, the subject of the Review, and, where appropriate, the geographic location of the subject and the other agency's control number.

(c) General Comments, if any This section will include those comments of a general nature and those which occur throughout the Review which ought to be consolidated in order to avoid needless repetition.

(d) Detailed Comments The format of this section shall follow the organization of the other agency's statement. These comments shall not approve, disapprove, support, or object to proposed actions of other Federal agencies, but shall constructively and objectively comment on the environmental-impact of the proposed action, and on the adequacy of the statement in describing the environmental impacts of the action, the alternatives, and the impacts of the alternatives.

(e) Summary Comments, if any in general, the Department will not take a position on the proposed action of another Federal agency, but will limit its comments to those above. However, in those cases where the Department has jurisdiction by statute, executive order, memorandum of agreement, or other authority the Department may comment on the proposed action. These comments shall be provided in this section and may take the form of support for, concurrence with, concern over, or objection to the proposed action and/or the alternatives.

B. Bureau and Office Comments:

(1) Bureau and office reviews of environmental statements prepared by other Federal agencies are considered informal inputs to the Department's comments and their content will generally conform to paragraph 7.5A of this chapter with the substitution of the bureau's or office's delegated jurisdiction or special environmental expertise for that of the Department.

B. Relationship to Other Concurrent Reviews:

(1) Where the Department, because of other authority or agreement, is concurrently requested to Review a proposal as well as its environmental

statement, the Department's comments on the proposal shall be separately identified and precede the comments on the environmental statement. A summary of the Department's position, if any, on the proposal and its environmental impact shall be separately identified and following the Review comments on the environmental statement.

(2) Where another Federal agency elects to combine other related reviews into the review of the environmental statement by including additional or more specific information into the statement, the introduction to the Department's Review comments will acknowledge the additional Review request and the Review comments will be incorporated -into appropriate parts of the combined statement Review. A summary of the Department's position, if any, on the environmental impacts of the proposal and any alternatives shall be separately identified and follow the detailed Review comments on the - combined statement.

7.6 Availability of Review Comments

A. Prior to the public availability of another Federal agency's final environmental statement, the Department shall not independently release to the public its comments on that agency's draft environmental statement. In accordance with Section 10(f) of the Council on Environmental Quality's Guidelines [516 DM 2, App. A], the agency that prepared the statement is responsible for making the comments available to the public, and requests for copies of the Department's comments shall be referred to that agency. Exceptions to this procedure shall be made only by the Assistant Secretary - Program Policy in consultation with the Solicitor and the Director of Communications.

B. Various internal Departmental memoranda, such as the Review comments of bureaus, offices, task forces, and individuals, which are used as inputs to the Department's Review comments are generally available to the public in accordance with the Freedom of Information Act (5 U.S.C. Section 552) and the Departmental procedures established by 43 C.F.R. 2. Upon receipt of such requests and in addition to following the procedures above, the responsible bureau or office shall notify and consult the Assistant Secretary Program Policy.

7.7 Procedures for Processing Environmental Reviews

A. General Procedures:

(1) All requests for reviews of draft and final environmental statements prepared by or for other Federal agencies shall be received and controlled by the Assistant Secretary - Program Policy.

(2) If a bureau or office, whether: at headquarters or field level, should receive an environmental statement for Review directly from outside of the Department, it should ascertain whether the statement is a preliminary, proposed, or working draft circulated for technical assistance or input in order to prepare a draft statement or whether the statement is in fact a draft environmental statement, or in some cases, a final

statement circulated for official Review.

(a) If the document is a preliminary, proposed, or working draft, the bureau or office should handle independently and provide whatever technical assistance possible within the limits of their resources, to the requesting agency. The response should clearly indicate the type of assistance being provided and state that it does not represent the office's or the Department's review of the draft environmental statement. Each bureau or office should provide the Field Representative and the Assistant Secretary - Program Policy copies of any comments involving significant or controversial issues.

(b) If the document is a draft or final environmental statement circulated for official Review, the bureau or office should inform the requesting agency of the Department's procedures in subparagraph (1) above and promptly refer the-request and the statement to the Assistant Secretary Program Policy for processing.

(3) All bureaus and offices processing and reviewing environmental statements of other Federal agencies will do so within the time limits specified by the Assistant Secretary - Program Policy. From thirty (30) to forty-five (45) days are normally available for responding to other Federal agency Review requests. Whenever possible the Assistant Secretary - Program Policy shall seek a forty-five (45) day waiting period. Further extensions shall be handled in accordance with paragraph 7.7B(3) of this chapter.

(4) The Department's Review comments on other Federal agencies' environmental statements shall reflect the full and balanced interests of the Department in the protection and enhancement of the environment. Lead bureaus shall be responsible for resolving any intra-Departmental differences in bureau or office Review comments submitted to them. The Office of Environmental Project Review is available for guidance and assistance in this regard. In cases where agreement cannot be reached, the matter shall be referred through channels to the Assistant Secretary - Program Policy or to the Field Representative, if appropriate.

B. Processing Environmental Reviews:

(1) The Assistant Secretary - Program Policy has delegated to the Director, Office of Environmental Project Review, the responsibility for distributing and monitoring the Review of all environmental statements referred to the Department by other Federal agencies. In carrying out this responsibility, the Director, Office of Environmental Project Review, shall determine which bureaus and offices will Review the statements, shall designate lead bureaus which shall prepare the Department's comments, shall indicate the intended Signature of the comments, and shall set and monitor Review schedules.

(2) The Office of Environmental Project Review shall secure and distribute sufficient copies of environmental statements for Departmental Review. Bureaus and offices should keep the Office of

Environmental Project Review informed as to their needs for Review copies, which shall be kept to a minimum, and shall develop internal procedures to efficiently and expeditiously distribute environmental statements to reviewing offices.

(3) Reviewing bureaus and offices which cannot meet the Review schedule shall so inform the lead bureau and shall provide the date that the Review will be delivered. The lead bureau shall inform the Office of Environmental Project Review in cases of headquarters-level response, or the Field Representative in cases of field-level response, if it cannot meet the schedule, why it cannot, and when it will. The Office of Environmental Project Review or the Field Representative. shall be responsible for informing the other Federal agency of any changes in the Review schedule.

(4) Reviewing offices shall route their Review comments through channels to the lead bureau, with a copy to the Office of Environmental Project Review. When, in cases, of headquarters-level response, Review comments cannot reach the lead bureau within the established Review schedule, reviewing bureaus and offices shall send a copy marked "Advance Copy" directly to the lead bureau.

(5) In cases of headquarters-level response:

(a) The lead bureau shall route the completed comments through channels to the Office of Environmental Project Review. Copies shall be prepaid and attached for all bureaus and offices from whom Review comments were requested, for the Office of Environmental Project Review, and for the Field Representative when the Review pertains to a project within his geographic jurisdiction. In addition, legible copies of all Review comments received shall accompany the Department's comments through the clearance process and shall be retained by the Office of Environmental Project Review;

(b) The Office of Environmental Project Review shall Review, secure any necessary additional surnames, surname, and transmit the Department's comments to the Assistant Secretary - Program Policy for signature or for his forwarding to another appropriate Secretarial Officer for signature. Upon signature, the Office of Environmental Project Review shall transmit the comments to the requesting agency, and shall reproduce and send ten (10) copies of the signed original to the Council on Environmental Quality.

(6) In cases of field-level response:

(a) The lead bureau shall route the completed comments to the appropriate Field Representative. Copies shall be prepared and attached for all offices from whom review comments were requested and for the Office of Environmental Project Review. In addition legible copies of all review comments received shall be

attached to the Office of Environmental Project Review's copy and to the Field Representative's file copy;

(b) The Field Representative shall Review, sign, and transmit the Department's comments to the agency requesting the Review. In addition he shall reproduce and send ten (10) copies of the signed original to the Council on Environmental Quality and send a copy of the CEQ transmittal memorandum, the Department's comments, and the bureau Review comments to the Office of Environmental Project Review.

(c) If the Field Representative determines in the course of his review of the Department's comments that the Review involves policy matters of Secretarial significance, he shall not sign and transmit the comments as provided in subparagraph (b) above, but shall forward the Review to the Assistant Secretary - Program Policy.

FWS

United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, D.C. 20240

OCT 6 1998

PEP - ENVIRONMENTAL STATEMENT MEMORANDUM NO. ESM98-2

To: Heads of Bureaus and Offices

From: Willie R. Taylor, Director
Office of Environmental Policy and Compliance

Subject: Procedures for Approving and Filing Environmental Impact Statements

1. Purpose and Scope

This memorandum prescribes procedures for filing environmental impact statements (EIS) with the Environmental Protection Agency (EPA). It pertains to both draft and final EISs and both delegated and non-delegated EISs. This memorandum is issued pursuant to 516 DM 4.22. It replaces ESM95-2.

2. Delegated EISs

A delegated EIS is one for which the decision authority on the proposed action rests by delegation with a single Assistant Secretary or a subordinate officer.

3. Non-Delegated EISs

A non-delegated EIS is one for which the decision authority on the proposed action requires the approval of more than one Assistant Secretary (or bureaus under more than one Assistant Secretary), OR is an EIS reserved or elevated to the Secretary (or Office of the Secretary) by expressed interest of the Secretary, Deputy Secretary, the Chief of Staff, the Solicitor or the Assistant Secretary for Policy, Management and Budget, OR is of a highly controversial nature or one in which the Secretary has taken a prominent public position in a highly controversial issue, OR faces a high probability of judicial challenge to the Secretary.

4. Notification

a. As early as possible in the NEPA compliance process for all proposed Departmental programs and projects, a bureau or office will notify the Office of Environmental Policy and Compliance (OEPC) of its determination under Sections 2 and 3. Bureaus will also notify OEPC when EISs are required for proposals where the determination of delegated vs. non-delegated is unclear.

b. The responsible bureau or office decides whether a particular EIS is delegated or non-delegated. OEPC may advise the bureau or office and the Assistant Secretary/Policy, Management and Budget (AS/PMB) on the bureau or office decision.

c. If OEPC does not concur with the determination, OEPC will advise the bureau in writing setting forth its reasons for the non-concurrence. When the determination is unclear, OEPC will advise the bureau in an effort to assist the bureau in making the determination.

d. Bureaus will make this determination no later than the filing of a Notice of Intent (NOI) and/or the conducting of scoping meetings.

e. OEPC will use the Quarterly Report of Environmental Impact Statements (ESM96-3) to track the notification process.

5. Procedures for Delegated EISs

a. Assistant Secretaries, bureaus, or offices, upon approval of a delegated EIS, but before its release to EPA and the public, are to contact OEPC by telephone and inform it of the title of the EIS and the date of its transmittal. The OEPC will assign the document a DOI control number and log it. Control numbers will only be given to authorized bureau personnel involved with the processing of the EIS. Control numbers will not be given to unauthorized persons such as contractors, joint lead agencies, or cooperating agencies. Control numbers should be secured as late as practicable, but prior to filing with EPA. Control numbers shall be stamped or written in ink on the outside cover of all copies transmitted to EPA and Interior bureaus and offices.

b. Before calling for a DOI control number, determine the exact status of the printing job. If the documents are printed and mailed or awaiting mailing from the printer, request a number. If the documents are printed and in transit back to the bureau for mailing, wait until the documents are ready for mailing to request a control number. If the document has not yet been given to the printer, do not request a control number.

c. At the time of transmittal to EPA, Assistant Secretaries, bureaus, and offices will file delegated EISs directly with EPA and publish separate bureau notices of availability in the Federal Register for all draft, final and supplemental EISs. The time period for review in the bureau notice must be consistent with the time period for review in EPA's notice of availability. The time period for review is also governed by ESM94-8. Five (5) copies of the EIS are required by EPA. The EPA will not accept the EIS without the DOI control number.

d. Concurrent with the filing of an EIS with EPA, bureaus are to distribute the document to Federal agencies with jurisdiction by law or special expertise and to State and local agencies, including Indian Tribes, that are authorized to set and enforce related

environmental standards, and to make it available to the public. Upon transmittal, the responsible official will promptly provide two (2) copies to the Department's Natural Resources Library, and four (4) copies to OEPC. In addition, OEPC will be furnished a copy of the transmittal letter to EPA and the bureau Federal Register notice.

e. Circulation to Interior bureaus will take place in accordance with ESM98-3.

f. Circulation to other Federal and State agencies is governed by ESM94-3.

6. Procedures for Non-Delegated EISs

a. Non-delegated EISs must be approved and filed with EPA by the AS/PMB. The AS/PMB has assigned this responsibility to OEPC.

b. Bureaus are encouraged to consult early with OEPC in scheduling and preparing these documents to avoid delays in their approval. The OEPC is available for guidance and associated review of preliminary drafts (or portions of drafts) at headquarters and, subject to the availability of resources, at OEPC's or bureau field offices. This advance consultation and coordination with OEPC will facilitate granting clearances to print documents with a minimum of formal correspondence and associated processing and mailing delays.

c. A clearance to print is OEPC's substantive approval of non-delegated EISs. It generally takes the form of a memorandum from the bureau to the Director, OEPC requesting a clearance to print. A concurrence line is provided at the bottom for the Director's signature. Once signed, OEPC will provide a fax transmission of the document so printing may commence. An example is shown in Attachment 1.

This can be by telephone.

d. Where adequate, early consultation and coordination is not achieved with OEPC, bureaus will transmit proposed EISs to OEPC for review and approval. This should be done concurrently with any bureau headquarters review. Bureaus should allow at least 2 weeks for OEPC's review, comment, and approval. In such cases, bureaus will also provide in their preparation schedules sufficient time to accommodate comments by OEPC.

e. In order to file non-delegated EISs with EPA, bureaus will forward, through their Assistant Secretary to OEPC:

a transmittal letter (Attachment 2)
a notice of availability (Attachment 3)
a draft press release (if required by any Interior process), and
five (5) printed copies of the EIS.

The transmittal letter, upon signature by the Director of OEPC, is the official document

signifying AS/PMB approval. After signature, a bureau may hand carry it and five (5) copies of the EIS to EPA and the notice of availability to the Federal Register if it so chooses; otherwise OEPC will mail them. The notice of availability must be in the form of three originals with the OEPC original signature and date on each.

f. A DOI control number will also be obtained by the same method outlined in Part 5.a. and b. above.

g. Concurrent with the filing of an EIS with EPA, bureaus are to distribute the document to Federal agencies with jurisdiction by law or special expertise and to State and local agencies, including Indian Tribes, that are authorized to set and enforce related environmental standards, and to make it available to the public. In addition, bureaus will provide two (2) copies to the Department's Natural Resources Library, and four (4) copies to OEPC for its distribution and files.

h. Circulation to Interior bureaus will take place in accordance with ESM98-3.

i. Circulation to other Federal and State agencies is governed by ESM94-3.

Attachments

Attachment 1

To: Director, Office of Environmental Policy and Compliance
Department of the Interior, MS 2340 MIB

From: (Authorizing Officer for the EIS)

Subject: Request for Approval to Print the Draft (*or Final*) Environmental Impact Statement for the ...

In accordance with PEP Environmental Statement Memorandum ESM 98-2, we request clearance to print the subject draft (*or final*) environmental impact statement. Please document this approval by signing the "concur" line below and returning the signed memorandum to this office.

(*Any additional information may be given here.*)

The draft (*or final*) environmental impact statement for the ... is approved for printing.

Concur:_____ Date:_____
Director, Office of Environmental
Policy and Compliance

Note:	This attachment may be updated as necessary without re-issuing the entire ESM.

Revision by
Terry Martin (OEPC)
3/22/00

Attachment 2

US Environmental Protection Agency
Office of Federal Activities
EIS Filing Section
Mail Code 2252-A, ~~Room 7241~~
~~Ariel Rios Building (South Oval Lobby)~~ 401 M ST., SW
~~1200 Pennsylvania Avenue~~
Washington, D.C. 20460 ~~20460~~

Dear Sir or Madam:

In compliance with Section 102(2)(C) of the National Environmental Policy Act of 1969 and in accordance with 40 CFR 1506.9, we are enclosing five (5) copies of a (*draft/final*) environmental impact statement for (*title of proposal*). This statement was prepared by the (*bureau*).

This EIS has been transmitted to all appropriate agencies, special interest groups, and the general public. The official responsible for the distribution of the EIS and knowledgeable of its content is (*name and phone number*).

Sincerely,

Willie R. Taylor
Director, Office of Environmental
Policy and Compliance

Enclosures

Note: If you are hand delivering your EIS, you will make your delivery to:

US Environmental Protection Agency
Office of Federal Activities
EIS Filing Section
Mail Code 2252-A, Room 7241
Ariel Rios Building (South Oval Lobby)
1200 Pennsylvania Avenue
Washington, D.C. 20460

Please check in with the building guard and call the EIS Filing Section on 202-564-2400.

Note:
1. This attachment may be updated as necessary without re-issuing the entire ESM.
2. The date of this attachment is March 23, 2000.

Revison by,
Terry Martin (OEPC)
10/19/99.

Attachment 3

DEPARTMENT OF THE INTERIOR
(*BUREAU*)

Notice of Availability of (*Draft/Final*) Environmental Impact Statement

AGENCY: (*Bureau*), Department of the Interior

ACTION: Notice of availability of a (*draft/final*) environmental impact statement (EIS) for the proposed (*title*)

*DATE: Comments will be accepted until (*date*)

*ADDRESSES: If you wish to comment, you may submit your comments by any one of several methods. You may mail comments to (*office name and address*). You may also comment via the Internet to (*office Internet address*). Please submit Internet comments as an ASCII file avoiding the use of special characters and any form of encryption. Please also include "Attn: (*any identifying names or codes*)" and your name and return address in your Internet message. If you do not receive a confirmation from the system that we have received your Internet message, contact us directly at (*office contact and phone number*). Finally, you may hand-deliver comments to (*office street address*). Our practice is to make comments, including names and home addresses of respondents, available for public review during regular business hours. Individual respondents may request that we withhold their home address from the record, which we will honor to the extent allowable by law. There also may be circumstances in which we would withhold from the record a respondent's identity, as allowable by law. If you wish us to withhold your name and/or address, you must state this prominently at the beginning of your comment. ~~However, we will not consider anonymous comments.~~ We will make all submissions from organizations or businesses, and from individuals identifying themselves as representatives or officials of organizations or businesses, available for public inspection in their entirety.[1]

FOR FURTHER INFORMATION CONTACT: (*office and address*)

SUPPLEMENTAL INFORMATION: A limited number of individual copies of the EIS may be obtained from (*the above contact or wherever*).

---

[1]This recommended text has its source in Alliance for the Wild Rockies, et al. v. Department of the Interior, et al., Civil No. 98-2912 (D.D.C., June 23, 1999). Its use is recommended by SOL memorandum dated August 20, 1999, and transmitted to NEPA contacts by OEPC memorandum dated September 10, 1999.

Copies are also available for inspection at the following locations:

** A public (*hearing/meeting*) will be held on the proposal on (*dates and locations*).

(*Include any other pertinent information which will assist the public.*)

Date

Willie R. Taylor
Director, Office of Environmental
Policy and Compliance

* Include only for draft EIS
** Include if appropriate to this notice

Note:
1. This attachment may be updated as necessary without re-issuing the entire ESM.
2. The date of this attachment is October 18, 1999.

United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, D.C. 20240

FEB 24 2000

PEP - ENVIRONMENTAL STATEMENT MEMORANDUM NO. ESM00-2

To: Heads of Bureaus and Offices

From: Willie R. Taylor, Director
Office of Environmental Policy and Compliance

Subject: EIS Filing Address Information for EPA

The Environmental Protection Agency's Office of Federal Activities has recently revised its mailing and hand delivery address for environmental impact statements.

The address is now:

US Environmental Protection Agency
Office of Federal Activities
EIS Filing Section
Mail Code 2252-A, Room 7241
Ariel Rios Building (South Oval Lobby)
1200 Pennsylvania Avenue, NW
Washington, DC 20460

If hand delivery is made, please check in with the building guard and call the EIS Filing Section on 202-564-2400 for verification and an escort to the filing office.

This information is currently located on the Internet at:
http://es.epa.gov/oeca/ofa/fileadmi.html. It is recommended that bureaus check Internet sites periodically to see if the addresses are still valid. OEPC will issue notices of Internet site changes as it becomes aware of them. Internet site changes must be made in ink and dated on the ESM.

Please circulate this information to all within your bureau who routinely file EISs with EPA.

This memorandum replaces ESM96-2, dated March 21, 1996.

3/28/00

HANDBOOK ON

DEPARTMENTAL REVIEW OF

SECTION 4(f) EVALUATIONS

Department of the Interior
National Park Service
U.S. Fish and Wildlife Service
Office of Environmental Policy and Compliance
Washington, DC 20240

February 2002

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PURPOSE

This handbook provides guidance in the review of and the preparation of Interior Department comments on Section 4(f) evaluations prepared by the U.S. Department of Transportation (DOT) and its modal administrations. The main modal administrations in DOT are the Federal Highway Administration (FHWA), the Federal Aviation Administration (FAA), the U.S. Coast Guard (USCG), the Federal Railroad Administration (FRA), and the Federal Transit Administration (FTA) (formerly the Urban Mass Transit Administration). Section 4(f) of the Department of Transportation Act of 1966 provides significant authority to the Secretary of the Interior to seek the protection of public (federal and non-federal) recreational lands, including parks and wildlife refuges, in the planning of DOT proposals.

SECTION 4(f) DEFINED

STATUTORY MANDATE: Section 4(f) of the Department of Transportation Act, as amended, now resides in the United States Code at 49 U.S.C. 303. It states:

> Sec. 303. Policy on lands, wildlife and waterfowl refuges, and historic sites
>
> (a) It is the policy of the United States Government that special effort should be made to preserve the natural beauty of the countryside and public park and recreation lands, wildlife and waterfowl refuges, and historic sites.
>
> (b) The Secretary of Transportation shall cooperate and consult with the Secretaries of the Interior, Housing and Urban Development, and Agriculture, and with the states, in developing transportation plans and programs that include measures to maintain or enhance the natural beauty of lands crossed by transportation activities or facilities.
>
> (c) The Secretary may approve a transportation program or project (other than any project for a park road or parkway under Section 204 of Title 23) requiring the use of publicly owned land of a public park, recreation area, or wildlife and waterfowl refuge of national, state, or local significance, or land of an historic site of national, state, or local significance (as determined by the federal, state, or local officials having jurisdiction over the park, area, refuge, or site) only if -
>
> (1) there is no prudent and feasible alternative to using that land; and
>
> (2) the program or project includes all possible planning to minimize harm to the park, recreation area, wildlife and waterfowl refuge, or historic site resulting from the use.

REGULATORY DEFINITION: The DOT regulations in the Code of Federal Regulations, at 23 CFR 771.107(e), define "Section 4(f)" as follows:

Section 4(f) refers to 49 U.S.C. 303 and 23 U.S.C. 138.

The following footnote was given, and it is repeated here for historical information to support the common use of the term "Section 4(f)."

> Section 4(f), which protected certain public lands and all historic sites, technically was repealed in 1983 when it was codified, without substantive change, as 49 U.S.C. 303. This regulation continues to refer to section 4(f) because it would create needless confusion to do otherwise; the policies section 4(f) engendered are widely referred to as "section 4(f)" matters. A provision with the same meaning is found at 23 U.S.C. 138 and applies only to FHWA actions.

ADMINISTRATIVE BACKGROUND

NATIONAL ENVIRONMENTAL POLICY ACT AND SECTION 4(f): With the exception of those laws and regulations that apply solely to DOT, this handbook may also apply to documents prepared by other federal agencies. This handbook also applies to the review of environmental impact statements (EISs) and environmental assessments (EAs) that may be included with Section 4(f) evaluations. Review of and comment on an EIS or EA/Section 4(f) evaluation should be in accord with instructions in the Department of the Interior (Interior) Manual, Part 516, Chapter 7 (516 DM 7).

The contents of an EIS or EA/Section 4(f) evaluation should comply with the provisions of the National Environmental Policy Act (NEPA) (PL 91-190, as amended) Council on Environmental Quality (CEQ) Regulations (40 CFR Parts 1500–1508), Section 4(f) of the Department of Transportation Act (49 U.S.C. 303), and the combined regulations of the FHWA and the FTA (23 CFR 771.101–771.137). Also applicable are the DOT Section 4(f) Policy Paper (revised June 7, 1989), the Department of the Interior Environmental Review Memorandum No. ERM94-4 (see appendix A), the Guidance on the Preparation and Processing of Environmental and Section 4(f) Documents (October 30, 1987), the FRA's Procedures for Considering Environmental Impacts (May 26, 1999), and the FAA's Airport Environmental Handbook (FAA Order 5050.4A, October 8, 1985). Copies of these documents are available on the Internet at the DOT Web site: http://www.dot.gov, which offers both DOT and modal administration search capabilities to locate the appropriate documents. The reader should remain current on the location of these documents because Internet addresses, as well as the information available at the addresses, can be updated periodically.

Interior's Office of Environmental Policy and Compliance (OEPC) manages the review and commenting process through its environmental review system. This system includes assignment of lead bureaus, reviewing bureaus, and review schedules. CEQ regulations cite two instances when an agency should review and comment on an EIS: jurisdiction by law or special expertise. The regulations are binding on all federal agencies.

The National Park Service (NPS) usually serves as Interior's lead bureau for preparing the Department's comments on projects that may affect units of the National Park System, other public park and recreation resources, historic and archeological properties, and unique natural areas. Because these resources may have important fish and wildlife resources, the Fish and Wildlife Service (FWS) should provide to the NPS, as appropriate, its views related to NEPA compliance, the Fish and Wildlife Coordination Act (FWCA), the Endangered Species Act (ESA), and other laws and executive orders.

The FWS is usually designated as lead bureau for projects involving fish and wildlife refuges, dedicated wetlands, and similar areas. However, because refuges often involve recreational uses and values, the NPS should provide its views to the FWS on Section 4(f) issues involving refuges.

When the Bureau of Land Management (BLM), the Bureau of Reclamation (BR), or the Bureau of Indian Affairs (BIA) is made the lead bureau for a project involving Section 4(f) lands under its direct jurisdiction, the bureau should actively solicit the views of the FWS and the NPS if they have not already been provided. As a practical matter, however, these three bureaus are seldom involved in Section 4(f) matters and are very rarely named lead bureau.

Some Section 4(f) reviews involve lands and areas of interest to more than one Interior bureau—for example, a park and a refuge, or a refuge and a historic site. The lead bureau in these cases must ensure that the views of all bureaus are considered for incorporation in the Department's comments. The lead bureau must also perform its lead role *even if it has no comments of its own*. Sometimes intra-Departmental conflicts arise. These conflicts must be resolved before a Departmental letter is finalized. The following general procedures apply:

- The field level official of the lead bureau resolves conflicts through inter-bureau discussions. If unsuccessful, then,
- OEPC's regional environmental officer resolves conflicts through regional level coordination. If unsuccessful, then,
- The lead (or any other) bureau refers the case to OEPC headquarters through its Washington office.

The OEPC is always available for informal consultations at any stage of the process. Attempts at resolution should be documented in the package sent to the OEPC. The OEPC's distribution memorandum and the comments of other Interior bureaus must be on hand when the Departmental letter of comment is prepared. If the comments of any bureau are not on hand, the bureau should be contacted by telephone and the call documented. *Original bureau comments must accompany the draft Departmental comments through the process for final review and signature by the OEPC.*

PERTINENT LEGISLATION: Reviewers should be aware of and know how to locate and apply

information on pertinent legislation and regulations such as (but not limited to) the following:

- National Historic Preservation Act of 1966, as amended, and its implementing regulations at 36 CFR 800, revised on June 17, 1999;
- Fish and Wildlife Coordination Act 16 U.S.C. 661-667;
- Endangered Species Act and implementing regulations for interagency consultation at 50 CFR 402;
- National Environmental Policy Act and implementing regulations at 40 CFR 1500-1508; and
- Department of Transportation Act and implementing regulations at 23 CFR 771.

SECTION 4(f) PROPERTIES UNDER THE DEPARTMENT'S JURISDICTION

ACCEPTED SECTION 4(f) PROPERTIES: It is important that reviewers familiarize themselves with Interior Department Environmental Review Memorandum ERM94-4 containing the Secretary of the Interior's letter of June 20, 1980, to the Secretary of Transportation (see appendix A). The Secretary's letter details Interior's jurisdiction in Section 4(f) matters. The letter declares that Interior jurisdiction extends to any public park, recreation area, or wildlife and waterfowl refuge within the scope of the Department's statutory responsibilities and that these responsibilities extend to certain state or locally owned parks, recreation areas, or wildlife and waterfowl refuges. In addition, the Department's jurisdiction extends to sites that the Department determines to be of national, state, or local historic significance, regardless of ownership under the National Historic Preservation Act.

Accordingly, Interior has declared the following listed lands as being significant parks, recreation areas, wildlife and waterfowl refuges, and historic sites, and has stated its opinion that Section 4(f) applies to them for any use by DOT. The following list was developed consistent with the advice of the Department of the Interior's solicitor. However, the list may not be exhaustive, and there may be other areas that have been inadvertently omitted or that may need to be evaluated on a case-by-case basis. The DOT Section 4(f) Policy Paper (revised June 7, 1989) must also be consulted in these matters. Issues where the Department may still be in conflict with DOT should be brought to the attention of the OEPC and the solicitor's office as necessary for final decision.

- Lands of the National Park System.
- National Park Service "Affiliated Areas."
- Lands of the National Wildlife Refuge System.
- Lands of the National Fish Hatchery System.
- Lands acquired for mitigation purposes pursuant to the authority of the Fish and Wildlife Coordination Act, including general plan lands under Section 3(b) of that act.
- Lands under the jurisdiction of the Bureau of Reclamation that are administered as parks, recreation areas, wildlife refuges, or historic sites.

- Lands under the jurisdiction of the Bureau of Land Management that are administered for recreation, cultural, and wildlife purposes.
- Indian lands held in trust by Interior as parks, recreation areas, wildlife refuges, or historic sites.
- Local and state lands, and interests therein, and certain federal lands under lease to the states, acquired or developed in whole or in part with moneys from the Land and Water Conservation Fund (LWCF).
- Recreation areas and facilities developed or improved, in whole or in part, with grants under the Urban Park and Recreation Recovery Act of 1978 (Title 10 of PL 95-625).
- State lands and interests therein acquired or developed or improved with federal grants for fish and wildlife conservation, restoration, or management such as the Federal Aid in Sport Fish Restoration Act of 1950 (Dingell-Johnson Act), the Federal Aid in Wildlife Restoration Act of 1937 (Pittman-Robertson Act), and the Anadromous Fish Act of 1965.
- Federal surplus real property that has been deeded to state and local governments for park, recreation, wildlife, and historic purposes.
- Abandoned railroad rights-of-way acquired by state and local governments for recreational or conservation uses under Section 809(b) of the Railroad Revitalization and Regulatory Reform Act of 1976.
- Properties listed on or eligible for inclusion in the National Register of Historic Places.
- Areas publicly owned in fee, less than fee, lease, or otherwise, that receive de facto use as park, recreation, or refuge lands. De facto use is determined on a case-by-case basis by the Interior bureau having statutory or program jurisdiction over or interest in the land in question. In the case of Indian trust lands, such determination will be made in consultation with the appropriate tribal officials. De facto use may also include publicly owned lands or interest therein proposed or under study for inclusion in the National Wild and Scenic Rivers System, the National Trails System, or the National Wilderness Preservation System, or as critical habitat for endangered or threatened species. Early coordination with Interior about the applicability of Section 4(f) is especially important whenever lands administered by the Bureau of Reclamation or the Bureau of Land Management, or Indian trust lands administered by the Bureau of Indian Affairs**,** are affected by DOT projects.

All of the lands listed above may also contain significant, but presently unknown or undesignated, historic or archeological sites or properties that fall under the protection of Section 4(f). This matter will be determined on a case-by-case basis by the administering bureau/tribal officials in consultation with the state historic preservation officer (SHPO) (or others with historical expertise). Coordination of this matter with Interior is, therefore, essential. Such coordination with respect to Section 4(f) should be undertaken in addition to (although it may be concurrent with) any coordination that may be required under Section 106 of the National Historic Preservation Act. It should be noted, however, that each law is independent of the other.

PROPERTIES TO WHICH SECTION 4(f) MAY APPLY: For some other properties, Interior

has no direct or program jurisdiction; for others, Interior and DOT disagree as to the applicability of Section 4(f). In general, Interior believes these properties should receive Section 4(f) protection. Surface waters associated with these lands are also subject to Section 4(f). DOT, however, does not recognize historic sites of state and local significance as automatically falling under the protection of Section 4(f), unless such sites are also on or eligible for the National Register. The responsible DOT official may, at his or her discretion, apply Section 4(f) to such historic sites, but this is not mandatory. Such application of Section 4(f) may require further discussion among the NPS, the OEPC, the Office of the Solicitor, and the SHPO.

The following are some common 4(f) problem areas that reviewers have encountered. The list is not all-inclusive. Such problems should be resolved on a case-by-case basis, with frequent reference to the DOT Section 4(f) Policy Paper:

Private Lands: Private lands leased by governmental entities and operated as community parks and recreation areas may fall under the protection of Section 4(f). Factors such as lease conditions, significance, and use of the area must be considered in determining the application of 4(f). At the very least, reviewers should recommend special attention for such areas and request Section 4(f) consideration by DOT.

Public School Property: Public school property serving only as a recreation area for a school is not covered by Section 4(f). However, an area that is open to general public use, and that serves the recreational needs of the community as well as the school, is covered by Section 4(f), if it is found to be significant by the officials having responsibility for providing recreation opportunities to the community.

Private School Property: Private school property that receives public financial assistance in return for public recreational use of that property may be subject to Section 4(f). Applicability depends on conditions of the lease and other circumstances. Therefore, all the necessary facts with appropriate analysis must be assembled for any private school case in which Section 4(f) may be applicable.

Fairgrounds: Fairgrounds or portions of them that are open to the general public as a community park, recreation area, or similar area are generally considered to be under Section 4(f) protection.

Public Open Space: Public open spaces will fall under the protection of Section 4(f) when they are part of a park or recreation area, a historic site, or a wildlife area and local park and recreation officials have determined them to be significant.

State Game Lands: Interior believes that all state lands and interests therein acquired or developed or improved for fish and wildlife conservation, restoration, or management with grants under the Pittman-Robertson Act, the Dingell-Johnson Act, Section 6 of the Endangered Species Act of 1973, or the Anadromous Fish Act of 1965 (including, but not limited to, state fish hatcheries, state wildlife conservation areas, and state game lands) are protected by Section

4(f). However, the final decision on applicability lies with DOT. In making its determination, DOT will rely on the official having jurisdiction over the lands to identify the kinds of activities and functions that take place. The FWS will normally be Interior's lead bureau for these involvements.

Wetlands Easements: Wetlands easements lands are acquired pursuant to the Act of March 16, 1934, as amended, 48 Stat. 451, 16 U.S.C. 718 (1970), and administered by the FWS. Interior considers wetlands easements protected under Section 4(f). The FWS will normally be the lead for these involvements.

Floodplains: Floodplains are not 4(f) areas unless otherwise designated as park and recreation lands or wildlife refuges under other authority.

Projects Involving Highway Rights-of-Way Temporarily Used for Park Purposes: These lands should include sufficient documentation to show that the affected parkland is within the highway right-of-way. The deed and accompanying maps drawn at the time the right-of-way was acquired will usually provide satisfactory evidence. If the deed is not available and the exact boundary cannot be determined from existing records, the highway agency should carry out sufficient design work to address the parkland taking and involvement, including an on-the-ground finding to support the fact that no parkland will be taken outside the designated right-of-way. Measures to minimize harm in such cases should include removal or relocation of facilities that may be involved, fencing, noise abatement, landscaping, and access. Measures should be coordinated with and approved by the park authority, and implemented at project expense. Evidence to that effect should be included in the final statement.

National Forest Lands: Usually Interior does not involve itself in national forest/4(f) matters after the Forest Service (FS) makes a decision that Section 4(f) is not applicable to national forest lands that are affected by transportation projects. However, Interior should make an independent evaluation of the park, recreational, or refuge values of the area in question, and as appropriate request DOT and the FS to reevaluate their position.

Wild and Scenic Rivers: In general, rivers under study for designation as wild and scenic rivers are not subject to Section 4(f), but publicly owned parks, recreation areas, refuges, and historic sites within their corridors would be. Publicly owned waters of designated wild and scenic rivers are protected by 4(f). Publicly owned lands within immediate proximity of such rivers may be protected by 4(f). Refer to the DOT Section 4(f) Policy Paper (revised June 7, 1989).

SECTION 4(f)/SECTION 106 INVOLVEMENTS

Environmental statement/Section 4(f) evaluations should document actions taken to preserve and enhance districts, sites, buildings, structures, and objects of historical, archeological, architectural, or cultural significance. Reviewers should, therefore, familiarize themselves with Section 106 of the National Historic Preservation Act as it pertains to these properties.

Section 4(f) requires a more rigorous level of consideration for historic properties than does Section 106. Section 106 requires only that effects on historic properties be considered and that the SHPO or the tribal historic preservation officer, as well as the Advisory Council on Historic Preservation (ACHP) if necessary, be afforded the opportunity to comment. Section 4(f), in contrast, requires that historic properties be used only if there is no feasible and prudent alternative.

Although transportation agencies often contend that Section 4(f) and Section 106 compliance duplicate each other, we do not agree. We do, however, favor concurrent compliance and processing under both laws. Field reviewers should recommend (during early coordination) the circulation of a draft environmental document (EA/EIS) with a combined preliminary Section 106 case report/Section 4(f) evaluation. When an EA/EIS is not required, the combined 106/4(f) document will suffice. Such draft documents must discuss proposed mitigation, and may include a *proposed* memorandum of agreement (MOA). The SHPO and Interior will then make their *independent* comments on the combined document. The final EIS or the final 4(f)/106 documentation would then include DOT's 4(f) approval determination and an executed MOA, or otherwise indicate disposition of the case.

A rather special case is presented by archeological sites, some of which are significant only or primarily because they contain information that can be fully extracted through a data recovery program. Recently revised regulations of the ACHP have resulted in changes to the Section 106 process so that when a site is excavated, the effect on the site is considered adverse without exception. The FHWA's procedures for considering impacts to archeological sites and the relationship to Section 106 are generally described at 23 CFR 771.135.

ORGANIZATION AND CONTENT OF DEPARTMENTAL COMMENT LETTERS

The following sections provide a standard format for Section 4(f) letters and EIS/4(f) letters. It is advisable to use this format so as to ensure that all 4(f) considerations are accounted for and processed.

COMMON LETTER CONTENT: The content of a Departmental letter of comment on environmental statement/Section 4(f) evaluations may have several major sections: general comments, Section 4(f) evaluation comments, environmental statement comments, Fish and Wildlife Coordination Act comments, and summary comments. Sections dealing with other specific laws, such as Section 6(f) of the Land and Water Conservation Fund Act, the Fish and Wildlife Coordination Act, or the Endangered Species Act, should be added if applicable.

Addressee: The letter must be addressed to the appropriate federal official, with a copy to the state, local, or other sponsor (if any exists). The address should be on the first page at the upper left-hand corner of the letter. The OEPC control number should also appear at the upper left-hand corner of the letter under the Departmental seal. The second and succeeding pages of the

letter should carry a header with the name of the addressee, exactly as it is shown on the first page, flush with the left margin and the page number located to the right in the same header. The complimentary close, "Sincerely," should be two lines below the last line of the letter and slightly to the right of center. If the signatory is known, type the signatory's name five lines below the complimentary close, with title below the name. Material accompanying a letter should be identified in the text, with a notation at the end indicating an enclosure. When a copy of the letter is being sent to someone other than the addressee, note this fact at the lower left hand corner under the signature and include each recipient's full address(es).

Project Identification: Generally, the initial paragraph should read something like this: "This letter is in response to your recent request for the Department of the Interior's comments on the (type of document received) for the (include project identification exactly as it appears in the OEPC's distribution memorandum)."

Reviewers should independently check project identification. Reviewers should also check type of review—for example, do not identify the review as a draft environmental statement/Section 4(f) evaluation unless a 4(f) evaluation is actually included. The OEPC frequently distributes a draft EIS for Interior 4(f) comments when the DOT agency does not recognize a 4(f) involvement. These are referred to as having a potential 4(f) involvement. In these cases, cite the document only as a draft EIS. Always include the project name, the county, and the state. The name of the city or town may be included if appropriate.

GENERAL COMMENTS: This section may contain comments of a general nature, and any that occur throughout the document should be consolidated to avoid needless repetition. Some examples are segmentation, scoping, coordination, maps, and graphics. The Section 4(f) and EIS sections of the letter may also contain a "General" section if it is appropriate to those sections.

Segmentation: Segmentation refers to the subdivision of a large project into smaller projects. NEPA requires that actions covered by an environmental statement should have independent significance and must be broad enough in scope to avoid subdivision of the project and to ensure meaningful consideration of alternatives. Segmentation can result in a lessening of the severity of a project's impact. While reviewers should be alert to this problem, they should raise the issue only if they can substantiate it and only if it obviously affects the interests of Interior.

Scoping and Early Coordination: Scoping and early coordination at the beginning of the location study can assist in identifying park and recreation, natural, and cultural areas of significance; agency and public concerns; and the need for preparation of environmental statements. Reviewers should determine whether scoping and early coordination with park and recreation bureaus having jurisdiction over the Section 4(f) lands involved has occurred. They should also check the list of agencies that have been requested to review the draft environmental statement. If, for instance, the SHPO has been consulted, the SHPO's comments should be included in the statement.

Maps and Graphics: Some statements provide only small-scale maps and very little other graphic information about a proposed project and the land uses within the transportation corridor. Other statements have more extensive graphics such as current U.S. Geological Survey maps, aerial photographs, photo mosaics, and orthophoto maps. Property boundaries showing major land uses (i.e., farm lands, park areas, residential areas) are often superimposed on these maps and graphics. Width of right-of-way can be shown on these maps, including a general right-of-way taking of land for interchange areas or for specific areas where there would be need for extensive cuts or fills. Reviewers should encourage the use of well-labeled maps and graphics in environmental statements. When necessary, we can always request more detailed boundary and right-of-way maps for specific 4(f) areas, which are especially important to have when discussing measures to minimize harm to Section 4(f) lands.

SECTION 4(f) EVALUATION COMMENTS:

General Comments: The first paragraph under Section 4(f) may include general comments as to the adequacy or inadequacy of the Section 4(f) submission. These may include concerns of a general nature, such as involvement under Section 6(f) or Section 7 of the LWCF Act, controversy over FS lands, or conflicts with the Wild and Scenic Rivers Act, the National Trails Act, the Federal Surplus Property Act, and others. We may review projects for which the DOT agency does not recognize, or rejects outright, the application of Section 4(f). This section would be a good place to address our differences with DOT about the application of 4(f), the use of 4(f) lands, determinations of significance, and other matters that may be needed to address the document's compliance with the requirements of DOT's 4(f) regulations.

Specific Comments:

Preliminary Section 4(f) Documents: Interior's Section 4(f) comments are provided on a clearly identifiable Section 4(f) document that discusses alternatives and measures to minimize harm. This may appear in a combined environmental statement/Section 4(f) evaluation or as a separate Section 4(f) document circulated for review and comment. However, there are instances where only *preliminary* Section 4(f) comments may be appropriate. Preliminary 4(f) comments are provided to give the sponsor an early indication of Interior's thoughts about the Section 4(f) information and involvements associated with a proposed project. In cases of this nature, we should make clear that the comments provided are preliminary and do not represent the results of formal consultation by DOT with Interior, pursuant to the consultative requirements of Section 4(f), and that this requirement will be fulfilled only when the Secretary of the Interior comments on a Section 4(f) document that may be prepared and approved by DOT for circulation. Normally, preliminary comments are provided in two kinds of cases: the case of environmental statements that have no identifiable Section 4(f) involvements but that Interior believes may involve Section 4(f) lands, or the case where the sponsor specifically asks for preliminary Section 4(f) comments before the circulation of a Section 4(f) document.

Alternatives and Their Impacts on Section 4(f) Lands: Section 4(f) requires a finding that there

is *no* feasible and prudent *alternative to the proposed use of the 4(f) property*. We must make an initial determination in writing that we concur (or do not concur). If we do not concur, we must state why.

CEQ regulations, as well as DOT Section 4(f) regulations, require rigorous exploration and objective evaluation of alternative actions that would avoid all use of Section 4(f) areas and that would avoid some or all adverse environmental effects. Analysis of such alternatives, their costs, and the impacts on the 4(f) area should be included in draft NEPA documents. In addition to the general CEQ regulation, the reviewer should be familiar with the specific 4(f) requirements of 23 CFR 771 and other regulations of DOT's modal administrations. The reviewer should consider applying the *Overton Park* criteria (*Citizens to Preserve Overton Park v. Volpe*, 401 U.S. 402 (1972)) to the analysis of alternatives, but in so doing should also reasonably apply the dictates of sound land use planning in accepting or rejecting alternatives. The criteria that the Supreme Court established in the *Overton Park* case stipulate that Section 4(f) lands are "…not to be lost unless there are truly unusual factors present…or…the cost of community disruption resulting from alternative routes reaches extraordinary magnitudes." If not satisfied with an analysis of alternatives, the reviewer should explain the reasons in detail or request additional information and data essential for comparing alternatives. Reviewers can always suggest alternatives of their own, for evaluation by the project proponent, and not confine their comments to the alternatives presented in the statement.

If, on the other hand, the reviewer is satisfied that all alternatives have been thoroughly examined by the sponsor and the federal agency and there is no feasible and prudent alternative to the taking of Section 4(f) lands, simply say: "We concur that there is no feasible and prudent alternative to the proposed use of (insert name of 4(f) area to be used)."

In dealing with alternatives, reviewers should avoid using the phrase "based on the information provided in the document." It is appropriate to use this phrase only in cases where we might have a thought about another alternative but are not prone to promote it for whatever reason. Unless this is the situation, this phrase should not be used. Also avoid using wording such as the "most" feasible and prudent alternative.

Measures to Minimize Harm to Section 4(f) Lands: The second phase of a 4(f) review is to ensure that all possible planning has been done to minimize harm to Section 4(f) lands. This is often the most important phase and the one where we can be most effective because of our special expertise in the protection and management of all types of 4(f) areas.

The following is a partial list of the kinds of measures that might be taken to minimize harm to Section 4(f) lands and properties:

- Replacement of the Section 4(f) lands to be taken or provision of compensation based on the market value of those lands.

- Horizontal and vertical alignment changes to reduce, if not eliminate, the 4(f) involvement.

- Elevated facility over the site (this may, however, increase aesthetic impacts).

- Depressed facility or tunnel through or under the site (this may increase costs, impacts on ground water, etc.).

- Reduction in the number of travel lanes, parking lanes, and so on, or reduction of median width (use of Jersey-type concrete barrier).

- Access improvement to 4(f) properties to help motorists and pedestrians.

- Access limitation, in some cases, to control induced development and other secondary effects.

- Landscaped buffer zones, noise barriers, and similar measures.

- Appropriate signing and marking of sites to increase public awareness (this may, however, produce aesthetic impacts or increase usage beyond carrying capacity).

- Sensitive aesthetic design of facilities to maintain and enhance ambiance—for instance, compatible architectural design, tinted concrete, special surface textures, stone or brick facings, use of weathering steel, prevention of rust staining on masonry surfaces, and graffiti prevention.

- Adaptive re-use of historic structures.

- Moving and adequate restoration of historic structures on appropriate new sites (this is usually a last-resort measure).

- Adequate recordation and curatorial care of demolished historic structures (this, too, is a last-resort measure).

- Coordination of construction with recreation activities to permit orderly transition and continual usage of Section 4(f) land and facilities.

- Various regulatory measures such as speed limits, traffic capacity limits, and limited access to adjacent lands.

Park and Recreation Areas: Reviewers are alerted that a general statement from the sponsor indicating that the sponsor will comply with all federal, state, and local standards and specifications to minimize harm is not acceptable. Also not acceptable is a statement that all

planning to minimize harm has been done because there is no feasible and prudent alternative. Reviewers should make sure that all possible site-specific planning has been done to identify and list the measures which will be undertaken, at project expense, to minimize harm to Section 4(f) areas.

Replacement of Section 4(f) Lands: Sponsors of transportation projects are responsible for minimizing harm to Section 4(f) lands. These lands may be replaced by the sponsor directly with lands of equivalent usefulness and location, but if monetary compensation is made (for areas not involving LWCF moneys), that compensation should be sufficient to replace the lost lands and improvements thereon. Compensation based on "fair market value" of land taken is not necessarily satisfactory because purchasing areas of reasonable equivalent usefulness and location may require paying more than the appraised value of lost lands.

Monetary Compensation for Use of Section 4(f) Lands Not Involving Land and Water Conservation Fund Moneys: If replacement lands are not available, monetary compensation equal to replacement value may be acceptable. This compensation should be earmarked for capital park and recreation purposes. The conversion of parklands to transportation uses without compensation, or the diversion of monetary compensation received to other uses, constitutes indirect subsidization of the transportation programs by recreation funds. The occurrence of either should give rise to serious reservation about the advisability of approving future federal grant applications for park and recreation purposes to the agency responsible. Reviewers should always keep in mind that from a strict 4(f) viewpoint, land replacement is simply one of the most logical methods to minimize harm.

Constructive Use: Constructive use occurs when transportation projects do not incorporate land from a Section 4(f) property but due to their proximity impacts are so severe that the protected activities, features, or attributes that qualify a resource for protection under Section 4(f) are substantially impaired. Constructive use remains a general issue between Interior and DOT because of its very subjective nature. However, the level, nature, and extent to which an area is constructively used should be subject to the expertise and determination of the agency responsible for management and administration of the parkland impacted by the constructive use. When constructive use is an issue in a particular project review, the reviewer is advised to consult 23 CFR 771.135(p); the DOT Section 4(f) Policy Paper; the October 5, 1987, FHWA letter from Eugene W. Cleckley to Bruce Blanchard (see appendix C); and the November 12, 1985, FHWA memorandum to regional FHWA administrators (see appendix D). These documents will provide background upon which to formulate comments on the review.

Projects Involving Section 6(f) of the LWCF Act: Section 6(f) provides, in part, that "…no property acquired or developed with assistance under this section shall, without the approval of the Secretary, be converted to other than public outdoor recreation uses. The Secretary shall approve such conversion only if he finds it to be in accord with the then existing comprehensive statewide outdoor recreation plan and only upon such conditions as he deems necessary to assure the substitution of other recreation properties of at least equal fair market value and reasonable

equivalent usefulness and location."

When a project results in a change in use of an LCWF-assisted park or recreation area, a determination has to be made, first by the state and ultimately by the NPS, as to whether a Section 6(f) involvement will result. If a Section 6(f) involvement will result and the NPS, under its delegated authority, is willing to consider approval of the conversion, then it is mandatory to acquire replacement land. *Only land will satisfy the provisions of Section 6(f). The value of new capital improvements or a reimbursement to the LCWF are not acceptable.* If the subject lands are considered part of the LWCF project scope, the NPS would generally consider a conversion of use to occur if one of the following actions were to be taken:

- Granting by the participant to another party either control or partial control of the land that would result in uses other than public outdoor recreation as approved by the NPS. Examples would be the construction and maintenance of a utility line, pipeline, irrigation ditch, road, or other similar facility, whether the intrusion is above or below ground level. A possible exception could occur if the participant, without relinquishing any control over the area, were to allow a non-owner to construct a subsurface water line, pipeline, underground utility, or similar facility that would not impair the present and future recreational use of the property and then to restore the surface area to its preconstruction condition.

- Constructing or installing structures or facilities by the project sponsor or others on lands considered within the project scope that would not be compatible with the existing outdoor recreation uses or would result in a nonrecreational use other than that acknowledged and approved by the NPS.

- Granting control or partial control of land for transportation rights-of-way, powerline rights-of-way, pipelines, sewer lines, and landfills, or for construction of structures such as fire stations, civic centers, libraries, indoor recreation facilities, communication towers, and tornado sirens.

The list above is not all-inclusive because other actions may also result in Section 6(f) involvement. The authority to determine whether a potential Section 6(f) involvement exists rests with the NPS, which administers the LWCF. As prerequisites for approval of any Section 6(f) conversion request, it should be determined that:

- All practical alternatives to the conversion have been evaluated and rejected on sound bases.

- The proposed replacement land is "…of reasonably equivalent usefulness and location."

- All necessary coordination with other federal agencies has been satisfactorily accomplished.

- The guidelines for environmental evaluation enumerated in LWCF Manual Part 650 have been completed and considered by the NPS during its review of the proposed 6(f) action. In cases where the proposed conversion arises from another federal action, final review of a state's proposal shall not occur until the region is assured that all environmental requirements related to that other action have been met.

- Clearinghouse review procedures set forth in LWCF Manual Part 66.1.ID have been adhered to if the proposed conversion and substitution constitute significant changes to the original LWCF project.

- The proposed conversion and substitution are in accord with a state comprehensive outdoor recreation plan.

It should be noted that Interior's policy on conflicts between grants-in-aid and transportation projects provides that not only the property actually developed or acquired with LWCF moneys, but the entire area identified in the project agreement, is subject to the requirements of the LWCF and the conditions of the project agreement. Further, Interior has established that when assistance is provided to only one of five entirely separate parks within a state park system, and this fact is clearly recognized in the grant project agreement, then an area being taken for highway construction from a park that received no assistance would not be subject to the provisions of Section 6(f) of the LWCF Act.

If we do not concur that the first proviso of Section 4(f) is satisfied (in other words, there are feasible and prudent alternatives to the proposed 4(f) use), then we could not concur in a 6(f) conversion either, and this should be so stated in our letter. If we *do* concur in the 4(f) taking, Interior would be willing to consider a conversion request, and 6(f) compliance becomes one (but not necessarily the only one) of the measures to minimize harm to the 4(f) area. In this case we should be helpful in stating *exactly* what would be required by Interior under 6(f). We should recommend that 6(f) details be worked out and that a full proposed replacement package be included in the final 4(f) document. Unless we foresee grave 6(f) problems, we should not make our 4(f) concurrence contingent upon 6(f) approval (tentative or otherwise); *final* 6(f) approval can be given *only after* 4(f) approval. Our 4(f) comments could be something like: "We have no objection to Section 4(f) approval, *provided that* all measures to minimize harm, including an acceptable Section 6(f) replacement package, as discussed above, are included in project plans."

Lands Acquired Under Section 7 of the LWCF Act: Unlike Section 6(f) of the Act, Section 7 has no requirement that land purchased by a federal agency with LWCF moneys under this section must continue to be used solely for outdoor recreation purposes. In such a situation, there is no legal necessity for reimbursement to the LWCF, or a replacement of the taken land, by either the administering agency or the agency preparing to use the land for other than recreation purposes.

Therefore, when a transportation project encroaches upon federal lands acquired under Section 7

of the LWCF, only the requirements of Section 4(f) apply. However, there is no reason we cannot use replacement land in this case if, in our view, that is appropriate. When Interior lands (NPS, BLM, FWS, BR, BIA) are involved, wording related to our follow-up action should follow the statement on our Section 4(f) position, for instance: "The Department of the Interior would be willing to consider a right-of-way permit application for this project upon receipt of notice of Section 4(f) approval." Or: "Because of our jurisdictional involvement, until the measures to minimize harm are mutually resolved, we do not concur with Section 4(f) approval and would defer acting on any right-of-way application." Or, with Section 6(f) involvements: "Upon receipt of notice of Section 4(f) approval by DOT, the NPS would be willing to consider a request for a conversion of use as required by Section 6(f) of the LWCF Act."

Lands Under the Urban Park and Recreation Recovery Act of 1978: Recreation areas and facilities developed or improved, in whole or part, with a grant under the Urban Park and Recreation Recovery Act of 1978 (Title 10 of PL 95-625) are subject to Section 1010 of the Act, which requires independent approval of the Secretary of the Interior for conversion to other than public recreation uses (see guidance above with respect to Section 6(f)).

Lands Under the Railroad Revitalization and Regulatory Reform Act of 1976: Abandoned railroad rights-of-way acquired by state and local governments for recreational or conservation uses with grants under Section 809(b) of the Railroad Revitalization and Regulatory Reform Act of 1976 require independent approval of conversion of use by the Secretary of the Interior (see guidance above on Section 6(f)).

Landscaping and Scenic Enhancement: Landscaping and scenic enhancement is a legitimate transportation project cost. A plan for landscaping and scenic enhancement should be developed jointly with and to the satisfaction of the agency having jurisdiction over affected Section 4(f) properties. The visual impact on Section 4(f) properties requires a professional value judgment. No one is better qualified to make this judgment than the land administrator who knows the historical, natural, recreational, and other environmental resource values that are to be preserved and protected.

Noise Abatement Measures: Noise abatement measures should be incorporated into projects when necessary to minimize harm to Section 4(f) lands. These may include planting special belts of trees and shrubs, building earthen berms or other noise barriers, building depressed roadways, and planting grass to reduce reflected noise. Noise abatement measures are especially important if affected Section 4(f) lands are used for passive recreation or for enjoyment as natural areas or historic sites. Reviewers might consider giving some advice about what constitutes an adverse noise impact on 4(f) lands.

Safety and Access: Project plans should include measures to protect the park user and the motorist. These measures may include fencing, pedestrian overpasses or underpasses, lights, traffic signals, and adequate vehicular (including bicycle) access to and from the park.

Project Design: Often highways are designed with wide median strips and require excessive right-of-way from Section 4(f) lands. In such situations, the amount of "take" can be reduced greatly in the Section 4(f) areas if the project uses a New Jersey-type concrete median barrier in lieu of a wide median strip. Use of such concrete barriers should be discussed as a measure to minimize harm to Section 4(f) lands.

Historic and Archeological Properties: Reviewers should keep in mind that the MOA concluded under the Section 106 consultation process by the DOT agency, the SHPO, and the ACHP is not a Section 4(f) document. The appearance of an MOA in a Section 4(f) document has historically been the exception rather than the rule.

Interior should independently review the measures to minimize harm for a historic site and express judgment about them. The measures to minimize harm may be only described in a Section 4(f) document with no reference to an MOA, or they may be identified in a proposed MOA. The reviewers should address the listed measures and comment accordingly.

An exception occurs when an NPS historic property is involved. Here we make Section 4(f) comments and become a signatory to the MOA in some cases. Hence reference to the MOA and the ACHP is acceptable. A number of measures to minimize harm to recreation resources discussed before, such as improved access, noise barriers, and landscaped buffer zones, may be applicable to historic sites. However, there are some specific measures to minimize harm that are unique to historic sites. These may include the following:

- Appropriate signing and marking of historic sites to increase public awareness. These measures may produce aesthetic impacts or increase usage beyond carrying capacity.

- Sensitive aesthetic design of facilities to maintain and enhance historic ambiance. Examples are compatible architectural design, tinted concrete, special surface textures, stone or brick facings, use of weathering steel, prevention of rust staining on masonry surfaces, and graffiti prevention.

- Adaptive re-use of historic structures, such as moving and adequate restoration of historic structures on appropriate new sites (usually a last-resort measure).

- Adequate recordation and curatorial care of demolished structures (again a last-resort measure).

ENVIRONMENTAL STATEMENT COMMENTS: This section is a consolidation of all bureau comments on the EIS, in addition to settlement by the lead bureau of any conflicting comments, recommendations, or positions. If lead bureau reviewers have doubts or questions, they should discuss the matter with the other reviewers who supplied the comments and enlist the assistance of the regional environmental officer as needed. *The lead bureau must provide this service even if it has no comments.* (See 516 DM 7.)

General Comments: This section of a Departmental letter contains Interior comments on the adequacy or inadequacy of the environmental statement with respect to the concerns of Interior in a general manner. General comments should be followed by detailed discussion of the specific shortcomings in the environmental statement and suggestions for improvements or areas where more information is needed.

Project Description: This section of the environmental statement should include a clear, concise description of the proposed project and its major design features. Especially important is information on the relationship of the project to resources of concern to Interior. The Departmental letter should request additional information when it is difficult or impossible to ascertain the extent of impacts of concern to Interior. This section need describe the environment only to the degree necessary to evaluate the impacts (with or without the project). In addition, the reviewers should be especially aware of those environmental attributes having potential recreation value, including the intangible qualities of aesthetics. Land use data should include acreage by farmland, wetlands, residential, commercial, public land, and type of use (recreation, school, etc.). Lands and waters supporting wildlife and fisheries should be identified, as should unique natural areas. Cultural resources should be identified, but care should be taken not to locate sites so precisely as to make them subject to vandalism.

Probable Impact of the Proposed Action on the Environment: This section should include the impact of the proposed project on ecological systems and use. Both primary and secondary significant consequences (e.g., changes in land use) should be analyzed. Other matters that should be discussed under this section include the following:

- Total acreage of right-of-way required for the project proposal and each of the alternatives, including a breakdown of farmland, wetlands, residential properties, recreational areas, and school property.

- Location of borrow/spoil areas. The selection, use, and restoration of borrow and spoil areas pose potentially adverse impacts. Our comments should note that borrow and spoil areas are the primary responsibility of the highway agency rather than the contractor, and that impacts resulting from development and use of borrow/spoil areas should be addressed in the environmental statement.

- Consultation with the SHPO for matters relating to historical, architectural, and archeological values, properties on the National Register of Historic Places, or properties in the process of being nominated to the Register.

- Impacts on local and regional general recreational values.

- Impacts on rare, endangered, or protected plant and animal species.

- Noise impacts—especially those on cultural and recreational resources.

- Effects on water resources, including location and area of impact and identification of stream channelization, channel changes, floodplains, and wetlands.

Channelization: This activity may affect life in the area of the stream to be channelized as well as the upstream and downstream ecosystem. Therefore, project alternatives passing through natural waters must be designed to maintain the functioning of the aquatic ecosystem that makes possible the continuance of a stream's water quality and prevention of flooding. The stream and its floodplain are an integral system that is designed to moderate the effects of flooding water and maintain high productivity in the stream proper. Disturbing the system inevitably results in a reduction of diversity of species and productivity.

Floodplains and Wetlands : Floodplains and wetlands are very valuable natural resources. They have great value as habitats for wildlife and as aquifer recharge areas. They also constitute natural floodwater absorbing areas. When confronted with inadequate information about projects involving floodplains and wetlands, reviewers should recommend that the statement include an evaluation of these areas in compliance with Presidential Executive Orders 11988 and 11990. These executive orders direct that special attention be given to floodplains and wetlands when planning the location of federally financed or supported new facilities such as highways.

Adverse Impacts That Cannot Be Avoided: These impacts may include water, air, or noise pollution, undesirable land use patterns, damage to wildlife systems, urban congestion, and threats to health. Water, air, or noise pollution should be discussed as they relate to Interior's interests. Although EPA has certain statutory responsibilities for air, water, and noise pollution, this does not mean that Interior should not tell other agencies when such pollution affects our program interests. While many Interior bureaus have certain in-house expertise, the Geological Survey is the recognized expert on ground and surface waters, the FWS on fish and wildlife resources, and the NPS on park, recreation, and cultural resources.

Alternatives: CEQ regulations require rigorous exploration and objective evaluation of alternative actions that might avoid some or all of the project's adverse environmental effects. The regulations further stipulate that sufficient analysis of such alternatives and their costs and impacts on the environment should accompany the proposed action through the agency review process in order not to foreclose prematurely options that have less detrimental effects. We should recommend further consideration of alternatives not discussed in the statement, and we should do this as early as possible in the process in order to be effective. There is no reason we have to confine our review to alternatives presented by the sponsor if we have sound reasons for suggesting others. Analysis of alternatives is especially important under Section 4(f), and Interior should always strive to make responsible and timely alternative recommendations to the DOT agency, rather than postponing any recommendation until the agency makes its final selection.

Irreversible and Irretrievable Commitment of Resources: In many statements, the only resources addressed are sand, gravel, concrete, other supplies, and human energy used in the highway construction. Curtailment of other uses of the environment is seldom given explicit treatment. Loss of flora, fauna, stream habitat, and wildlife habitat and changes in drainage patterns all represent commitments of resources that may not be reclaimed. Any land taken from a fish and wildlife refuge, state game area, public recreational area, or historic site becomes an irreversible and irretrievable commitment of resources and should be so identified in environmental statements.

Minimizing Harm to the Environment: Details of actions to minimize harm to the environment should be included in the statement. A general statement that the sponsor will comply with all federal, state, and local standards and specifications is not acceptable. Actions to minimize harm should be explained in detail. These may include control of air, water, and noise pollution; landscaping; and sign and billboard removal. We should consider recommending appropriate mitigation measures for the whole project, not just for 4(f) areas (note that for 4(f) areas our mitigation recommendations are essential). As lead bureau, the NPS will find that the FWS will probably have numerous mitigation recommendations for wetlands and other fish and wildlife values that it wants incorporated into the Departmental letter. NPS reviewers should be familiar with the FWS policy in this area so that they can properly evaluate the comments. (See *FWS Mitigation Policy* in the *Federal Register*, January 23, 1981, as amended.)

Multiple use and joint development programs should be recommended wherever they can be used to reduce impacts or enhance the environment.

Another mitigation measure that should be considered in our review is improving access to navigable water. Funds apportioned to the states may be used for construction of access ramps adjacent to bridges under construction, reconstruction, replacement, repair, or alteration on the federal-aid primary, secondary, and urban system highways.

FISH AND WILDLIFE COORDINATION ACT COMMENTS: Under provisions of the Fish and Wildlife Coordination Act, the FWS investigates and reports on projects affecting certain waters of the United States. Whenever federal permits are required for transportation project implementation, reviewers should make sure that the FWS's FWCA comments and a tentative position are received and included in the Departmental letter. Close coordination must be maintained with the appropriate FWS field office.

HOW TO ADDRESS COMMENTS OF OTHER DEPARTMENTAL BUREAUS: The comments of all Interior bureaus must be appropriately incorporated in the Departmental letter. We emphasize this so that, in a lead bureau role, a bureau develops a letter that reflects total Departmental concerns rather than just the items of interest to that bureau's programs. These comments can be used verbatim or edited. Major changes or deletions, however, must be discussed with the bureau supplying the comments and such discussion documented in the package sent forward.

Reviewers should avoid specific mention of each Interior agency in the Departmental letter because the comments belong to the Department. We usually write "The Department believes…" in a Departmental letter. However, when a comment is clearly related to a bureau and recognizing the bureau by name is important, the letter should do so. An example would be: "The FWS informs us that it will oppose the issuance of a USCG bridge permit pursuant to its responsibilities under the FWCA…."

Otherwise, if any bureau has major problems in its area of expertise, we should say something like: "Because of the above hydrologic problems, we recommend that you consult further with the USGS, which would be happy to provide technical assistance in the development of a mitigation plan for inclusion in the final statement…."

We must always send copies of all comments received with the proposed Departmental letter of comment so that OEPC's file will be complete. A "No Comment" phone call from another bureau constitutes its comment; make a record of this, including date, on a separate sheet and forward it with the package.

SUMMARY COMMENTS:
Content of Section 4(f) Evaluation Comments: Reviewers should keep in mind that Section 4(f) evaluation comments focus on

- Concurring or not concurring (with supporting evidence) with the agency's response to the first proviso of Section 4(f).
- Concurring or not concurring (with supporting evidence) with the agency's response to the second proviso of Section 4(f).

Content of Summary Comments: Based on our discussion of alternatives and measures to minimize harm under Section 4(f) evaluation comments, the text of the summary comments may include different scenarios, as follows:

- *Full Concurrence with Both Provisos of Section 4(f)*: On projects where we are in full concurrence with both provisos of Section 4(f), a simple sign-off sentence is recommended, such as: "The Department of the Interior has no objection to Section 4(f) approval of this project."

- *Concurrence with Only the First Proviso*: On projects where we concur only with the first proviso of Section 4(f) and have problems with the measures to minimize harm, the following situations may arise:

- In a situation where we recommend further investigation and consultation for resolution of suggested additional measures to minimize harm, and where we will accept whatever decision is reached among the parties involved, the summary comments can state: "The Department of the Interior has no objection to Section 4(f) approval of this project,

contingent upon resolution (among the FHWA, the state highway/transportation agency, and all other involved parties [cite by name]) and documentation in the final statement of the additional measures to minimize harm, as recommended under the Section 4(f) evaluation comments."

- In a situation where we have recommended additional measures to minimize harm about which we feel strongly, we can state: "The Department of the Interior has no objection to Section 4(f) approval of this project, *provided* the measures to minimize harm mentioned above are included in project plans and documented in the final statement." This should be followed with the standard technical assistance offer, such as: "Because this Department has a continuing interest in this project, we are willing to cooperate and coordinate with you on a technical assistance basis in further project evaluation and assessment. For matters pertaining to cultural and recreational resources, please contact (provide necessary contact person as well as mailing and telephone information)."

Objection to Section 4(f) Approval: On projects where we object to Section 4(f) approval, the Interior objection may take several forms, the most common of which are the following:

- Interior objects to the preferred alternative and indicates a preference for another or identifies and recommends further alternatives for study and evaluation. Measures to minimize harm can be discussed for our alternatives, or we can defer comments on measures to minimize harm pending the selection of a feasible and prudent alternative. We should urge field consultation among involved parties to select a feasible and prudent alternative and develop measures to minimize harm. Indicate that in order to resolve recreational and cultural resource issues mentioned above, we would be willing to provide expeditious review of any revised Section 4(f) documentation that may be circulated for review and comment.

- Interior concurs that there is no feasible and prudent alternative, yet it objects to the project because measures to minimize harm are grossly inadequate. Our summary comments might read: "The Department of the Interior does not concur with Section 4(f) approval of this project at this time. We would be pleased to reconsider this position upon receipt of revised material that includes adequate information and full discussion of measures to minimize harm as mentioned earlier in our Section 4(f) evaluation comments."

Lack of Section 4(f) Information in the Document: There may be occasions where a project's involvement with Section 4(f) lands/properties has been totally ignored by the project sponsor. The lack of Section 4(f) information in the statement, namely the absence of discussion of the provisos of Section 4(f), should be pointed out in our letter and a recommendation made that a Section 4(f) evaluation be prepared and circulated for review.

- Summary comments could be: "The Section 4(f) evaluation comments in this letter are

provided to give you an early indication of our thoughts about the Section 4(f) information and involvements. They do not represent the results of formal consultation by DOT with the Department of the Interior, pursuant to the consultative requirements of Section 4(f). Such requirements would be fulfilled only when the Office of the Secretary of the Interior comments separately on any Section 4(f) evaluation that may be prepared and approved by you for circulation." Follow this with the normal technical assistance paragraph.

- Another option may be appropriate to use in those few cases where we have no formal Section 4(f) evaluation but field-level consultations uncover the highway agency's preference for a particular alternative and we can concur that (1) there is no feasible and prudent alternative and (2) the measures to minimize harm are *totally* adequate. In the interest of efficiency, we then could sign off at this early stage. Our summary comments would normally state: "Usually we make preliminary Section 4(f) comments when commenting on Section 4(f) information in a draft environmental statement. However, for this case, we are willing to provide you with Section 4(f) comments that will satisfy the consultative requirements of Section 4(f) of the Department of Transportation Act. If a certain alternative is selected, we would concur that there is no feasible and prudent alternative to use of the Section 4(f) area for the proposed transportation project. In addition, contingent upon a commitment for the implementation of all proposed measures to minimize harm, we would concur that the second proviso of Section 4(f) will be satisfied. Accordingly, the Department of the Interior offers no objection to Section 4(f) approval of the alternative." The summary comments should also succinctly indicate any major non-Section 4(f) problems we have with the project, but they should not repeat minor criticisms of the environmental documentation.

The examples above are intended primarily as suggestions and are offered to assist the reviewer facing a unique situation for the first time. Reviewers are urged to continue to develop letters that are responsive to the specific conditions of each statement under review.

APPENDICES

A. Andrus letter of June 20, 1980, currently embodied in ERM94-4. Letter states what we believe constitute 4(f) properties.

B. Acronym list.

C. Letter from FHWA to OEPC dated October 5, 1987, explaining continuing areas of disagreement between DOT and Interior on various Section 4(f) issues.

D. Letter from FHWA's Office of Environmental Policy to FHWA regional administrators on constructive use.

APPENDIX A. ANDRUS LETTER ON SECTION 4(f) PROPERTIES

This memorandum has been electronically scanned from the original signed by Jonathan P. Deason on August 17, 1994.

PEP - ENVIRONMENTAL REVIEW MEMORANDUM NO. ERM94-4

To: Heads of Bureaus and Offices

From: Director, Office of Environmental Policy and Compliance

Subject: Section 4(f) of the Department of Transportation Act

The Secretary has identified, by the attached letter of June 20, 1980, to the Secretary of Transportation, those park and recreation areas, wildlife and waterfowl refuges and historic sites which are under Interior's direct and indirect jurisdiction and which are significant within the context of Section 4(f) of the DOT Act (49 U.S.C. 303, formerly 49 U.S.C. 1653 [f]).

This guidance should be provided to all Departmental officials who have land management or program responsibilities for those areas and resources to which Section 4 (f) would apply, in addition to those personnel who normally review DOT NEPA/4 (f) documents.

This memorandum replaces ER80-2.

Attachment

This letter has been electronically scanned from the original signed by Cecil D. Andrus on June 20, 1980.

United States Department of the Interior

Office of the Secretary
Washington, DC 20240

Honorable Neil Goldschmidt
Secretary
U.S. Department of Transportation
Washington, D.C. 20590

Dear Secretary Goldschmidt:

I am aware of your concerns to expedite the planning process for transportation projects. To the fullest extent we can, I want my Department to assist you in that effort.

It has been our observation, principally with highway projects, that certain delays can be traced to resolution of questions concerning (1) what constitutes land falling under the provisions of Section 4(f) of the DOT Act and (2) whether or not such land is significant within the meaning of Section 4(f).

In order to be helpful and to assist in expediting your transportation project-planning process, a list has been developed identifying areas pursuant to my jurisdictional responsibility as the Federal official for making determinations of significance in accordance with Section 4(f) of the DOT Act, 49 U.S.C. 1653(f). That responsibility is contained in the following provision:

"After August 23, 1968, the Secretary [of Transportation] shall not approve any program or project which requires the use of any publicly owned land from a public park, recreation area, or wildlife and waterfowl refuge of national, State, or local significance as determined by the Federal, State, or local officials having jurisdiction thereof, or any land from an historic site of national, State, or local significance as so determined by such officials unless . . . ."[emphasis added]

The Solicitor of this Department advises that our jurisdiction extends to any public park, recreation area, or wildlife and waterfowl refuge within the scope of the Department's statutory responsibilities and that these responsibilities extend to certain State or locally owned (in fee, less than fee, lease, easement, or otherwise) parks, recreation areas or wildlife and waterfowl refuges. In addition, the Department's jurisdiction extends to sites which the Department determines to be of national State, or local historic significance, regardless of ownership. See Stop H-3 Ass'n. v. Coleman 533 F2d 434, 441 (1976) Cert. denied 429 U.S. 999 (1976).

Jurisdiction to determine areas of national, State, or local historic significance includes any property "significant in American history, architecture, archeology, and culture." Id. at 441 note 13.

Accordingly, the Department of the Interior declares the following listed lands as being significant parks, recreation areas, wildlife and waterfowl refuges and historic sites and therefore Section 4(f) would be applicable to all for any Department of Transportation use. The list has been developed consistent with my Solicitor's advice. Moreover, this list may not be exhaustive and there may be other areas that have been inadvertently omitted or that may need to be evaluated on a case-by-case basis.

1. All lands or interests therein authorized, established, or administered as part of the National Park System.

2. All National Park Service "Affiliated Areas."

3. All lands or interests therein authorized, established, or administered as National Wildlife Monuments, or as part of the National Wildlife Refuge System, including Waterfowl Production Areas (wetland easements).

4. All lands or interests therein authorized, established, or administered as part of the National Fish Hatchery System.

5. All waters, lands, and interests therein acquired for mitigation purposes pursuant to the authority of the Fish and Wildlife Coordination Act (16 U.S.C. 661-667e). Such lands and waters are in many cases administered by other Federal agencies, notably the Corps of Engineers, or by State agencies, pursuant to general planning authority (Sec. 663(b)). They may not be made subject to transactions that would "defeat the initial purpose of their acquisition." (Sec. 663(d)).

6. All lands or interests therein under the jurisdiction of the Water and Power Resources Service which are administered or which receive de facto use as parks, recreation areas, wildlife refuges, or historic sites.

7. All lands or interests therein under the jurisdiction of the Bureau of Land Management which are administered or which receive de facto use as parks, natural areas, natural systems (e.g., flood plains, wetlands, or riparian habitat), environmental education areas, cultural and historic areas, areas of critical environmental concern, recreation areas, or wildlife refuges, or which meet wilderness criteria or are wilderness study areas.

8. All lands held in trust by this Department for the benefit of Indian Tribes which are administered by the Tribe as parks, recreation areas, wildlife refuges, or historic sites, or which receive similar de facto use.

9. All local and State lands, and interests therein, and certain Federal lands under lease to the States, acquired or developed in whole or in part with monies from the Land and Water Conservation Fund Act. Such lands, and interests therein, are also subject to Section 6(f) of the Act requiring independent approval of conversion of use by the Secretary of the Interior.

10. All recreation areas and facilities (as defined in Section 1004) developed or improved, in whole or in part, with a grant under the Urban Park and Recreation Recovery Act of 1978 (Title 10 of P.L. 95-625). Such recreation areas and facilities are also subject to Section 1010 of the Act which requires independent approval of the Secretary of the Interior (Heritage Conservation and Recreation Service) for a conversion to other than public recreation uses.

11. All State lands and interests therein acquired or developed or improved for fish and wildlife conservation, restoration, or management with grants under the Pittman-Robertson Act, the Dingell-Johnson Act, Section 6 of the Endangered Species Act of 1973, and/or the Anadromous Fish Act of 1965 (including, but not limited to, State fish hatcheries, State wildlife conservation areas, and State game lands). For most of these lands, conversion to a non-designated use requires independent approval by the Secretary of the Interior.

12. All Federal surplus real property which has been deeded to State and local governments for use and management as park demonstration areas, recreation areas, or wildlife conservation preserves and refuges, and all historic monuments and properties so deeded, under the Recreation Demonstration Act of 1942, or the Federal Property and Administrative Services Act of 1949, as amended. Most of these lands are also subject to independent approval of conversion of use by the Secretary of the Interior.

13. All abandoned railroad rights-of-way acquired by State and local governments for recreational and/or conservation uses with grants under Section 809(b) of the Railroad Revitalization and Regulatory Reform Act of 1976. Such lands are also subject to independent approval of conservation of use by the Secretary of the Interior.

14. All properties included in or eligible for inclusion in the National Register of Historic Places.

15. All areas publicly owned in fee, less than fee, lease, or otherwise, which receive de facto use as park, recreation, or refuge lands, and which are listed on the National Registry of Natural Landmarks[1], the National Registry of Environmental Landmarks[2], the World Heritage List (U.S. listings based on nominations by Secretary of the Interior[3]), or designated as Biosphere Reserves

[1]Program administered by Heritage Conservation and Recreation Service.

[2]Program administered by the National Park Service.

[3]Handled by Heritage Conservation and Recreation Service.

by the Secretary General, United Nations Educational, Scientific and Cultural Organization (after consultation with the Secretary of the Interior[4] and the Secretary of State).

De facto use, as mentioned above, will be determined on a case-by-case basis by the Interior bureau having statutory or program jurisdiction over or interest in the land in question. In the case of Indian trust lands, such determination will be made by us, in consultation with the appropriate Tribal officials. De facto use may also include publicly owned lands or interests therein proposed or under study for inclusion in the National Wild and Scenic Rivers System, the National Trails System, or the National Wilderness Preservation System, or as critical habitat for endangered or threatened species. Early coordination with this Department concerning applicability of Section 4(f) is especially important whenever lands administered by the Water and Power Resources Service or Bureau of Land Management, or whenever Indian trust lands (Tribal Officials/Bureau of Indian Affairs), are affected by DOT projects. Needless to say, such early coordination concerning other aspects of Section 4(f) is equally important when the lands and interest or our other bureaus are affected.

All of the above lands may also contain significant, but presently unknown or undesignated, historic or archeological sites or properties falling under the protection of Section 4(f). This will be determined on a case-by-case basis by the administering bureau/Tribal officials in consultation with the SHPO (and/or others with historical expertise). Coordination with this Department, therefore, is also essential in this matter. Such coordination with reference to Section 4(f) should be in addition to (although it may be concurrent with) any coordination that may be required under Section 106 of the National Historic Preservation Act. We would note however, that each is independent of the other.

You may be assured that we stand ready to provide timely technical assistance in the preparation of Section 4(f) documentation for projects involving our lands or interests in lands. You realize, of course, that this Department must make an independent and separate (1) judgment of the need for use of its lands, or interests in lands, by a Department of Transportation program or project, as well as (2) documented determination of project compatibility with the purpose for which the land was acquired (as authorized by Congress) and is being managed.

Also, any approval of conversion of use or of transfers of land is an action requiring our compliance with the National Environmental Policy Act. Such compliance with NEPA would be satisfied by an environmental document prepared by the lead agency and approved by the appropriate bureau(s) in this Department [reference: 40 CFR 1501.5 and .6]. Again, we stand ready to provide timely technical assistance in the preparation of such documents.

There are, of course, other Section 4(f) properties over which the Department of the Interior has no direct or program jurisdiction, which should continue to receive Section 4(f) protection. These include, but are not limited to, community and village parks and playgrounds; State,

[4]Handled by National Park Service.

county and regional park, recreation and refuge lands; school playgrounds open to general public use; State fairgrounds; and all properties determined to have State and local significant historic values, but which were determined not eligible for the National Register. This Department is committed to timely review of Section 4(f) statements prepared for such involvements.

I would appreciate it if you made the above information available to your operating administrations. Additionally, we hope you would instruct the Federal Highway Administration to have this letter included as an addendum to each State's Highway Action Plan, developed pursuant to 23 U.S.C. 109(h) and FHPM 7-7-1. Only with this broad distribution do we believe that the several administrative levels of a State highway agency will be cognizant of the contents of this letter and be able to work with you and us in expediting the planning process.

Thank you for your attention to this matter.

Sincerely,

CECIL D. ANDRUS

Secretary

cc:Council on Environmental Quality

APPENDIX B. LIST OF ACRONYMS USED IN THIS HANDBOOK

ACRONYM LIST

ACHP	Advisory Council on Historic Preservation
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BR	Bureau of Reclamation
CEQ	Council on Environmental Quality
DOI	Department of the Interior
DOT Act	Department of Transportation Act
DOT	U.S. Department of Transportation
EA	Environmental Assessment
EIS	Environmental Impact Statement
ER	Environmental Review System
ERM	Environmental Review Memorandum
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FS	Forest Service
FTA	Federal Transit Administration
FWCA	Fish and Wildlife Coordination Act
FWS	Fish and Wildlife Service
LWCF	Land and Water Conservation Fund Act
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding

NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act of 1966
NPS	National Park Service
NRHP	National Register of Historic Places
OEPC	Office of Environmental Policy and Compliance
REO	Regional Environmental Officer; OEPC
RRRRA	Railroad Revitalization and Regulatory Reform Act of 1976
SHPO	State Historic Preservation Officer
SOL	Office of the Solicitor; DOI
UPRRA	Urban Park and Recreation Recovery Act of 1978
USCG	U.S. Coast Guard

APPENDIX C. FHWA LETTER TO OEPC ON DISAGREEMENTS BETWEEN DOT AND INTERIOR

This letter has been electronically scanned from the original signed by Eugene W. Cleckley on October 5, 1987.

U.S. Department of Transportation
Federal Highway Administration
400 Seventh Street, S.W.
Washington, D.C. 20590

October 5, 1987

In Reply Refer To: HEV-11

Mr. Bruce Blanchard
Director, Office of Environmental
Project Review
U.S. Department of the Interior
Washington, D.C. 20240

Dear Mr. Blanchard:

Thank you for your constructive comments on our Section 4(f) Policy Paper. We have revised the policy paper (copy enclosed) to incorporate most of your comments. However, there are some major areas (constructive use, public parks and recreation areas, historic sites, archeological sites, late designation, wild and scenic rivers, joint development, and wildlife management areas) where we still disagree. The following is a summary of these areas.

Constructive Use - You stated you might consider the following as examples of constructive use: (1) where the proximity of a highway alters a habitat area in a wildlife refuge or interferes with the normal behavior of wildlife populations; (2) where a highway reduces the level of access to a park or recreation area; and (3) where a highway changes the character of the view from a historic district that is incompatible with the historic nature of the district. Your description of the threshold for constructive use of Section 4(f) resources contains terms such as alters, interferes, reduces, and changes. We agree that these types of impacts where they are sufficiently severe to substantially impair the resource would be a constructive use. However, standing alone, we view these terms as establishing a lower threshold than those generally found in case law. A number of court decisions, including Adler v. Lewis, 675 P.2d 1085 (9th Cir. 1982) (copy enclosed), have established "substantial impairment" as the threshold for

constructive use.

Public Parks and Recreation Areas - You stated that public housing and military recreation areas, even if they have some restrictions on the use of them, should be protected by Section 4(f). The Section 4(f) statute applies to "publicly owned land of a public park, recreation area, or wildlife and waterfowl refuge." We take this to mean that the land must be open to the entire public to be protected by Section 4(f). We agree with you that recreation areas associated with public housing and military bases do not need unrestricted public access to receive protection under Section 4(f). We have added a sentence to question 2.C. to clarify this point. The Federal Highway Administration strongly encourages the preservation of parks and recreation areas that are not open to the public at large. A statement to that effect has been added to the policy paper.

Historic Sites - You want to afford Section 4(f) protection to historic sites if they are not on or eligible for the National Register of Historic Places. Obviously, we cannot afford Section 4(f) protection to every site which is claimed historic by any individual. It has been a longstanding Department of Transportation Policy to apply Section 4(f) to all sites on or eligible for the National Register. In addition, our environmental regulation and this policy paper extend Section 4(f) protection to other historic sites based on an individual site-by-site review.

Archeological Sites - You want to afford Section 4(f) protection to archeological sites even if they are important chiefly because of what can be learned by data recovery and have minimal value for preservation in place. This position is contrary to our Section 4(f) regulation. This portion of our regulation was upheld in the Belmont case (Town of Belmont v. Dole, 755 F.2d 28 (lst Cir. 1985)).

Late Designation - You want to afford Section 4(f) protection to properties which are designated as significant historic sites even after acquisition for highway purposes. You base your position on a belief that such a situation would be the result of a totally inadequate effort to identify historic properties at the time of search. Our policy clearly states that, if the effort was not adequate (using the Section 106 requirements at the time of search), Section 4(f) would apply. Our policy does not seek to obtain any advantage because of inadequate resource identification, but rather to disqualify properties which did not meet the eligibility requirements at the time of search (for example, the property was not old enough).

Wild and Scenic Rivers - You stated that (1) all rivers now in the System have been designated for their recreational and park (conservation, etc.) values, (2) the primary use of all publicly owned lands within their boundaries is for Section 4(f) purposes, and (3) the officials having jurisdiction will certify that this is so if asked. We do not necessarily base application of Section 4(f) on titles or systems designation; instead, we base Section 4(f) application on actual function. If portions of the publicly owned lands are designated or function primarily for recreational purposes, then those portions would be subject to Section 4(f). We do not believe that publicly owned lands designated only for conservation values are recreational areas subject to Section 4(f).

Joint Development - You expressed a desire to apply Section 4(f) to park or recreation land reserved for highway right-of-way if the reserved land is managed and/or maintained with park or recreation funds. Section 4(f) application to publicly owned land is not based on the type of funds spent to manage or maintain that land. Public land reserved for highway right-of-way is considered highway right-of-way. Section 4(f) does not apply to either authorized or unauthorized temporary occupancy of highway right-of-way pending project development. Applying Section 4(f) to the temporary occupancy of this land would be a strong deterrent to State and local governments to permit such activities and would encourage these areas to be fenced off. We believe that temporary occupancy of highway right-of-way (reserved for future construction) for park or recreation should be encouraged by our Section 4(f) policy rather than discouraged.

Wildlife Management Areas (WMA) - You stated that Federal WMAs are part of the National Wildlife Refuge System and therefore are considered to be a refuge within the meaning of Section 4(f). We have revised the discussion on wildlife management areas to state that such areas would be protected by Section 4(f) where they perform the same functions as a refuge (i.e., protection of species). As explained in answer 2A, we would, of course, rely heavily on the views of the officials having jurisdiction over these areas in determining their function.

Enclosed is a copy of the Section 4(f) policy paper (along with a summary of your position). Since we included most of your comments, we felt that it would be counterproductive to send your memo intact to our field organization along with the Section 4(f) policy paper. Consequently, we summarized your position for the major areas on which we disagree. A copy is enclosed. We appreciate the assistance you have given us in finalizing our paper.

Sincerely yours,

EUGENE W. CLECKLEY

Chief, Environmental Operations Division

APPENDIX D. LETTER TO FHWA REGIONAL ADMINISTRATORS ON CONSTRUCTIVE USE

This memorandum has been electronically scanned from the original signed by Ali F. Sevin on November 12, 1985.

U.S. Department of Transportation
Federal Highway Administration

MEMORANDUM

Subject: Section 4(f) - Constructive Use

From: Director, Office of Environmental Policy
Washington, D.C. 20590

To: Regional Federal Highway Administrators
Regions 1-10, and Direct Federal Program Administrator

Concern has been expressed from several State highway agencies and from several Federal Highway Administration (FHWA) offices about the results of litigation on constructive use of Section 4(f) lands. The two most notable cases are I-CARE in Fort Worth, Texas, and H-3 in Hawaii

While each of these decisions represented major setbacks for the respective projects and may present formidable obstacles from the standpoint of nationwide precedent, we believe that FHWA can construct a defensible position on the proper application of the constructive use doctrine on future projects.

The first step in the defense is a recognition that a constructive use can occur. The second step is to establish a threshold or standard for determining when the constructive use occurs. The FHWA has determined that the threshold for constructive use is proximity impacts which substantially impair the function of a park, recreation area, or waterfowl or wildlife refuge, or substantially impair the historic integrity of a historic site.

Steps 3, 4, and 5 are project specific and should be applied whenever there is a likelihood that constructive use could occur or will be an issue on a project. The third step is to identify the functions, activities, and qualities of the Section 4(f) resource which may be sensitive to proximity impacts. The, fourth step is to analyze the proximity impacts on the Section 4(f) resource. Impacts (such as noise, water runoff, etc.) which can be quantified, should be quantified. Other proximity impacts (such as visual intrusion) which lend themselves to qualitative analysis should be qualified. The fifth step is to determine whether these impacts

substantially impair the function of the Section 4(f) resource or the historic integrity of a historic site. This determination on impairment should, of course, be coordinated with the public agency which owns the park, recreation area, or refuge, or with the State Historic Preservation Officer in the case of historic sites.

If it is concluded that the proximity effects do not cause a substantial impairment, the FHWA can reasonably conclude that there is no constructive use. Project documents should, of course contain the analysis of proximity effects and whether there is substantial impairment to a Section 4(f) resource. Except for responding to review comments in environmental documents which specifically address constructive use, the term "constructive use" need not be used. Where it is decided that there will be a constructive use, the draft Section 4(f) evaluation must be cleared with the Washington Headquarters prior to circulation.

ALI F. SEVIN

United States Department of the Interior

OFFICE OF THE SECRETARY
Washington. D.C. 20240

AUG 17 1994

PEP - ENVIRONMENTAL REVIEW MEMORANDUM NO. ERM94-4

To: Heads of Bureaus and Offices

From: Director, Office of Environmental Policy and Compliance

Subject: Section 4(f) of the Department of Transportation Act

The Secretary has identified, by the attached letter of June 20, 1980, to the Secretary of Transportation, those park and recreation areas, wildlife and waterfowl refuges and historic sites which are under Interior's direct and indirect jurisdiction and which are significant within the context of Section 4(f) of the DOT Act (49 U.S.C. 303, formerly 49 U.S.C. 1653 [f]).

This guidance should be provided to all Departmental officials who have land management or program responsibilities for those areas and resources to which Section 4 (f) would apply, in addition to those personnel who normally review DOT NEPA/4 (f) documents.

This memorandum replaces ER80-2.

Jonathan P. Deason

Attachment

SECTION 4(f) of the DOT ACT

Section 4(f) of the Department of Transportation Act (80 Stat. 931; Public Law 89-670) as amended in Section 18 of the Federal-Aid Highway Act of 1968 (82 Stat. 815; Public Law 90-495).

"(f) It is hereby declared to be the national policy that special effort should be made to preserve the natural beauty of the countryside and public park and recreation lands, wildlife and waterfowl refuges, and historic sites. The Secretary of Transportation shall cooperate and consult with the Secretaries of the Interior, Housing and Urban Development, and Agriculture, and with the States in developing transportation plans and programs that include measures to maintain or enhance the natural beauty of the lands traversed. After the effective date of the Federal-Aid Highway Act of 1968, the Secretary shall not approve any program or project which requires the use of any publicly owned land from a public park, recreation area, or wildlife and waterfowl refuge of national, State, or local significance as determined by the Federal, State, or local officials having jurisdiction thereof, or any land from an historic site of national, State, or local significance as so determined by such officials unless (1) there is no feasible and prudent alternative to the use of such land, and (2) such program includes all possible planning to minimize harm to such park, recreational area, wildlife and waterfowl refuge, or historic site resulting from such use."

Section 4(f) is Codified in:

23 U.S.C. 138 and 49 U.S.C. 1653(f)

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

Honorable Neil Goldschmidt
Secretary
U.S. Department of Transportation
Washington, D. C. 20590

JUN 20 1980

Dear Secretary Goldschmidt:

I am aware of your concerns to expedite the planning process for transportation projects. To the fullest extent we can, I want my Department to assist you in that effort.

It has been our observation, principally with highway projects, that certain delays can be traced to resolution of questions concerning (1) what constitutes land falling under the provisions of Section 4(f) of the DOT Act and (2) whether or not such land is significant within the meaning of Section 4(f).

In order to be helpful and to assist in expediting your transportation project-planning process, a list has been developed identifying areas pursuant to my jurisdictional responsibility as the Federal official for making determinations of significance in accordance with Section 4(f) of the DOT Act, 49 U.S.C. 1653(f). That responsibility is contained in the following provision:

> "After August 23, 1968, the Secretary [of Transportation] shall not approve any program or project which requires the use of any publicly owned land from a public park, recreation area, or wildlife and waterfowl refuge of national, State, or local significance as determined by the Federal, State, or local officials having jurisdiction thereof, or any land from an historic site of national, State, or local significance as so determined by such officials unless . . . ." [emphasis added]

The Solicitor of this Department advises that our jurisdiction extends to any public park, recreation area, or wildlife and waterfowl refuge within the scope of the Department's statutory responsibilities and that these responsibilities extend to certain State or locally owned (in fee, less than fee, lease, easement, or otherwise) parks, recreation areas or wildlife and waterfowl refuges. In addition, the Department's

jurisdiction extends to sites which the Department determines to be of national, State, or local historic significance, regardless of ownership. See Stop H-3 Ass'n v. Coleman 533 F2d 434, 441 (1976) Cert. denied 429 U.S. 999 (1976). Jurisdiction to determine areas of national, State, or local historic significance includes any property "significant in American history, architecture, archeology, and culture." Id at 441 note 13.

Accordingly, the Department of the Interior declares the following listed lands as being significant parks, recreation areas, wildlife and waterfowl refuges and historic sites and therefore Section 4(f) would be applicable to all for any Department of Transportation use. The list has been developed consistent with my Solicitor's advice. However, this list may not be exhaustive and there may be other areas that have been inadvertently omitted or that may need to be evaluated on a case-by-case basis.

1. All lands or interests therein authorized, established, or administered as part of the National Park System.

2. All National Park Service "Affiliated Areas."

3. All lands or interests therein authorized, established, or administered as National Wildlife Monuments, or as part of the National Wildlife Refuge System, including Waterfowl Production Areas (wetland easements).

4. All lands or interests therein authorized, established, or administered as part of the National Fish Hatchery System.

5. All waters, lands, and interests therein acquired for mitigation purposes pursuant to the authority of the Fish and Wildlife Coordination Act (16 U.S.C. 661-667e). Such lands and waters are in many cases administered by other Federal agencies, notably the Corps of Engineers, or by State agencies, pursuant to general planning authority (Sec. 663(b)). They may not be made subject to transactions that would "defeat the initial purpose of their acquisition." (Sec. 663(d)).

6. All lands or interests therein under the jurisdiction of the Water and Power Resources Service which are administered or which receive de facto use as parks, recreation areas, wildlife refuges, or historic sites.

applicability of Section 4(f) is especially important whenever lands administered by the Water and Power Resources Service or Bureau of Land Management, or whenever Indian trust lands (Tribal Officials/Bureau of Indian Affairs), are affected by DOT projects. Needless to say, such early coordination concerning other aspects of Section 4(f) is equally important when the lands and interest of our other bureaus are affected.

All of the above lands may also contain significant, but presently unknown or undesignated, historic or archeological sites or properties falling under the protection of Section 4(f). This will be determined on a case-by-case basis by the administering bureau/Tribal officials in consultation with the State Historic Preservation Officer(and/or others with historical expertise). Coordination with this Department, therefore, is also essential in this matter. Such coordination with reference to Section 4(f) should be in addition to (although it may be concurrent with) any coordination that may be required under Section 106 of the National Historic Preservation Act. We would note however, that each is independent of the other.

You may be assured that we stand ready to provide timely technical assistance in the preparation of Section 4(f) documentation for projects involving our lands or interests in lands. You realize, of course, that this Department must make an independent and separate (1) judgment of the need for use of its lands, or interests in lands, by a Department of Transportation program or project, as well as (2) documented determination of project compatibility with the purpose for which the land was acquired (as authorized by Congress) and is being managed.

Also, any approval of conversion of use or of transfers of land is an action requiring our compliance with the National Environmental Policy Act. Such compliance with NEPA would be satisfied by an environmental document prepared by the lead agency and approved by the appropriate bureau(s) in this Department [reference: 40 CFR 1501.5 and .6]. Again, we stand ready to provide timely technical assistance in the preparation of such documents.

12. All Federal surplus real property which has been deeded to State and local governments for use and management as park demonstration areas, recreation areas, or wildlife conservation preserves and refuges, and all historic monuments and properties so deeded, under the Recreation Demonstration Act of 1942, or the Federal Property and Administrative Services Act of 1949, as amended. Most of these lands are also subject to independent approval of conversion of use by the Secretary of the Interior.

13. All abandoned railroad rights-of-way acquired by State and local governments for recreational and/or conservation uses with grants under Section 809(b) of the Railroad Revitalization and Regulatory Reform Act of 1976. Such lands are also subject to independent approval of conversion of use by the Secretary of the Interior.

14. All properties included in or eligible for inclusion in the National Register of Historic Places.

15. All areas publicly owned in fee, less than fee, lease, or otherwise, which receive de facto use as park, recreation, or refuge lands, and which are listed on the National Registry of Natural Landmarks[1/], the National Registry of Environmental Landmarks[2/], the World Heritage List (U.S. listings based on nominations by Secretary of the Interior[3/]), or designated as Biosphere Reserves by the Secretary General, United Nations Educational, Scientific and Cultural Organization (after consultation with the Secretary of the Interior[4/] and the Secretary of State).

De facto use, as mentioned above, will be determined on a case-by-case basis by the Interior bureau having statutory or program jurisdiction over or interest in the land in question. In the case of Indian trust lands, such determination will be made by us, in consultation with the appropriate Tribal officials. De facto use may also include publicly owned lands or interests therein proposed or under study for inclusion in the National Wild and Scenic Rivers System, the National Trails System, or the National Wilderness Preservation System, or as critical habitat for endangered or threatened species. Early coordination with this Department concerning

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1/ Program administered by Heritage Conservation and Recreation Service.
2/ Program administered by National Park Service.
3/ Handled by Heritage Conservation and Recreation Service.
4/ Handled by National Park Service.

7. All lands or interests therein under the jurisdiction of the Bureau of Land Management which are administered or which receive de facto use as parks, natural areas, natural systems (e.g., flood plains, wetlands, or riparian habitat), environmental education areas, cultural and historic areas, areas of critical environmental concern, recreation areas, or wildlife refuges, or which meet wilderness criteria or are wilderness study areas.

8. All lands held in trust by this Department for the benefit of Indian Tribes which are administered by the Tribe as parks, recreation areas, wildlife refuges, or historic sites, or which receive similar de facto use.

9. All local and State lands, and interests therein, and certain Federal lands under lease to the States, acquired or developed in whole or in part with monies from the Land and Water Conservation Fund Act. Such lands, and interests therein, are also subject to Section 6(f) of the Act requiring independent approval of conversion of use by the Secretary of the Interior.

10. All recreation areas and facilities (as defined in Section 1004) developed or improved, in whole or in part, with a grant under the Urban Park and Recreation Recovery Act of 1978 (Title 10 of P.L. 95-625). Such recreation areas and facilities are also subject to Section 1010 of the Act which requires independent approval of the Secretary of the Interior (Heritage Conservation and Recreation Service) for a conversion to other than public recreation uses.

11. All State lands and interests therein acquired or developed or improved for fish and wildlife conservation, restoration, or management with grants under the Pittman-Robertson Act, the Dingell-Johnson Act, Section 6 of the Endangered Species Act of 1973, and/or the Anadromous Fish Act of 1965 (including, but not limited to, State fish hatcheries, State wildlife conservation areas, and State game lands). For most of these lands, conversion to a non-designated use requires independent approval by the Secretary of the Interior.

There are, of course, other Section 4(f) properties over which the Department of the Interior has no direct or program jurisdiction, which should continue to receive Section 4(f) protection. These include, but are not limited to, community and village parks and playgrounds; State, county and regional park, recreation and refuge lands; school playgrounds open to general public use; State fairgrounds; and all properties determined to have State and local significant historic values, but which were determined not eligible for the National Register. This Department is committed to timely review of Section 4(f) statements prepared for such involvements.

I would appreciate it if you made the above information available to your operating administrations. Additionally, we hope you would instruct the Federal Highway Administration to have this letter included as an addendum to each State's Highway Action Plan, developed pursuant to 23 U.S.C. 109(h) and FHPM 7-7-1. Only with this broad distribution do we believe that the several administrative levels of a State highway agency will be cognizant of the contents of this letter and be able to work with you and us in expediting the planning process.

Thank you for your attention to this matter.

Sincerely,

Lewis D. Andrus

SECRETARY

cc: Council on Environmental Quality

United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, D.C. 20240

MAR 22 1999

PEP - ENVIRONMENTAL REVIEW MEMORANDUM NO. ERM99-2

To: Heads of Bureaus and Offices

From: Director, Office of Environmental Policy and Compliance

Subject: Interventions in Proceedings of the Federal Energy Regulatory Commission (FERC)

1. PURPOSE

This memorandum describes the procedures to be followed in the Department for intervention in the formal proceedings of FERC. These procedures are in accordance with 452 DM 2.3 A (1) and apply to hydroelectric power and natural gas projects under consideration by FERC.

2. POLICY

It is the Department's policy that FERC intervention actions are delegated to bureau Regional Directors and Regional Solicitors with only occasional elevations to headquarters as appropriate and as described in Part 4 below.

3. PROCESS

A. The Regional Director, or equivalent official, of a bureau requesting intervention will circulate a proposal to intervene (with supporting information) to the Regional Solicitor (RSOL), the Regional Environmental Officer (REO), and regional officials of other bureaus in the region. Bureau supporting information shall include the status of consultations with State, local, and other appropriate entities regarding their concerns with the project and their intervention intentions.

The initiating bureau usually arrives at a decision to seek intervention during the application review process conducted by the Office of Environmental Policy and Compliance (OEPC) under 516 DM 7. The initiating bureau should use the circulation list contained in the OEPC distribution memorandum. In some cases the initiating bureau may make a decision to seek intervention before or after the formal application review process. In these cases the initiating bureau is advised to consult with the REO to determine which other bureaus may have an interest in the matter.

B. The bureau circulation will request comments and recommendations from other bureaus within five working days. It

is the responsibility of the initiating bureau to deliver the circulation documents as expeditiously as possible. It is strongly recommended that hand delivery and fax transmission be used to meet this requirement. Timing is important because late filings at FERC require preparation of additional documentation to make a case for our late intervention. Late filings also mean the decision must be made by the Commission. The decision is automatic if the Department is on time.

C. Other bureaus may provide "no comment" responses to the initiating bureau by telephone. All substantive comments and recommendations in support or opposition shall use either hand delivery or fax transmission to meet the five working day requirement. If the initiating bureau receives no comment within the review period from a particular bureau, it may assume that there are no comments.

D. The RSOL will review the proposal for legal issues and advise the initiating bureau of these findings. This advice and the remainder of the regional record will form the basis of the later decision to (not to) intervene by the Office of the Solicitor.

E. The REO will review the proposal for intra-Departmental, Federal-State, or potential environmental policy issues and advise the initiating bureau of these findings. This advice and the remainder of the regional record will form the basis of the later decision to (not to) intervene by the Office of the Solicitor. The REO shall receive a copy of the record as supplied to the Office of the Solicitor whenever the REO has made substantive comments and/or recommendations.

F. Both sets of findings in "D." and "E.", along with other bureau comments, will serve to guide the initiating bureau regarding potential elevation within the Department. It is at this time that it should be clear whether or not elevation of the request within the Department is needed.

G. If no comments are received by the initiating bureau, that bureau will request the Office of the Solicitor to decide the issue and, if appropriate, file the intervention petition before the close of FERC's comment period.

H. If the initiating bureau and other bureaus determine that intervention is necessary and there are no inter-bureau conflicts, the initiating bureau will request, on behalf of other bureaus, the Office of the Solicitor to decide the issue and, if appropriate, file the intervention petition before the close of FERC's comment period.

I. If the initiating bureau and other bureaus determine that intervention is necessary and there are inter-bureau conflicts that cannot be resolved, the procedures in Part 4 below will be followed.

J. OEPC shall notify the Office of the Solicitor at the appropriate time of its concurrence (non-concurrence) with the intervention request in accordance with 452 DM 2.3 A (5). In most cases, this will likely occur under "E." above but may occur later in controversial cases where the record takes longer to develop.

K. The Office of the Solicitor shall keep track of all FERC intervention activities and include OEPC on the official service list for a copy of any intervention petition filed at FERC. This copy need only be furnished to OEPC headquarters for the central project file.

L. Post-licensing proceedings often involve compliance matters which provide limited time frames for Departmental responses. In such cases, the Office of the Solicitor is authorized to file intervention petitions as necessary to protect and advance the Department's interests in that project proceeding. Such interventions may be made on behalf of any bureau(s) for which the Department intervened in the underlying licensing proceeding, and are made with the concurrence of OEPC [452 DM 2.3A(5)]. Bureaus not seeking intervention in post-licensing matters may be removed from future intervention petitions by notice to the attorney of record.

4. ELEVATION AND CONFLICT RESOLUTION

A. Any intervention request may be elevated to headquarters for Secretarial or other senior management approval upon the recommendation of the RSOL or the REO acting through their respective headquarters' offices whether or not inter-bureau conflict is involved.

B. If bureau conflicts cannot be resolved in the field, the initiating bureau shall forward a request for resolution to the bureau director who will seek resolution with other bureau directors.

C. If resolution cannot be achieved by the bureau directors, the initiating bureau will seek resolution with the assistant secretaries and the Assistant Secretary-Policy, Management and Budget serving as the Department's Dispute Resolution Specialist will apply alternative dispute resolution techniques.

D. If necessary, any assistant secretary seeking to resolve an intervention issue and not fully satisfied with the dispute resolution process may request that the Secretary review the issue.

E. The Secretary may address bureau conflicts at any stage in this process and resolve the matter as he or she may determine to be appropriate.

F. Upon completion of the dispute resolution process, the

Office of the Solicitor will proceed with the filing of the intervention petition unless the decision was not to intervene.

5. REISSUE

This memorandum replaces ERM94-6.

United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, D.C. 20240

MAR 27 2000

PEP - Environmental Review Memorandum NO. ERM00-2

To: Heads of Bureaus and Offices

From: Director, Office of Environmental Policy and Compliance

Subject: Departmental Participation in Hydroelectric Power Licensing by the Federal Energy Regulatory Commission (FERC)

1. BACKGROUND AND PURPOSE

This memorandum supplements 516 DM 7. The Office of Environmental Policy and Compliance (OEPC) provides oversight, guidance, and process management for the Department's review of FERC applications and associated exhibits, studies, and environmental documents for hydroelectric projects covered by the Federal Power Act (FPA), as amended. Following an extensive Secretarial hydropower initiative (1998-2000) to improve bureau coordination, a number of existing Departmental policies and practices in this area were revised and a number of new policies and practices were introduced. In addition, measures are provided to coordinate legal and technical review and to assure the development of a sound administrative record in FERC licensing proceedings. Legal review for the Department is provided by the Office of the Solicitor (SOL).

The purpose of this memorandum is to provide additional information, policies, and procedures resulting from the Secretarial initiative and past practices to be used by all bureaus in the review of FERC applications. It is not intended to replace any other bureau procedural guidance and such guidance is recommended where necessary. Handbooks and other less formal guidance may be prepared, published, and utilized by bureaus so long as they do not conflict with this memorandum.

2. REISSUE

This memorandum has been revised and reissued as ERM00-2. ERM00-2 replaces ERM94-5 which is no longer applicable to Interior's hydropower review activity.

3. TYPES OF APPLICATIONS

This section outlines the types of applications commonly received from FERC during their conduct of a permitting, licensing or re-licensing action. Bureaus are cautioned to carefully track projects and comment at all appropriate times during the permitting and licensing processes. In

general, bureaus may rely on the distribution from OEPC of FERC notices and review documents to alert them of pending FERC developments. However, bureaus are also strongly urged to maintain local information on all hydroelectric projects at their field and regional offices so that they do not have to catch up on licensing actions further along in the process. In this regard, notices of intent to file for a new license which are issued by FERC approximately five years before license expiration are circulated by OEPC for information [see 5.D(2), below].

A. Preliminary Permit - An application for a preliminary permit is a voluntary action and is not a prerequisite to filing a license application. The permit grants a priority over other competing interests in applying for a project license during the permit period. The permit period may be up to three years. Permits are generally sought to study new projects or to add power to existing non-power projects (18 CFR 4.80-4.84). Because of the voluntary nature of the permit, any comments made by Interior on a permit do not automatically carry over to the licensing process. Preliminary permits carry standard consultation conditions set by FERC. FERC does not include any special conditions. Therefore, bureaus do not need to itemize conditions for the permit but should be ready to provide consultative advice regarding their programs, facilities, and missions. A preliminary permit does not grant the permittee unrestricted access to Federal lands and facilities or occupancy rights to disturb existing landscapes and natural resources. A bureau may independently contact a permittee for the purpose of advising that permission to enter Federal lands or facilities may be restricted or prohibited and may require a special use permit issued by the bureau and subject to the requirements of the National Environmental Policy Act (NEPA).

B. License - A license application is a request to construct, operate, and maintain a new hydroelectric project (original license) or to continue to operate a previously constructed hydroelectric project (new license or relicense) or to install and operate hydroelectric power facilities at an existing Federal or non-Federal dam or canal, including any directly associated transmission facilities. The type of license application depends on the size of the power installation with a major project license issued to any project with an installed capacity of more than 1.5 megawatts and a minor license issued for projects with installed capacity of 1.5 megawatts or less. FERC's licensing program also involves a number of other actions proposed by an applicant. These include: amendments to a project license, termination, surrender, transfer, or Federal capture of a project license and apply both to major and minor projects (18 CFR 4.40-4.71, 4.200-4.202, and 16.1-16.26).

Close attention must be given to licensing actions to ensure that the Department seeks the necessary terms and conditions in the license that will protect its program area of interest. We may oppose the issuance of a project license when the proposal would cause a serious and significant impact on our programs or projects, would conflict with an authorized project, or would conflict with a specific jurisdictional concern of the Department. If the license expires before a new license is issued and the United States does not exercise the right of take over, FERC issues annual licenses to the licensee under the terms and conditions of the existing license until the property is taken over or a new license is issued (18 CFR 16.18).

A license, like a preliminary permit, does not grant the permittee unrestricted access to Federal

lands and facilities or occupancy rights to disturb existing landscapes and natural resources. A bureau may independently contact a permittee for the purpose of advising that permission to enter Federal lands or facilities may be restricted or prohibited and may require a special use permit issued by the bureau and subject to the requirements of NEPA.

C. Exemptions from Licensing - The exemption process is less time consuming than the licensing process and leads to the construction and operation of the following types of projects which may be conditioned by FERC and the resource agencies. The exemption process is still considered a form of licensing and has strict fish and wildlife protection provisions. In both types of exemptions the Department has an opportunity to provide comments, recommended terms and conditions, and mandatory terms and conditions to protect resources managed by the Department. Exemptions do not have expiration dates.

(1) Small conduit hydroelectric facilities are projects with a total installed capacity of 15 megawatts or less on conduits located entirely on non-Federal lands (although it appears that the conduit itself may be federally owned) and not an integral part of a dam. FPA amendments raised this limit to 40 megawatts in the case of a facility constructed, operated, and maintained by an agency or instrumentality of a State or local government solely for municipal water supply. A standard article requires compliance with any terms and conditions determined appropriate to protect fish and wildlife resources by Federal or State fish and wildlife agencies identified within the comment period (18 CFR 4.90-4.96).

(2) Small hydroelectric projects are projects with a total installed capacity of 5 megawatts or less at existing, non-Federal dams or utilizing a natural water feature without the need for a dam or man-made impoundment. FPA amendments allow exemptions at new dams and diversions only if they do not have substantial adverse effects on the environment, are not located on protected river segments, and meet any mandatory terms and conditions set by Federal and State fish and wildlife agencies under the FPA. Standard articles require (a) compliance with any terms and conditions determined appropriate to protect fish and wildlife resources by Federal or State fish and wildlife agencies within the comment period and (b) any rights to use or occupy any Federal lands be obtained from the relevant land management agencies (18 CFR 4.101-4.108).

4. PROHIBITIONS, PRESCRIPTIONS, TERMS AND CONDITIONS, AND AGREEMENTS

A. Prohibitions - FERC is prohibited from issuing original licenses under Part I of the FPA (or exemptions from such Part) for any hydroelectric power project located within the boundaries of any unit of the National Park System that would have a direct adverse effect on Federal land within such unit or unless projects have been specifically authorized by Congress. The FERC is prohibited from issuing licenses for construction of hydroelectric projects on or having a direct and adverse effect on any river listed as a component of the National Wild and Scenic River System including potential additions to the system during such periods as the Wild and Scenic River Act provides. The FERC is also prohibited from licensing projects in wilderness areas under the jurisdiction of the Department of the Interior or in Federal reservations under Interior's supervision where FERC finds that the project will interfere or be inconsistent with the purpose

for which the reservation was created or acquired [16 U.S.C. 797(e)].

B. Mandatory Prescriptions

(1) Section 4(e) of the FPA requires FERC to accept any license terms and conditions, which the Secretary deems necessary for the protection and utilization of a reservation under the Department's supervision. The project must occupy land within the reservation. FERC will make a determination whether the project is consistent with the purpose(s) for which the reservation was created or acquired. Departmental reservations include such lands as Indian reservations, wildlife refuges, reclamation projects, acquired lands held for public purposes, and public lands withdrawn, reserved or withheld from private appropriation and disposal. The Department's comments will specifically identify any Section 4(e) conditions and be supported by substantial evidence in the record. It should be noted that Section 4(e) pertains to licenses, not permits; and the Department interprets it to pertain to those few unique circumstances where exemptible projects could occupy Departmental reservations. FERC states that Section 4(e) pertains only to licenses.

(2) Section 18 of the FPA requires FERC to accept any license terms and conditions for the construction, maintenance, and operation of such fishways as may be prescribed by the Secretary. Departmental comments will specifically identify any Section 18 prescriptions and be supported by appropriate fisheries information and substantial evidence in the record. Further, when the Department cannot establish the need for fishways at the time of licensing, it may exercise its Section 18 authority by reserving the authority to prescribe fishways in the future. In post-licensing situations, either a specific reservation of authority to prescribe or a standard FERC "L-Form" article (Article 15) provides our access for Section 18 prescriptions and can be supplemented by any case-specific, non-standard articles we provide during our review.

(3) Section 30(c) of the FPA pertains to exemptions from licensing and requires FERC to accept such terms and conditions as the FWS determines are appropriate to prevent loss of or damage to fish and wildlife resources and to otherwise carry out the purposes of the Fish and Wildlife Coordination Act. This is interpreted by the Department to include recreational fishing access. Departmental comments will specifically identify any Section 30(c) conditions provided by the FWS and the underlying bases for making them, along with substantial evidence in the record.

C. Recommended Terms and Conditions

(1) Section 10 of the FPA allows FERC to prescribe terms and conditions within any permit or license for a number of reasons. The FERC has established a number of standard articles that are included in all permits and licenses (the L-Forms). In addition, the Department has the right and responsibility under its various authorities to recommend to FERC other non-standard terms and conditions for its consideration. The FERC uses a number of typical articles which provide uniformity for non-standard terms and conditions recommended by Federal agencies. The Department's comments will transmit its recommended terms and conditions, including the underlying bases for making them, along with substantial evidence in the record.

FERC will consider our recommendations, but may or may not accept them or will accept them with modifications. The FERC order issuing a license discusses its disposition of any Departmental recommendations.

(2) Exemptions from licensing are also subject to standard and discretionary terms and conditions issued by FERC. The Department can and should, where appropriate, recommend non-standard terms and conditions for these exemptions in areas other than fish and wildlife resources which are mandatory under Section 30(c). The situation is similar to Section 10 and FERC will consider our recommendations, but may or may not accept them or will accept them with modifications.

(3) Section 10 also has a provision for the protection, mitigation, and enhancement of fish and wildlife resources. FERC is required to base such conditions on the recommendations of Federal and State fish and wildlife agencies. When disagreements arise, FERC is required to attempt to resolve the disagreements with these agencies. If resolution cannot be obtained and FERC does not adopt the agency recommendations, FERC must publish its findings that such conditions are inconsistent with the FPA and/or the conditions selected by FERC comply with Section 10(j)(1) of the FPA.

D. Agreement About Reclamation Facilities - The Department is agreeable, under certain conditions, to the development of hydropower by non-Federal entities at Reclamation projects provided that (1) it is compatible with the authorized purposes of the Reclamation project and (2) power generation is not an authorized purpose of the Reclamation project.

A Memorandum of Understanding (November 6, 1992) provides a process by which FERC and Reclamation resolve issues related to licensing authority at Reclamation facilities. Reclamation and FERC will attempt to resolve issues related to licensing authority in advance of the issuance of any notice by FERC. If FERC proceeds with issuance of a public notice and jurisdiction remains at issue, Reclamation may re-assert jurisdiction, with or without comments, recommendations, and Section 4(e) terms and conditions, under Departmental review procedures contained in this memorandum.

A Memorandum of Understanding (June 22, 1981) provides for the establishment of construction criteria and selected working relationships with FERC when non-Federal projects are licensed at Reclamation projects. However, it does not recognize the Secretary's authority to mandate conditions pursuant to Section 4(e) of the FPA. Departmental comments will specifically identify any such conditions provided by the Bureau of Reclamation.

5. CONSULTATION AND REVIEW PROCEDURES

A. Pre-Application Consultation - FERC requires all applicants for a license or exemption from licensing to consult with each appropriate Federal and State resource agency before submitting its application (18 CFR 4.38). Consultation consists of the following:

(1) First Stage - Applicant provides detailed maps, general engineering design,

proposed operational mode, environmental setting and mitigation to the extent known, streamflow information, and detailed descriptions of any proposed studies. The first stage consultation ends when resource agencies and Indian Tribes have timely filed their comments and recommendations [18 CFR 4.38(b)(6)].

(2) Second Stage - Applicant conducts all reasonable studies and obtains all reasonable information requested by the resource agencies and Indian Tribes. The second stage consultation ends ninety days after the applicant supplies draft application documents to the resource agencies and Indian Tribes [18 CFR 4.38(c)(10)] or at the conclusion of the last joint meeting held in cases where a resource agency or Indian Tribe has responded with substantive disagreements.

(3) Third Stage - Applicant files the application documents with FERC [18 CFR 4.38(d)]. The applicant must also file copies of the application with the resource agencies. This is the only mailing bureaus will receive. Bureaus are strongly advised to save these copies because it may be some time before the application is ready for formal review and the OEPC review request is issued. Similar requirements for applicants for new licenses at existing facilities (relicense applications) are found at 18 CFR 16.8. In response to application filing, FERC will issue a tendering notice inviting comments on the application and the need for any further studies to be done. Following that FERC will issue a notice accepting the application for filing and inviting comments, protests, and motions to intervene.

B. Bureau Review - Bureaus will be involved in all three stages of consultation as necessary to protect their program interests and to develop the Department's complete position on a particular project.

C. Legal Review - In order to ensure the development of a strong, defensible administrative record for all FERC licensings, bureau responses to FERC requests need to be consistent with one another, and with Department policy. To achieve this, the Department must work to identify bureau interests, coordinate bureau comments where there are cross-Department issues, and routinely subject those comments to legal review. Since the FERC licensing process is quasi-judicial, the Department has adopted policies to insure that adequate legal review of its submissions to FERC is carried out.

(1) For every licensing project, the Solicitor's Office will designate an Attorney Point of Contact (also, Designated Attorney) at the beginning of the licensing process (i.e., during first stage consultation) for the provision of general legal advice throughout that process. The Attorney Point of Contact is likely to become the "Attorney of Record" for the project if the Department intervenes in FERC's process. At the client's request and within resource constraints, the Designated Attorney will provide legal representation and legal review of draft comments submitted to FERC or the applicant through the Departmental review process. SOL will keep OEPC informed of these Attorney Points of Contact and Attorneys of Record so that the attorney can be identified on all OEPC distribution memoranda.

(2) Bureaus will provide the Office of the Solicitor three business days for informal

legal review of all bureau tendering and scoping comments before bureaus submit those comments to FERC. Bureaus will fax those draft comments to the appropriate Solicitor's Office at least one week before the FERC deadline in order to allow sufficient time for possible revisions.

D. Departmental Review

(1) The first and second stages of consultation will occur at regional and field offices of the Department's bureaus with assistance provided by the Regional Environmental Officers (REO) upon request. The third stage filing is the point where OEPC assumes process management of the Department's review in accordance with this section. The OEPC will initiate third stage review activities whenever it has an official notice from FERC announcing that:

- the application is accepted for filing and invites comments, protests, and interventions;
- the application is "not ready for environmental analysis" but invites intervention in the proceeding;
- and/or the application is "ready for environmental analysis".

Any bureau on the OEPC review request not in receipt of copies of the application should call the applicant's contact noted in the FERC notice and request those copies. It is not likely that OEPC will have any extra copies since OEPC will have already distributed those copies in its possession. Copies are often available electronically on CD-ROM and over the Internet at FERC's web site. The notices generally give an Internet address.

(2) All bureaus receive FERC's notices of intent to file for a new license, which is required five years before license expiration, via the environmental review system. This action gives bureaus notice that they may need to determine the importance of a project, develop a bureau position, and track its progress through the FERC process. It is recommended that bureaus begin working with applicants as early as possible after this notice of intent to insure full consideration of their resource concerns.

(3) Bureaus should recommend that any studies needed to define and mitigate impacts to our properties and resources be completed prior to issuance of a license unless such studies are dependent on post construction operations. Bureaus are also encouraged to make study requests during pre-filing consultation and whenever a tendering notice is issued so studies are completed and available for use in developing terms and conditions and recommendations.

(4) OEPC is the focal point for Departmental receipt, review, and comment on policies, regulations, and project applications of FERC. OEPC maintains all necessary databases to assist bureaus in tracking and reviewing critical FERC projects.

(a) All applications and other matters that may affect more than one bureau or the policy interests of the Secretary will be controlled by OEPC. In this regard OEPC may designate reviewing and lead bureaus, review schedules, and the responsible office for forwarding comments to FERC. Upon request OEPC also revises these designations as necessary when brought to its attention by bureau personnel or others.

(b) Post-review process issues of interest to a single bureau are usually assigned to that bureau with only a requirement to keep OEPC informed of the results. Examples include Section 10(j) fish and wildlife consultation where recommendations previously transmitted to FERC via the Departmental comment letter are later resolved by FWS and FERC at the field level and any other single bureau issue occurring later than the date of the Department's comments. It is recommended that the REO be consulted if there is any doubt about a single bureau issue. The REO can assist in coordinating a reply if other bureaus are involved. For legal review, bureaus should maintain contact with and seek the advice of the Designated Attorney or the Attorney of Record.

(c) As a general rule OEPC will assign projects five megawatts or less in capacity to REOs for signature and projects larger than five megawatts to headquarters, with controversial issues referred as necessary to the Assistant Secretary-Policy, Management and Budget or other senior policy officials. Projects known or later found to occupy National Park System lands are assigned to headquarters. Projects known or later found to occupy Federal reservations may be assigned to headquarters depending on the policy nature of the issue.

(5) OEPC forwards to the bureaus, through the environmental review (ER) system, certain FERC notices it retrieves from the Internet. This provides a significant time saving over waiting for FERC's mailing of the notices. Bureaus receiving notices via the Internet or any other means must always check with their ER staff and/or OEPC to determine if a control number has been assigned and to receive review instructions if not previously made available.

(6) As soon as memoranda regarding FERC notices are ready for distribution, OEPC will forward, via fax, certain time-sensitive project notices directly to the appropriate bureau reviewers in the field. This is another time saving practice utilized for the following types of notices:

- Applications Tendered and Requesting Additional Studies
- Notice of Filing Accepted
- Notice of Scoping, Scoping Meetings, Scoping Documents, etc.
- Notice of Request to Intervene
- Applications Ready for Environmental Analysis
- Notices of Draft or Final Environmental Assessments or Statements

OEPC will maintain a current list of field office fax numbers for this purpose.

(7) In its licensing process FERC (rather than the applicant) must consult with the Department pursuant, but not limited, to the following statutes and subordinate regulations, directives, or procedures.

- Federal Power Act
- Water Resources Planning Act
- Wild and Scenic Rivers Act
- Fish and Wildlife Coordination Act
- Endangered Species Act
- National Historic Preservation Act
- National Environmental Policy Act

(8) In addition, the Department may have additional jurisdiction over all or portions of a FERC hydroelectric project pursuant, but not limited, to the following statutes:

- Reclamation Law
- Federal Land Policy and Management Act
- Alaska Native Claims Settlement Act
- Alaska National Interest Lands and Conservation Act
- National Park Service Organic Act
- National Wildlife Refuge System Administration Act
- Land and Water Conservation Fund Act
- Urban Park and Recreation Recovery Act
- Federal Property and Administrative Services Act
- Recreation Demonstration Project Act
- National Trails System Act
- Mining Law of 1872

E. Alternative Administrative Process

(1) This is a parallel process to the three stage consultation process (see 18 CFR 4.34 and related modifications to existing sections of FERC's rules). It is also known as the "collaborative process" and "alternative licensing process".

(2) OEPC notices will identify use of the collaborative process by an applicant through the ER system. Appropriate instructions will be outlined in the distribution memoranda.

(3) Bureaus must be aware of the requirements of this process so that they can use and participate in this process to its fullest extent and understand its larger demand on their field resources.

(4) REOs may facilitate Interior's participation in this process if requested and if time permits.

6. TIME PERIODS FOR DEPARTMENTAL REVIEW

A. Permits - The FERC rules do not specify a review period. The notice from FERC announcing the permit will indicate a review period, and it is usually 60 days. Time extensions are not routinely sought on permit applications because FERC issues all permits with a set of standard conditions requiring the permittee to consult with all agencies concerned with natural resources and environmental matters.

B. Licenses and Exemptions - FERC regulations state that all review comments and recommendations and mandatory terms and conditions and prescriptions are due to FERC no later than 60 days after FERC announces the application as being "ready for environmental analysis". Extensions may be granted by FERC for good cause or extraordinary circumstances. Therefore, the OEPC review request will specify a firm date for response by bureaus to the lead bureau and to OEPC. All comments and recommendations received by that date will be considered for the Departmental letter. Any comments and recommendations received after that date may be considered for a supplemental letter to FERC.

C. Time Extensions - OEPC will seek time extensions based upon a written request from an REO or any reviewing bureau. All such requests must provide the reason(s) for the extension. These requests may be electronically transmitted to OEPC.

7. INTERVENTION

A. Intervention is the legal process by which the Department becomes a formal party to FERC's quasi-judicial process and establishes its right to appeal permits, licenses, and exemptions and associated terms and conditions once they are issued. Petitions to intervene and subsequent proceedings are processed by the Solicitor's Office.

B. Procedures for requesting intervention in FERC's proceedings are found in 452 DM 2. Reviewers should follow the additional guidance found in ERM99-2.

8. NATIONAL HYDROPOWER MEETING

To assist in managing the Department's activities relating to hydropower licensing, the Department will hold an annual hydropower meeting for the appropriate Departmental bureaus and staff. The meeting's main purposes are: (1) to foster discussions among bureaus and other Departmental offices on broad policy matters relating to FERC hydropower licensing and (2) to identify, discuss, and prepare for those hydropower projects of critical importance to the Department in the coming year. This meeting is subject to the availability of funding and a willing bureau sponsor.

PROPOSED REVISED PROCEDURES

DEPARTMENT OF THE INTERIOR
DEPARTMENT MANUAL

516 DM 2
Appendix 1

Chapter 2; Appendix 1

Departmental Categorical Exclusions

The following actions are CX's pursuant to 516 DM 2.3A(2). However, environmental documents will be prepared for individual actions within these CX if any of the extraordinary circumstances listed in 516 DM 2, Appendix 2, apply.

1.1 Personnel actions and investigations and personnel services contracts.

1.2 Internal organizational changes and facility and office reductions and closings.

1.3 Routine financial transactions including such things as salaries and expenses, procurement contracts (in accordance with applicable procedures for sustainable or "green" procurement), guarantees, financial assistance, income transfers audits, fees, bonds, and royalties.

1.4 Departmental legal activities including, but not limited to, such things as arrests, investigations, patents, claims legal opinions. This does not include bringing Judicial or administrative civil or criminal enforcement Actions which are already excluded in 40 CFR 1508.18 (a).

1.5 Nondestructive data collection, inventory (including field, aerial, and satellite surveying and mapping), study, research and monitoring activities.

1.6 Routine and continuing government business, including such things as supervision, administration, operations, maintenance, renovations, and replacement activities having limited context and intensity (e.g., limited size and magnitude or short-term effects).

1.7 Management, formulation, allocation, transfer, and reprogramming of the Department's budget at all levels (This does not exclude the preparation of environmental documents for proposals included in the budget when otherwise required.)

1.8 Legislative proposals of an administrative or technical nature (including such things as changes in authorizations for appropriations, minor boundary changes, and land title transactions) or having primarily economic, social, individual or institutional effects; and comments and reports on referrals of legislative proposals.

1.9 Policies, directives, regulations, and guidelines that are of an administrative, financial, legal, technical, or procedural nature and whose environmental effects are too broad, speculative, or conjectural to lend themselves to meaningful analysis and will later be subject to the NEPA process, either collectively or case-by-case.

1.10 Activities which are educational, informational, advisory, or consultative to other agencies, public and private entities visitors, individuals, or the general public.

1.11 Hazardous fuels, reduction activities using prescribed fire not to exceed 4,500 acres, and mechanical methods for crushing, piling, thining, pruning, cutting, chipping, mulching, and mowing, not to exceed 1,000 acres. Such activities: Shall be limited to areas (1) in wildland-urban interface and (2) Condition Classes 2 or 3 in Fire Regime Groups I, II, or III, outside the wildland-urban interface; Shall be identified through a collaborative framework as described in "A Collaborative Approach for Reducing Wildland Fire Risks to Communities and the Environment 10-year Comprehensive Strategy Implementation Plan;" Shall be conducted consistent with agency and Departmental procedures and applicable land and resource management plans; Shall not be conducted in wilderness areas or impair the suitability of wilderness study areas for preservation as wilderness; Shall not include the use of herbicides or pesticides or the construction of new permanent roads or other new permanent infrastructure; and may include the sale of vegetative material if the primary purpose of the activity is hazardous fuels reduction.

1.12 Post-fire rehabilitation activities not to exceed 4,200 acres (such as tree planting, fence replacement, habitat restoration, heritage site restoration, repair of roads and trails, and repair of damage to minor facilities such as campgrounds) to repair or improve lands unlikely to recover to a management approved condition from wildland fire damage, or to repair or replace minor facilities damaged by fire. Such activities: Shall be conducted consistent with agency and Departmental procedures and applicable land and resource management plans; shall not include the use of herbicides or pesticides or the construction of new permanent roads or other new permanent infrastructure, and shall be completed within three years following a wildland fire.*

* Refer to the Environmental Statement Memoranda Series for additional, required guidance

PROPOSED REVISED PROCEDURES

DEPARTMENT OF THE INTERIOR
DEPARTMENT MANUAL

516 DM 2
Appendix 2

Chapter 2; Appendix 2

Categorical Exclusions; Extraordinary Circumstances

Extraordinary circumstances exist for individual actions within CXs which may:

2.1 Have significant adverse effects on public health or safety.

2.2 Have adverse effects on such natural resources and unique geographic characteristics as historic or cultural resources; park, recreation or refuge lands; wilderness areas; wild or scenic rivers; national natural landmarks; sole or principal drinking water aquifers; prime farmlands; wetlands (Executive Order 11990); floodplains (Executive Order 11988); national monuments; and other ecologically significant or critical areas.

2.3 Have highly controversial environmental effects or involve unresolved conflicts concerning alternative uses of available resources [NEPA Section 102 (2) (E)].

2.4 Have highly uncertain and potentially significant environmental effects or involve unique or unknown environmental risks.

2.5 Establish a precedent for future action or represent a decision in principle about future actions with potentially significant environmental effects.

2.6 Be directly related to other actions with individually insignificant but cumulatively significant environmental effects.

2.7 Have adverse effects on properties listed, or eligible for listing, in the National Register of Historic Places.

2.8 have adverse effects on species listed, or proposed to be listed, on the List of Endangered or Threatened Species, or have adverse effects on designated Critical Habitat for these species.

2.9 Have the potential to violate a Federal law, or a State, Local, or tribal law or requirement imposed for the protection of the environment.

2.10 Have the potential for a disproportionately high and adverse effect on low income or minority populations (Executive Order 12898).

2.11 Restrict access to and ceremonial use of Indian sacred sites by Indian religious practitioners or adversely affect the physical integrity of such sacred sites (Executive Order 13007).

2.12 Significantly contribute to the introduction, continued existence, or spread of noxious weeds or non-native invasive species known to occur in the area or actions that may promote the introduction, growth, or expansion of the range of such species (Federal Noxious Weed Control Act and Executive Order 13112).

United States Department of the Interior

FISH AND WILDLIFE SERVICE

WASHI

NGTON, D.C. 20240

ADDRESS ONLY THE DIRECTOR.
FISH AND WILDLIFE SERVICE

In Reply Refer To:
FWS/DHC/BFA APR 6 1993

Memorandum

To: Service Directorate

From: Deputy Director

Subject: The Fish and Wildlife Service and the National Environmental Policy Act

On March 1, 1993, Secretary Babbitt asked all bureaus in the Department of the Interior (Department) to rededicate their commitment to the policy set forth in the National Environmental Policy Act of 1969 (NEPA), with a view toward effective conservation and environmental protection (copy attached). I strongly support the Secretary's commitment.

The Fish and Wildlife Service (Service) leads the Department in providing careful scrutiny and review of other Federal agency proposals during external reviews. The purpose of these reviews by Service field and Regional offices is to assist other agencies to adequately consider fish and wildlife resources in their proposals and to incorporate measures to protect and enhance resources under our stewardship. I strongly urge you to provide your comments to other agencies early in their scoping process to seek avoidance and potential resolution of conflicts. By providing clear, concise, and detailed comments on agency "notices of intents," we can be instrumental in the early resolution of important concerns on wetlands, endangered species, migratory birds, and anadromous fish.

I strongly urge you to effectively utilize the planning and decision making functions of NEPA in the execution of Service proposals. Your plans should reflect the Service's commitment to meeting the twin objectives of NEPA: (1) the careful consideration of detailed information on significant environmental impacts before decision making; and (2) recognition of the important role of the public in both the decision making process and the implementation of that decision. These objectives embody the principles of NEPA to make better environmental decisions.

Our renewed attention to making effective use of NEPA will further the resource programs of the Service and of the Department.

Attachment IN-9

U.S. DEPARTMENT OF INTERIOR, FISH AND WILDLIFE SERVICE

RECORD OF DECISION

SOUTH TONGUE POINT LAND EXCHANGE AND MARINE INDUSTRIAL PARK DEVELOPMENT PROJECT CLATSOP COUNTY, OREGON

This Record of Decision (ROD) has been developed by the U.S. Fish and Wildlife Service (Service) in compliance with the agency decision-making requirements of the National Environmental Policy Act (NEPA) of 1969, as amended. The purpose of this ROD is to document the decision of the Service for the selection of an alternative for implementing the South Tongue Point Land Exchange and Marine Industrial Park Development Project (Project). Alternatives have been fully described and evaluated in the May 1994, Final Environmental Impact Statement (EIS) for the Project.

This ROD is designed to: a) state the Service's decision, present the rationale for its selection, and portray its implementation; b) identify the alternatives considered in reaching the decision; and c) state whether all means to avoid or minimize environmental harm from implementation of the selected alternative have been adopted (40 CFR 1505.2).

Based upon the review of the alternatives and their environmental consequences described in the Final EIS for the Project, the decision of the Service is to implement Alternative A, the Preferred Alternative. The selected action entails the transfer of lands under Federal administration for lands under Oregon State administration. Former State lands will be conveyed to the Service=s Lewis and Clark National Wildlife Refuge (Refuge). The State of Oregon will sponsor the development of a marine industrial park by on the former Federal lands.

Timing of implementation of various components of the project will occur based on funding and the availability of personnel and other resources. The Project's land exchange component is expected to enhance habitat and wildlife protection on the Refuge. The Project's development component is expected to create real property assets and associated income for the Common School Fund of the State of Oregon, encourage new industrial employment within the South Tongue Point area

For further information, please contact: Ben Harrison, U.S. Fish and Wildlife Service, 911 NE llth Avenue, Portland, Oregon 97232-4181, telephone: (503) 231-2231.

PROJECT DESCRIPTION

The U.S. General Services Administration (GSA) is proposing to convey approximately 130 acres of upland and submerged lands administered by the U.S. Army Corps of Engineers (Corps) to the Division of State Lands (Division), an agency of the State of Oregon. In exchange for the Federal land, the Division is proposing to convey approximately 3,930 acres of State-owned land within the administrative boundary of the Refuge to GSA, which will in turn transfer those lands to the Service..

Under the proposed land exchange, the Service would gain fee title ownership to certain lands within the administrative boundary of the Refuge which would provide a more substantial and durable means of protecting wildlife resources from incompatible uses. Other State administered lands within the Refuge will be managed by the Service under a long-term cooperative management agreement with the Division. The Division has proposed to develop a multi-tenant marine industrial park on the property conveyed to it.

KEY ISSUES

Through public scoping and with input from various agencies and publics, key issues were identified. These focused on the following subject areas: 1) certain aspects of the physical environment, especially the potential for hazardous materials to be released from local sediments; 2) certain aspects of the biological environment, especially wetlands and threatened and endangered species; and 3) certain aspects of the cultural and social environment, especially the local and regional economy. These factors were also examined for the State-owned islands proposed as additions to the Refuge. These issues were thoroughly examined in the Draft and Final EIS.

ALTERNATIVES

More than 20 alternatives were considered before limiting the alternatives to be advanced for further study. Alternatives considered but not advanced for detailed analysis included alternative development concepts, alternative sites, and single versus multi-tenant developments. Alternatives advanced for detailed analysis include (A) the proposed land exchange and development of a multi-tenant marine industrial development; (B) the proposed land exchange and multi-tenant marine industrial development with connecting road to North Tongue Point; and (C) a No Action Alternative. Adverse and beneficial impacts of each alternative are considered.

Alternative A

Alternative A comprises two elements: (1) the land exchange, and (2) the multi-tenant marine industrial development.

(1) Approximately 3,930 acres of State-owned land within the administrative boundary of the Lewis and Clark National Wildlife Refuge would be exchanged through GSA to the

service for the 130 acres on South Tongue Point. The remaining 950 acres would be managed under a long-term cooperative agreement between the Division and the Service.

(2) Development of the multi-tenant marine industrial site would occur in two phases. Phase 1 would involve site infrastructure developments and construction of marine industrial facilities. Construction would begin in 1994 and occur at a rate supported by market conditions.

Alternative B

Alternative B comprises the same two elements as Alterative A with the addition, in Phase 2, of a road connecting South Tongue Point to North Tongue Point. Construction of the connecting road would be dependent upon the need for additional land to support marine industrial development and increased port activities at North Tongue Point.

Alternative C

With the No Action Alternative, South Tongue Point would remain in its present. undeveloped condition except for the existing Corps Field Station. There would be no land exchange. The No Action Alternative would not have direct adverse impacts to the physical and biological environment. However, the No Action Alternative would not have direct economic benefits from job creation and tax revenues.

DECISION

The Service's decision is to implement the Preferred Alternative, Alternative A, as it is described in the Final EIS for the South Tongue Point Land Exchange and Marine Industrial Development Project. This decision is based on a thorough review of the alternatives and their environmental consequences.

Other Agency Decisions

A Record of Decision will be produced by the Corps. The responsible officials at the Corps will adopt the Final EIS as part of the permit process required by Section 404 of the Clean Water Act.

A Record of Decision will be produced by GSA. The responsible officials at GSA will adopt the EIS in order to comply with National Environmental Policy Act requirements for the disposal and exchange of Federal properties.

RATIONALE FOR DECISION

The Preferred Alternative has been selected for implementation based on consideration of a number of environmental and social factors. Alternative A has been selected as the preferred. alternative because: 1) the land exchange provides the most durable means for protecting wildlife habitats and enhancing wildlife populations; 2) the development component avoids

significant adverse environmental impacts; and 3) the project will result in significant economic benefits in a economically depressed area.

Alternative A was selected because it balances resource protection with water dependent development. The preferred alternative provides a net benefit for wildlife and benefits for the local economy. The land exchange is the most practical means available to secure and protect additional lands from incompatible uses within the administrative boundary of the Refuge. Migratory bird and resident wildlife populations will benefit from additional secure habitat and be enhanced through wildlife management programs which could not be without fee title ownership. The. development component has been carefully designed to minimize adverse environmental effects. Wintering bald eagles will benefit from compensatory measures designed to enhance foraging opportunities. A net gain in wetlands will be realized through successful implementation of mitigation measures.

Implementation of the Preferred Alternative extends the protection of the environmental resources and maintenance of environmental quality beyond what would be achieved under either of the other two alternatives. Alternative B was not selected as the preferred alternative due to the significant impacts expected to resident bald eagles. Alternative C, the No Action Alternative, was not selected as the preferred alternative because, it would not result in the Service increasing habitat protection within the Refuge.

Marvin L. Plenert, Regional Director
Date6/20/94

ENVIRONMENTAL QUALITY

Fish and Wildlife Service

Record of Decision; Black-Footed Ferret Reintroduction Conata Basin/ Badlands, SD

AGENCY: Fish and Wildlife Service

ACTION: Notice.

SUMMARY: Pursuant to regulations* promulgated by the Council on Environmental Quality *(40 CFR 1505.2)* and the implementing procedure of the U.S. Fish and Wildlife Service for the National Environmental Policy Act of *1969 (40 U.S.C. 1501* et seq.). the Department of Interior has p record of decision on the *F0 South Dakota.* Environmental *Impact Statement, Black-Footed Ferret* Reintroduction, Conata Basin/Badlands, South *Dakota.*

The record of decision is a concise statement of what decisions were made, BGNG (No Action). BGNG and their progeny will be classified as a nonessential experimental population under Federal rule making requirements.

Other Alternatives Considered

Five alternatives, including the preferred alternative, were analyzed in the final environmental impact statement. All action alternatives propose to reintroduce black-footed ferrets as a nonessential experimental population. The alternatives included: Alternative A-Black-footed ferrets would not be reintroduced into BNP or the Conata Basin/Badlands area near Wall, South Dakota as described in Alternative C in the Final Environmental *Impact* Statement, Black-Footed Ferret Reintroduction. Alternative B-Black-footed ferrets would be released only in BNP in a reintroduction area of appr6dmately *25.000* acres which contains about 3.200 acres of prairie dog colonies. *Alternative* D-Reintroduce black-footed ferrets into a *42,000* acre reintroduction area on BNP and BGNG and their progeny will be classified as a nonessential experimental population under Federal rule making requirements.

mean to avoid or minimize environmental impacts that could result from implementation of the preferred plan have been identified and are considered acceptable.

Decision

The Fish-and Wildlife Service will accept the proposed action to release captive reared black-footed ferret$ into. Conta Basin Badlands. South *Dakota.* After careful evaluation of each alternative and considering the issues of public response; legislative intent; management objectives; and Cost. socioeconomic. and environmental impact statement. The Service considers that all practicable

what alternatives were considered, and with initial releases in BGNG.
effects, the Fish and Wildlife Service
acceptable mitigation manures believes that the proposed
action
represents the most balanced
course of
approximately *8,000*
management of the
This reintroduction effort is an black-footed
ferret.
Alternative E-
Release black-footed **21,1994.**
Is
feints into a in.000 acre
Service. and the Forest Service. Each
BGNG Robert D. Jacobsen
consisting of the entire north unit of the***Acting Regional Director, M***
1973. as ***States region.***
over threatened and (FR Doc.
94-IS478 6-24-94; 41:45 SMI
this initial. The initial black-footed ""4 **4"O'W-m**
prepare a separate record of decision to
the most
cover its respective responsibilities itable habitat within the
under the reintroduction program.
The Selected Alternative Environmentally Preferable Alternative
The Fish and Wildlife Service
C. releases black-footed ferrets consider Alternative E to be the
most
environmentally preferred
alternative.
The levels of active prairie dog
habitat
(16.997 he)
Alternatives C
on the Badlands National Park (BNP)
and the Buffa Gap National Grassland potential risks to the black-footed ferret
measures
occur an the BNP. This area contains
approximately 8.000 acres *(3,238* and trapping restriction and possible
black-tailed prairie dog colonies. A
an
nonessential experimental population
area of approximately 1.282.200 acres isAlternative C was selected bemuse it
program that
a

of the black-footed ferret is chaige from endangered to nonessential experimental to allow for greater additional management flexibility. AH of the proposed reintroduction area is public land administered by either the National Park Service or the Forest Service.

The purpose of the proposed action is to use experimental techniques to reintroduce and establish a free cooperatively managed wild population of black-footed ferrets in the Conata Basin/Badlands experimental population area near Wall. South Dakota. The released black-footed ferrets am

compatible with the existing recreational and agricultural land uses in the area thereby garnishing support. It is the Fish and Wildlife Ser-Ace's assessment that the benefits of additional support outweigh the possible benefits of extending land use restrictions associated with the expanded reintroduction area of Alternative E.

~ minimization of Impacts

Public concerns. potential impacts, and methods to mitigate those impacts addressed in the final environmental

REVISED FINDING OF NO SIGNIFICANT IMPACT
PROPOSED LAND ACQUISITION FOR NATIONAL EDUCATION AND

VICINITY OF HARPER'S FERRY, WEST VIRGINIA

acquire property near Shepherdstown, West Virginia, for the

An Environmental Assessment (EA) was prepared which addressed

alternative (copy enclosed). The acquisition of a selected site

construct a facility that would provide a training center for

the site would accommodate a development envelope of at least 250

Federal, State., and local plans and requirements.

Impact (FONSI) was published in the Federal Register on July 9,

B Driggs (Quarry) and Springs Run. 'However, due to the difficulty in remediating minor contamination on the site, the Service has determined that it is not in the best interest of the government to acquire Site E.

The new selected alternative is Site D -- Terrapin Neck. Site D is located approximately three miles north of Shepherdstown, West Virginia. The Potomac River serves as the northern boundary, with Terrapin Neck Road to the east, and Shepherd Grade Road bordering the southwestern sections of the site. The site occupies approximately 525 acres and is comprised of forested land, agricultural land, and open fields.

Site D was selected because it has many of the amenities which would be supportive of the NCTC goal. The picturesque site overcooks the Potomac River Valley and is surrounded by a diversity*of habitats. Several 18th and 19th century buildings occur on the site that will be maintained for their historical value. Community acceptance of Site D is anticipated to be good. Except for several debris piles containing minor, former farm related refuse, no other hazardous materials or-evidence of other contaminants occur on the property. Although some minor improvements may be needed, the capacity of existing roadways appears adequate. We anticipate no adverse impacts to State or Federal rare, threatened, or endangered species that may occur on the site.

The other land acquisition alternatives considered were the Gibson and Capriotti Properties, Cooper Farm, Nalls Property, Driggs (Quarry)/Springs Run, and no-action.

The previous plan to include a public education (habitat) component to theNCTCC has been dropped.

A small portion of reverie wetlands system is located in the northern part of the site and a small pond occurs near the farm buildings, but all reasonable alternatives were considered in the evaluation of this project. Any project-caused wetland and flood plain impacts will be minor to negligible. The project complies with the provisions of Executive Orders 11988 and 11990.

Based on my review and evaluation of the enclosed Environmental Assessment and other supporting documentation, I have determined that the acquisition of Site D for the Service's National Education and Training Center is not.. a major Federal action which would significantly affect the quality of the. human environment within the meaning of Section 102(2)(C) of the National Environmental Policy Act of 1969. Accordingly, preparation of an environmental impact statement on the proposed action is not required.

Director
Acting
FEB 2 0 1992
Date

Reference:
Environmental Assessment, dated December 1990

Enclosure

xhibit

UNITED STATES FISH AND WILDLIFE SERVICE
ENVIRONMENTAL ACTION STATEMENT

Within the spirit and intent of the Council on Environmental Quality's regulations for implementing the National Environmental Policy Act (NEPA), and other statutes, orders, and policies that protect fish and wildlife resources, I have established the following administrative record and determined that the action of (describe action):

Check One:

is a categorical exclusion as provided by 516 DM 2, Appendix 1 and 516 DM 6, Appendix 1. No further NEPA documentation will therefore be made.

is found not to have significant environmental effects as determined by the attached environmental assessment and finding of no significant impact.

is found to have significant effects and, therefore, further. consideration of this action will require a notice of intent to be published in the Federal Register announcing the decision to prepare an EIS.

is not approved because of unacceptable environmental damage, or violation of Fish and Wildlife Service mandates, policy, regulations, or procedures.

is an emergency action within the context of 40 CFR 1506.11. Only those actions necessary to control the immediate impacts of the emergency will be taken. Other related actions remain subject to NEPA review. Other supporting documents (list): Signature Approval

(1) Originator Environmental Date	Date	(2) WO/RO Coordinator
(3) AWARD Date	Date	(4) Director/Regional Director

[Federal Register: January 16, 1997 (Volume 62, Number 11)]
[Notices]
[Page 2375-2382]
From the Federal Register Online via GPO Access [wais.access.gpo.gov]
[DOCID:fr16ja97-40]

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DEPARTMENT OF THE INTERIOR

National Environmental Policy Act Revised Implementing Procedures

AGENCY: Department of the Interior.

ACTION: Notice of Final Revised Procedures for the Fish and Wildlife Service (Service).

SUMMARY: This notice announces final revised procedures for implementing the **National Environmental Policy Act** (NEPA) for actions implemented by the Fish and Wildlife Service in Appendix 1 in the Department of the Interior's (**Departmental**) **Manual** (**516 DM 6**). The revisions update the agency's procedures, originally published in 1984, based on changing trends, laws, and consideration of public comments. Most importantly, the revisions reflect new initiatives and Congressional mandates for the Service, particularly involving new authorities for land acquisition activities, expansion of grant programs and other private land activities, and increased Endangered Species **Act** (ESA) permit and recovery activities. The revisions promote cooperating agency arrangements with other Federal agencies; early coordination techniques for streamlining the NEPA process with other Federal agencies, Tribes, the States, and the private sector; and integrating the NEPA process with other **environmental** laws and executive orders.

EFFECTIVE DATE: January 16, 1997.

FOR FURTHER INFORMATION CONTACT: Don Peterson, **Environmental** Coordinator, Fish and Wildlife Service, at (703) 358-2183.

Departmental Manual

516 DM 6 Appendix 1

Fish and Wildlife Service

1.1 NEPA Responsibility

A. The Director is responsible for NEPA compliance for Fish and Wildlife Service (Service) activities, including approving recommendations to the Assistant Secretary (FW) for proposed referrals to the Council on **Environmental** Quality (CEQ) of other agency actions under 40 CFR 1504.

B. Each Assistant Director (Refuges and Wildlife, Fisheries, International Affairs, External Affairs, and Ecological Services) is responsible for general guidance and compliance in their respective areas of responsibility.

C. The Assistant Director for Ecological Services has been delegated oversight responsibility for Service NEPA compliance.

D. The Division of Habitat Conservation (DHC--Washington), which reports to the Assistant Director for Ecological Services, is responsible for internal control of the **environmental** review and analysis of documents prepared by other agencies and **environmental** statements prepared by the various Service Divisions. This office is also responsible for preparing Service NEPA procedures, guidelines, and instructions, and for supplying technical assistance and specialized training in NEPA compliance, in cooperation with the Service Office of Training and Education, to Service entities. The Washington Office **Environmental** Coordinator, who reports to DHC, provides staff assistance on NEPA matters to the Director, Assistant Directors, and their divisions and offices, and serves as the Service NEPA liaison to the CEQ, the Department's Office of **Environmental Policy** and Compliance (OEPC), and NEPA liaisons in other Federal agencies, in accordance with **516 DM 6**.2.

E. Each Regional Director is responsible for NEPA compliance in his/her area of responsibility. The Regional Director should ensure that Service decisionmakers in his/her area of responsibility contact affected Federal agencies and State, Tribal and local governments when initiating an action subject to an EA or EIS. An individual in each Regional Office, named by title and reporting to the Assistant Regional Director for Ecological Services, other appropriate Assistant Regional Director, or the Regional Director, will have NEPA coordination duties with all program areas at the Regional level similar to those of the Washington Office **Environmental** Coordinator, in accordance with **516 DM 6**.2.

1.2 General Service Guidance

Service guidance on internal NEPA matters is found in 30 AM 2-3 (organizational structure and internal NEPA compliance), 550 FW1-3 (in preparation), 550 FW 3 (documenting and implementing Service decisions on Service actions), and 550 FW 1-2 (replacement to 30 AM 2-3 in preparation). These guidance documents encourage Service participation as a cooperating agency with other Federal agencies, encourage early coordination with other agencies and the public to resolve issues in a timely manner, and provide techniques for streamlining the NEPA process and integrating the NEPA process with other Service programs, **environmental** laws, and executive orders. Some Service programs have additional NEPA compliance information related to specific program planning and decisionmaking activities. Service program guidance on NEPA matters must be consistent with the Service **Manual** on NEPA guidance and **Departmental** NEPA procedures. For example, additional NEPA guidance is found in the Federal Aid Handbook (521-523 FW), refuge planning guidance (602 FW 1-3), Handbook for Habitat Conservation Planning and Incidental Take Processing, and North American Wetlands Conservation **Act** Grant Application Instructions.

1.3 Guidance to Applicants

A. Service Permits. The Service has responsibility for issuing permits to Federal and State agencies and private parties for actions which would involve certain wildlife species and/or use of Service-administered lands. When applicable, the Service may require permit applicants to provide additional information on the proposal and on its **environmental** effects as may be necessary to satisfy the Service's requirements to comply with NEPA, other Federal laws, and executive orders.

(1) Permits for the Taking, Possession, Transportation, Sale, Purchase, Barter, Exportation, or Importation of Certain Wildlife Species. The Code of Federal Regulations, Part 13, Title 50 (50 CFR 13) contains regulations for General Permit Procedures. Section 13.3 lists types of permits and the pertinent Parts of 50 CFR. These include: Importation, Exportation, and Transportation of Wildlife (Part 14); Exotic Wild Bird Conservation (Part 15); Injurious Wildlife (Part 16); Endangered and Threatened Wildlife and Plants (Part 17); Marine Mammals (Part 18); Migratory Bird Hunting (Part 20); Migratory Bird Permits (Part 21); Eagle Permits (Part 22); Endangered Species Convention (Part 23); and Importation and Exportation of Plants (Part 24). Potential permit applicants should request information from the appropriate Regional Director, or the Office of Management Authority, U.S. Fish and Wildlife Service, Department of the Interior, Washington, DC 20240, as outlined in the applicable regulation.

(2) Federal Lands Managed by the Service. Service lands are administered under the **National** Wildlife Refuge System Administration **Act** of 1966 (16 U.S.C. 668dd-668ee), the Refuge Recreation **Act** of 1962 (16 U.S.C. 460k-460k-4), and the Alaska **National** Interest Lands Conservation **Act** of 1980 (16 U.S.C. 410hh-3233, 43 U.S.C. 1602-1784). inherent in these acts is the requirement that only those uses that are compatible with the purposes of the refuge system unit may be allowed on Service lands. The Service also complies with Executive Order 12996, signed March 25, 1996, entitled ``Management and General Public Use of the **National** Wildlife Refuge System.'' This Executive Order identifies general public uses that will be given priority consideration in refuge planning and management, subject to meeting the compatibility requirement and if adequate funding is available to administer the use. Detailed procedures regarding comprehensive management planning and integration with NEPA are found in the Service **Manual** (602 FW 1-3). Reference to this and other **National** Wildlife Refuge System requirements are found in the Code of Federal Regulations, Title 50 parts 25-29, 31-36, 60, and 70-71. Under these regulations, these protections are extended to all Service-administered lands, including the **National** Fish Hatchery System.

B. Federal Assistance to States, Local or Private Entities.

(1) Federal Assistance Programs. The Service administers financial assistance (grants and/or cooperative agreements) to State, local, and private entities under the Anadromous Fish Conservation **Act** (CFDA #15.600); North American Wetlands Conservation **Act**; Fish and Wildlife **Act** of 1956; Migratory Bird Conservation **Act**; Food Security **Act** of

[[Page 2381]]

1985; Food, Agriculture, Conservation and Trade **Act** of 1990; Partnerships for Wildlife **Act** of 1992; and Consolidated Farm and Rural Development **Act**. The Service administers financial assistance to States under the Sport Fish Restoration **Act** (CFDA #15.605), Wildlife Restoration **Act** (CFDA #15.611), Endangered Species **Act** (CFDA #15.612 and 15.615), Coastal Wetlands Planning Protection and Restoration **Act** (CFDA #15.614), and Clean Vessel **Act** of 1992 (CFDA #15.616).

(2) Program Information and NEPA Compliance. Information on how State, local, and private entities may request funds and assist the Service in NEPA compliance relative to the Anadromous Fish Conservation **Act** may be obtained through the Division of Fish and Wildlife Management Assistance, U.S. Fish and Wildlife Service, Department of the Interior, Arlington Square Building, Room 840, Washington, D.C. 20240. Similar information regarding the North American Wetlands Conservation **Act** may be obtained through the North American Waterfowl and Wetlands Office. U.S. Fish and Wildlife Service, Department of the

Interior, Arlington Square Building, Room 110, Washington, D.C. 20240. All other requests for information on how funds may be obtained and guidance on how to assist the Service in NEPA compliance may be obtained through the Chief, Division of Federal Aid, U.S. Fish and Wildlife Service, Department of the Interior, Arlington Square Building, Room 140, Washington, D.C. 20240.

1.4 Categorical Exclusions

Categorical exclusions are classes of actions which do not individually or cumulatively have a significant effect on the human environment. Categorical exclusions are not the equivalent of statutory exemptions. If exceptions to categorical exclusions apply, under **516 DM** 2, Appendix 2 of the **Departmental Manual**, the **departmental** categorical exclusions cannot be used. In addition to the actions listed in the **departmental** categorical exclusions outlined in Appendix 1 of **516 DM** 2, the following Service actions are designated categorical exclusions unless the action is an exception to the categorical exclusion.

A. General.

(1) Changes or amendments to an approved action when such changes have no or minor potential **environmental** impact.

(2) Personnel training, **environmental** interpretation, public safety efforts, and other educational activities, which do not involve new construction or major additions to existing facilities.

(3) The issuance and modification of procedures, including manuals, orders, guidelines, and field instructions, when the impacts are limited to administrative effects.

(4) The acquisition of real property obtained either through discretionary acts or when acquired by law, whether by way of condemnation, donation, escheat, right-of-entry, escrow, exchange, lapses, purchase, or transfer and that will be under the jurisdiction or control of the United States. Such acquisition of real property shall be in accordance with 602 **DM** 2 and the Service's procedures, when the acquisition is from a willing seller, continuance of or minor modification to the existing land use is planned, and the acquisition planning process has been performed in coordination with the affected public.

B. Resource Management. Prior to carrying out these actions, the Service should coordinate with affected Federal agencies and State, Tribal, and local governments.

(1) Research, inventory, and information collection activities directly related to the conservation of fish and wildlife resources which involve negligible animal mortality or habitat destruction, no introduction of contaminants, or no introduction of organisms not indigenous to the affected ecosystem.

(2) The operation, maintenance, and management of existing facilities and routine recurring management activities and improvements, including renovations and replacements which result in no or only minor changes in the use, and have no or negligible **environmental** effects on-site or in the vicinity of the site.

(3) The construction of new, or the addition of, small structures or improvements, including structures and improvements for the restoration of wetland, riparian, instream, or native habitats, which result in no or only minor changes in the use of the affected local area. The following are examples of activities that may be included.

i. The installation of fences.

ii. The construction of small water control structures.

iii. The planting of seeds or seedlings and other minor revegetation actions.

iv. The construction of small berms or dikes.

v. The development of limited access for routine maintenance and management purposes.

(4) The use of prescribed burning for habitat improvement purposes, when conducted in accordance with local and State ordinances and laws.

(5) Fire management activities, including prevention and restoration measures, when conducted in accordance with **departmental** and Service procedures.

(**6**) The reintroduction or supplementation (e.g., stocking) of native, formerly native, or established species into suitable habitat within their historic or established range, where no or negligible **environmental** disturbances are anticipated.

(7) Minor changes in the amounts or types of public use on Service or State-managed lands, in accordance with existing regulations, management plans, and procedures.

(8) Consultation and technical assistance activities directly related to the conservation of fish and wildlife resources.

(9) Minor changes in existing master plans, comprehensive conservation plans, or operations, when no or minor effects are anticipated. Examples could include minor changes in the type and location of compatible public use activities and land management practices.

(10) The issuance of new or revised site, unit, or activity-specific management plans for public use, land use, or other management activities when only minor changes are planned. Examples could include an amended public use plan or fire management plan.

(11) Natural resource damage assessment restoration plans, prepared under sections 107, 111, and 122(j) of the Comprehensive **Environmental** Response Compensation and Liability **Act** (CERCLA); section 311(f)(4) of the Clean Water **Act**; and the Oil Pollution **Act**; when only minor or negligible change in the use of the affected areas is planned.

C. Permit and Regulatory Functions.

(1) The issuance, denial, suspension, and revocation of permits for activities involving fish, wildlife, or plants regulated under 50 CFR Chapter 1, Subsection B, when such permits cause no or negligible **environmental** disturbance. These permits involve endangered and threatened species, species listed under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), marine mammals, exotic birds, migratory birds, eagles, and injurious wildlife.

(2) The issuance of ESA section 10(a)(1)(B) ``low-effect'' incidental take permits that, individually or cumulatively, have a minor or negligible

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effect on the species covered in the habitat conservation plan.

(3) The issuance of special regulations for public use of Service-managed land, which maintain essentially the permitted level of use and do not continue a level of use that has resulted in adverse **environmental** effects.

(4) The issuance or reissuance of permits for limited additional use of an existing right-of-way for underground or above ground power, telephone, or pipelines, where no new structures (i.e., facilities) or major improvement to those facilities are required; and for permitting a new right-of-way, where no or negligible **environmental** disturbances are anticipated.

(5) The issuance or reissuance of special use permits for the administration of specialized uses, including agricultural uses, or other economic uses for management purposes, when such uses are compatible, contribute to the purposes of the refuge system unit, and result in no or negligible **environmental** effects.

(**6**) The denial of special use permit applications, either initially or when permits are reviewed for renewal, when the proposed action is determined not compatible with the purposes of the refuge system unit.

(7) Activities directly related to the enforcement of fish and wildlife laws, not included in **516 DM** 2, Appendix 1.4. These activities include:

(a) Assessment of civil penalties.

(b) Forfeiture of property seized or subject to forfeiture.

(C) The issuance or reissuance of rules, procedures, standards, and permits for the designation of ports, inspection, clearance, marking, and license requirements pertaining to wildlife and wildlife products, and for the humane and healthful transportation of wildlife.

(8) Actions where the Service has concurrence or coapproval with another agency and the action is a categorical exclusion for that agency. This would normally involve one Federal action or connected

actions where the Service is a cooperating agency.

D. Recovery Plans.

Issuance of recovery plans under section 4(f) of the ESA.

E. Financial Assistance.

(1) State, local, or private financial assistance (grants and/or cooperative agreements), including State planning grants and private land restorations, where the **environmental** effects are minor or negligible.

(2) Grants for categorically excluded actions in paragraphs A, B, and C, above; and categorically excluded actions in Appendix 1 of **516 DM** 2.

1.5 Actions Normally Requiring an EA

A. Proposals to establish most new refuges and fish hatcheries; and most additions and rehabilitations to existing installations.

B. Any habitat conservation plan that does not meet the definition of ``low-effect'' in the Section 10(a)(1)(B) Handbook.

C. If, for any of the above proposals, the EA determines that the proposal is a major Federal action significantly affecting the quality of the human environment, an EIS will be prepared. The determination to prepare an EIS will be made by a notice of intent in the Federal Register and by other appropriate means to notify the affected public.

1.**6** Major Actions Normally Requiring an EIS

A. The following Service proposals, when determined to be a major Federal action significantly affecting the quality of the human environment, will normally require the preparation of an EIS.

(1) Major proposals establishing new refuge system units, fish hatcheries, or major additions to existing installations, which involve substantive conflicts over existing State and local land use, significant controversy over the **environmental** effects of the proposal, or the remediation of major on-site sources of contamination.

(2) Master or comprehensive conservation plans for major new installations, or for established installations, where major new developments or substantial changes in management practices are proposed.

B. If, for any of the above proposals it is initially determined that the proposal is not a major Federal action significantly affecting the quality of the human environment, an EA will be prepared and handled in accordance with 40 CFR 1501.4(e)(2). If the EA subsequently indicates the proposed action will cause significant impacts, an EIS will be prepared.

Dated: January 13, 1997.

Willie Taylor,
Director, Office of **Environmental Policy** and Compliance, Office of the Secretary, U.S. Department of the Interior.
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Index to 505 FW

Chapter 1 Policy and Responsibilities

Chapter 2 NEPA Assistance

Chapter 3 Review of Environmental Documents

Chapter 4 Other Related Reviews

Chapter 5 CEQ Referrals

1.1 **Purpose.** This part establishes policy and provides uniform guidance to Fish and Wildlife Service (Service) personnel participating in other agencies' National Environmental Policy Act (NEPA) processes and with Federal and State agencies in the review of environmental documents (40 CFR 1508.10) and other related project reviews.

1.2 **Scope.** This part addresses Service reviews of actions being planned by other Federal agencies under NEPA and other related reviews for which the Service has legal jurisdiction and/or special expertise. It does not address Service compliance with NEPA for its own actions, which are in 550 FW.

1.3 **Policy.** Service personnel shall provide timely input and effective participation in other agencies' environmental documents and other project reviews to further our mission of providing Federal leadership to achieving a national net gain of fish and wildlife and the natural systems which support them.

1.4 **Authority.** Major authorities, regulations, and guidance which establish and promulgate the above purpose are listed below. The chapter on other Related Reviews (505 FW 4) addresses additional authorities for Service reviews.

A. 42 U.S.C. 4321-4347, National Environmental Policy Act of 1969, as amended.
B. 40 CFR 1500-1508, Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA, July 1, 1986.
C. 46 FR 18026, CEQ's Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations, March 23, 1981.
D. **48 FR 34263,** CEQ's Guidance Regarding NEPA Regulations, July 28, 1983.
E. 516 DH I and 7. Department of the Interior's (Departmental or DOI) Manual; Department of the Interior, Office of Environmental Policy and Compliance (OEPC) Environmental Review (ER) Memoranda.

1.5 **Terms Used**.

A. Definition of Terms. Terms particular to NEPA, environmental documents, and other project-reviews are defined in CEQ's NEPA regulations (40 CFR 1508). A list of acronyms and abbreviations common to all chapters is found in Exhibit 1.
B. Environmental Review (ER) Number. Environmental documents and other project reviews are forwarded by DOI's OEPC to the Service and other DOI bureaus for review and comment. These documents are controlled by assignment of an ER number. The number before the slash represents the calendar year and the number after the slash represents the sequential order of the document, e.g., ER 93/0167. The same ER number is generally assigned to subsequent documents concerning the same project; if not, the

OEPC memorandum will generally cross reference related ER-numbered documents.

C. **Environmental Coordination (EC) Number**. Environmental documents and other project reviews that are not assigned an ER number by OEPC, including those from other DOI bureaus, are assigned a sequential EC number by the Division of Habitat Conservation. These documents are normally reviewed in the same manner as ER-numbered documents.

D. **Environmental Document (ED) Number**. To provide a coordinated internal review of Service environmental impact statements (EIS) or other documents, DHC may assign sequential ED numbers to these documents. ED-numbered documents should be reviewed in the same manner as ER-numbered documents.

E. **Ecological Services (ES) Environmental Review Distribution Transmittal.** The Department's OEPC, via a memorandum, transmits controlled documents to the bureaus with specific instructions, such as requirements for any interrelated reviews, assignment of lead bureau responsible for collating comments, and deadlines for providing comments (Exhibit 2). From the OEPC memorandum, the Service prepares the ES Environmental Review Distribution Transmittal (transmittal), which provides specific Service deadlines and instructions for routing comments, as well as any other additional instructions or guidance to aid the reviewer (Exhibit 3).

1.6 **Responsibilities.**

A. Director.

(1) Responsible for overall management and guidance of the Service's review of environmental documents and other project reviews.

(2) Approves Service recommendations to the Assistant Secretary for all proposed referrals of other agency actions to CEQ under 40 CFR 1504.

(3) Maintains signature authority to request, approve, or decline-Service participation as a-cooperating agency on EISs prepared by other Federal agencies that affect more than one Region.

(4) Maintains signature authority for Service comments on proposed rulemaking, environmental documents involving programmatic or nation-wide actions, documents of a controversial nature, documents of interest to the Secretary, and documents involving more than one Region.

B. Assistant Director - Ecological Services.

(1) Exercises oversight responsibility for the Service's review of other agencies' environmental documents and other related reviews.

(2) Designates a Washington Office Environmental Coordinator responsible for overseeing matters pertaining to NEPA pursuant to 516 DM 6.2.

(3) Assists the Director in coordinating and processing referrals to do and emergency actions under NEPA. Advises OEPC, CEQ, and the Washington Office of the involved Federal agency of potential referral pursuant to 40 CFR 1504 and 505 FW 5.

C. Chief, Division of Habitat Conservation.

(1) Prepares NEPA policies, directives, guidance, and training materials for Service personnel related to environmental reviews and other related reviews.

(2) Coordinates and controls distribution of and deadlines for reviewing and commenting on environmental documents and other project reviews controlled by DOI and the Service. Also controls and distributes the review of environmental documents and other project reviews prepared by the Service and other bureaus in DOI.

(3) Designates a lead Service program area to collate and submit the Service's response when environmental reviews involve proposals that involve two or more program areas.

(4) Maintains Service lead in collating comments when environmental reviews involve more than one Region, unless otherwise directed.

(5) Informs OEPC of any agreements to assume cooperating agency status or any declinations pursuant to 40 CFR 1501.6(c) and 516 DM 2.5.

(6) Maintains the Service's administrative record of all environmental reviews controlled by the Service and DOI, including a record of all acceptances or declinations to be a cooperating agency.

D. Washington Office Environmental Coordinator.

(1) Provides staff support to ensure NEPA responsibilities delegated to the Assistant Director - Ecological Services, and Chief, Division of Habitat Conservation, are carried out in accordance with CEQ's NEPA regulations, DOI's NEPA procedures, and Service NEPA guidance, and

(2) Serves as Service liaison to CEQ, OEPC, and other Federal agency NEPA staff on NEPA matters, including potential CEQ referrals under NEPA, pursuant to 516 DM 6.2.

(3) Reviews nationally-significant environmental documents, including nondelegated EISs, of interest or concern to the Director.

(4) Conducts and coordinates training, including the preparation of training materials, for Washington and Regional Office personnel, including the Regional Environmental Coordinators, on environmental reviews and other related reviews.

(5) Provides technical assistance, quality control and overview regarding the Service-wide review of controlled environmental documents and other project reviews prepared by other Federal agencies.

E. Regional Director.

(1) Designates an individual in the Regional Office, pursuant to 516 DM 6.2 and Appendix 1.1E, who has responsibility for coordinating region-wide reviews of environmental documents and related reviews.

(2) Ensures quality control of all environmental review comments submitted by offices and divisions under his/her control to the Director, Department, other Federal agencies, and State agencies.

(3) Ensures that Regional and field office personnel are adequately trained in environmental review matters.

(4) May enter into cooperating agreements with other Federal agencies in the preparation of EISs affecting the Region, or decline Service participation as a cooperating agency for proposed actions where the Service has special expertise.

(5) Advises AD-ES (Attention: DHC), and OEPC, if appropriate, of Service acceptance or declination of requests for cooperating agency status. In accordance with 40 CFR 1501.6 and 516 DM 2.5, any declination to a request to be a cooperating agency where the Service has significant jurisdiction by law [refer to 505 FW 2.2(A)] must be reported to CEQ. Such responses shall be routed to the Director for his/her signature.

(6) Submits Service comments controlled by OEPC directly to the lead collating bureau, the Department's Regional Environmental Officer (REO), or OEA, as directed, for all environmental reviews involving proposals within the Region. The Regional-Director may not redelegate this responsibility below the Regional Office level, except for notices of intent (NOI).

(7) Provides "no comments" to lead collating bureau, RED, OEPC, or Service Washington Office, as appropriate, for controlled environmental reviews.

(8) Advises the Director and the RED, as appropriate, whenever significant controversy exists over environmental reviews or before taking any actions which involve major policy considerations or the potential for substantial controversy.

(9) Advises the AD-ES whenever incorporating "may refer" language in Service comments on draft EISs, as this matter may ultimately involve the Secretary. The Regional Director must actively seek resolution of referral issues pursuant to 40 CFR 1504 and 505 FW 5 prior to submission of the referral package to the Secretary.

(10) Coordinates internal Regional review of Service NEPA documents prepared in the Region with affected program areas in the Region.

F. Regional Environmental Coordinator.

(1) Coordinates significant Regional environmental review issues on an interagency and intra-Service level.

(2) Collates comments from other DOI bureaus when the Service is designated lead bureau by OEA.

(3) Coordinates with counterparts in other agencies to resolve Regional NEPA-related conflicts.

(4) Provides staff assistance to the Regional Director in coordinating potential CEQ referrals with Regional and field office personnel and DHC.

(5) Prepares and coordinates training for Regional and field office personnel on environmental reviews and other related reviews.

(6) Maintains a record of all DOI and Service Washington Office controlled environmental reviews involving the Region, including a record of "no , comments." REC will ensure that a signed copy of all Regional comments are provided to DHC. Advises DHC of all acceptances or declinations to be a cooperating agency on another agency's EIS.

(7) Serves as the Regional staff point of contact and liaison with OEPC staff, the RED, other Federal agency NEPA staff, and DOI and Service Washington Office staff on controlled environmental documents and other project reviews.
(8) Coordinates all requests from the Region for extensions of time directly with the lead collating bureau, REO, OEPC, or the Service Washington Office, as appropriate. REC will ensure that all Service reviewers are aware of any approved extensions of time.

G. Service Divisions and Offices. Most interagency coordination on environmental reviews is conducted by Ecological Services field offices, and their specific responsibilities are outlined below. However, other Service offices and divisions (e.g., Division of Endangered Species, Division of Environmental Contaminants, Division of Refuges, Division of Fish Hatcheries) may also be notified of such reviews, when appropriate.

(1) Provide early cooperation and coordination with other agencies and other Service offices and divisions in their NEPA processes. This includes providing technical assistance or commenting on preliminary working drafts and participating in scoping activities and as a cooperating agency.
(2) Provide site-specific review and comment on NEPA-related documents and for preparing comment letters and memoranda.
(3) Unless otherwise instructed, have signature authority for comments on notices of intent to prepare environmental documents.
(4) Service Washington offices and divisions, with input from Regional and field offices, coordinate reviews of programmatic or nationwide EISs prepared by other agencies.

1.7 NEPA Reference Handbook. The NEPA Reference Handbook, authorized in 550 JFW 1, includes the full texts of various NEPA authorities, texts of selected authorities for related reviews, and checklists and samples for the preparation and review of environmental documents.

Exhibits 1-3 are available from the Division of Habitat Conservation (703) 358-2183.

Exhibit 1, Abbreviations and Acronyms
Exhibit 2, Memorandum (Review of"Final Environmental Statement for the Fish Creek Reservoir Expansion, Routt County, Colorado)
Exhibit 3, Environmental Review Distribution Transmittal

2.1 Early Involvement. Early Fish and Wildlife Service (Service) involvement with other agencies in project planning and National Environmental Policy Act (NEPA) scoping is necessary for achieving full consideration of fish and wildlife resource values and for resolving resource conflicts. When environmentally acceptable and unacceptable actions are identified early in the planning process, the need for subsequent intensive Service review of environmental documents and other project reviews is reduced and fewer project revisions are required late in the planning process. Early involvement can occur prior to scoping, during scoping, or as a cooperating agency.

2.2 Cooperating Agencies. Basic procedures for cooperating agencies are described in 40 CFR 1501.6. Service responsibilities for compliance with 40 CFR 1501.6 are described in 032 FW, 505 FW 1.6, and 516 DM 2.5.

A. **NEPA Regulations.** The Council on Environmental Quality's (CEQ) NEPA regulations point out two instances in which an agency may be requested to cooperate: jurisdiction by law or special expertise. The Department of the Interior's (DOI) Environmental Statement Memorandum No. ES84-3 lists Federal agencies with jurisdiction by law or special expertise on environmental quality issues (refer to Service NEPA Reference Handbook). If the Service has significant jurisdiction by law, CEQ'snipe regulations state that the Service shall be a cooperating agency, if requested. Examples of significant jurisdiction by law include actions that may significantly affect lands and water administered under the National Wildlife Refuge System, or lands and waters administered as national fish hatcheries. The issuance of permits, consultation, or reporting requirements are not sufficient to be deemed significant jurisdiction by law, within the meaning of CEQ's NEPA regulations. If the Service does not have significant jurisdiction, but has special expertise on certain environmental issues (e.g., protection of wetlands, protection of threatened and endangered species), CEQ's NEPA regulations state that the Service may be a cooperating agency.

B. **Cooperating Agency Request.** The request to be a cooperating agency may involve technical assistance or review of early planning efforts, as is required in scoping, or the Service could be requested to develop specific information and/or to prepare analyses, including writing portions of an environmental impact statement (EIS). The level of commitment is negotiable, will be determined on a case-by-case basis, and may involve deliberations between the lead agency and the Service field office. When a major commitment of resources will be necessary, the Regional Director or designee should negotiate with the

lead agency or applicant for a transfer of funds. The lead agency still makes the final decision as to the content of its EIS. Exhibit 1 depicts the process for evaluating a request to be a cooperating agency.

C. **Negotiations**. The Service normally does not have the capability to develop basic data because of recommitted and limited staff resources. The Service can, however, provide available information, professional opinions, and technical assistance in conducting necessary studies. Th~ Service should advise the lead agency that State fish and wildlife resource agencies are often capable of providing basic data. Agreed upon time limits in which the Service will provide studies and analyses should be established prior to being undertaken, and should be adhered to. The services of, and data available from, all Service divisions should be utilized as appropriate.

D. **Funding.** Action agencies with a continuing need for Service cooperation should be encouraged to make long-term commitments or supply needed funds and personnel. For example, scopes of work (SOW) for funds from the Corps of Engineers (Corps) and the Bureau of Reclamation (BR) describe the products to be delivered by the Service, deadlines for delivery, and the amount of funds for the Service. Funding and other issues may need to be negotiated annually between those agencies and Service field offices. As applicable, SOWs should include descriptions of the level of effort and funding necessary for adequate Service participation as a cooperating agency. This discussion of funding pertains only to Service participation as a cooperating agency. The costs of scoping participation and of reviewing and commenting on EISs are normally borne by the reviewing Federal agencies.

E. **Declinations.** The benefits of early coordination in another agency's planning cannot be over-emphasized. Such coordination encourages early resolution of fish and wildlife resource concerns, which may result in more environmentally acceptable actions. Careful assessment of the resources to be impacted and the magnitude and severity of potential impacts should be made before the Service declines a request to coop~rate. If, however, the Service is precluded from cooperating due to other program commitments, or if a mutually satisfactory agreement as to the level of involvement (e.g., transfer of funds and/or personnel) cannot be reached, the Regional Director should notify the requesting lead agency as soon as possible in writing of the Service's intention not to be a cooperating agency.

2.3 Scoping. Basic procedures are described in 40 CFR 1501.7.

A. **Scoping Process.** "Scoping" is defined in CEQ's NEPA regulations as "an early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action." Potential alternatives should be described, if known. Scoping is a document design process for the NEPA document, not a

single event or meeting. Scoping ends with the issuance of the draft EIS. The Service should provide clear, concise and detailed comments on agency "notices of intents," to seek early resolution of important concerns on wetlands, endangered species, migratory birds, anadromous fish, and other resources. Thus, scoping is a crucial step in the early planning stage for the Service to identify fish and wildlife resource concerns and to define the depth to which such concerns should be addressed in an EIS.

B. Initiation of Informal Scoping. Conflicts should be addressed by the Service as soon as possible with the lead Federal agency. If possible, this should occur before formal scoping commences to better assure environmentally sensitive planning.

C. Initiation of Formal Scoping. Initiation of an agency's scoping process formally commences with Federal Register publication of a notice of intent (NOI) to prepare an EIS. CEQ's NEPA regulations intend for coordination to take place as fully as possible prior to release of a draft EIS. At a minimum, Service input into the scoping process and our responses to the NOI should indicate our general jurisdictional and/or environmental concerns, proposed resolutions, or our no objection to project implementation if it is determined there will be little or no impact on fish and wildlife resources. If the proposed action may affect any resources for which the Service has jurisdictional responsibility, the lead agency must be notified at this time and a process established for resolving any concerns. Replies to NOIs may be made directly to the lead agency by the project leader pursuant to 505 FW 1.6(B)(8).

D. Service Participation in Scoping.

(1) Service personnel should normally attend scoping meetings. If attendance is precluded due to travel restrictions or other commitments, written Service comments from the field level should be provided in accordance with instructions in the scoping invitation or public notice.

(2) If the Service is aware that a proposed project may have potential, significant impacts on fish and wildlife resources under the jurisdiction of the Service (e.g., national wildlife refuges, endangered species), the Service field office should advise the sponsoring agency that the Service will be participating in the scoping process and may wish (or requests) to be a cooperating agency.

(3) Service participation in scoping should be coordinated with the appropriate State agencies with regard to the conservation of fish and wildlife resources of mutual interest.

(4) All Service reports and project recommendations must be provided to the lead agency to permit incorporation into project plans, including the draft EIS.

(5) Service reports resulting from participation in the scoping process will be coordinated with other reports or compliance required by the Fish and Wildlife Coordination Act (FWCA), Endangered Species Act, and other laws.

(6) Service input into scoping processes should be documented in EISs, and Service comments should point out any omissions or discrepancies in the use of this input. The Service NEPA Reference Handbook contains a sample Service comment letter to the lead Federal agency on its NOI to prepare an EIS.

2.4 Resolving Federal Agency Planning Inconsistencies.

A. This section describes general guidance for resolving agency differences. For example, the Service may believe another agency's actions are inconsistent with CEQ's NEPA regulations. The Service may have clearly indicated to the agency that their proposed action is "major or significant," but the agency may have prepared an environmental assessment (EA) when the Service believes an EIS is required.

B. In instances such as these, the Service should make its concerns known to the agency formally in writing. To be effective, the Service's comments must emphasize substantive concerns and reference any previous attempts to resolve them. Service comments should describe the requirements of CEQ's NEPA regulations and, whenever appropriate, the agency's procedures for implementing these and other regulations. Most importantly, the Service should clearly state what the other agency must do to adequately address Service concerns.

C. Major differences on policy and procedural matters can be elevated to the Regional Director or Director for resolution. However, all coordination measures should be tried at the lower organizational levels prior to elevating an issue. If Service Regional and Washington Office efforts are unsuccessful in resolving a major issue, a letter summarizing the issues can be drafted to CEQ, in consultation with the Departments's Office of Environmental Policy and Compliance, seeking their review and assistance in resolving the issue. This is not a formal referral under 40 CFR 1504, but a request for CEQ to review a matter of concern to the Service. CEQ's style for resolution generally involves bringing all involved Federal parties together to clearly and succinctly present their positions. CEQ would likely provide its recommendations to the agencies for resolving the issue(s), either informally or formally (in writing), depending on the circumstances.

Exhibit 1, Evaluating A Request To Cooperate, is available from the Division of Habitat Conservation (703) 358-2183.

3.1 Duty to Comment.

A. The Council on Environmental Quality's (CEQ) National Environmental Policy Act (NEPA) regulations (40 CFR 1503.2) require Federal agencies to review and comment on environmental impact statements (EIS) for proposed actions within their expertise or jurisdiction. Throughout another agency's NEPA process, Fish and Wildlife Service (Service) review activities should focus on clear, meaningful analysis of significant environmental issues. The Service should assist a lead agency in making a reasoned decision consistent with the purpose, objectives, and goal of NEPA. Better ElSs, in and of themselves, are not the goal of NEPA nor of Service involvement in the NEPA process. The goal of NEPA is better environmental decisions.

B. Other Federal agencies should provide the Department of the Interior's (DOI) Office of Environmental Policy and Compliance (OEPC) with sufficient copies of environmental and other project review documents to allow distribution of the documents to the Service and other DOI bureaus being requested to participate in the review. When necessary, Service reviewing offices may remind other Federal agencies or State offices which prepare and distribute environmental documents to provide appropriate copies to OEPC. Normally, other Federal agencies should provide the following number of copies to OEPC.

   (1) Twelve copies of a draft and six copies of a final document for projects in the Eastern United States, including Minnesota, Iowa, Missouri, Arkansas, and Louisiana. The same number of copies should be provided for projects in America Samoa, Guam, Hawaii, Puerto Rico, and the Virgin Islands.

   (2) Eighteen copies of a draft and nine copies of a final document for projects in the Western United States westward of the westward boundaries of Minnesota, Iowa, Missouri, Arkansas, and Louisiana.

   (3) Eighteen copies of a draft and nine copies of a final document for review requests which are national in scope, such as agency regulations, scientific reports, special reports, program plans, and other interagency documents.

   (4) Sixteen copies of a draft and eight copies of a final document for projects in Alaska.

C. When Service field offices receive other agency environmental documents directly from that agency instead of through transmittal from OEPC, they should advise the Service's Division of Habitat Conservation (DHC) (Attention: Environmental Review Technician) and OEA staff to ensure the document will be distributed by the Department for formal review. Service field offices should reply, in most cases, through formal Departmental review channels and not directly to the other agency.

D. Service reviews and comments on other agency environmental documents should accomplish the following objectives.
   (1) Encourage agencies to contribute to the maintenance and enhancement of fish and wildlife values during their actions.
   (2) Assure that all potential beneficial and adverse effects of a proposed action are recognized by the lead agency, and are understandably presented to the general public and decision makers.
   (3) Assure that practicable alternatives less damaging to fish and wildlife resources are adequately described, realistically evaluated, and adopted where feasible.
   (4) Assure that mitigation measures to offset unavoidable losses are adequately developed and included as part of the preferred alternative. Service mitigation recommendations and comments on other agency mitigation plans should be consistent with 501 FW 2, Service Mitigation Policy.

3.2 Administrative Procedures.

A. Department's Office of Environmental Policy and Compliance (OEPC)
   (1) OEPC, under the Assistant Secretary for Policy, Management, and Budget (AS/PMB), is responsible for managing and coordinating DOI review of environmental documents and other project reviews (112 DM 4). One of OEPC's primary responsibilities is to ensure that a consolidated, single, consistent DOI response is prepared for Departmental signature. In addition to the Washington Office staff, OEPC has Regional Environmental Officers (REO) that handle many regional problems, serve on interagency task forces and regional commissions, and are authorized to sign DOI NEPA comment letters to other agencies on items of mainly regional concern. OEPC receives draft final EISs from Federal agencies outside DOI and assigns them for review to those DOI bureaus having jurisdiction or special expertise regarding a proposed action and its impacts.
   (2) OEPC also receives and distributes for review various other environmental documents, such as environmental reports, proposed regulations, and Department of Transportation section 4(f) statements. OEPC does a preliminary review of the documents and determines which bureau, by virtue of jurisdiction or special expertise, will be "lead," that is, will have the responsibility of consolidating bureaus' comments into a single response for signature of either the REO or OEPC. In some cases the lead is retained by OEPC, and bureau comments are consolidated in Washington by OEPC staff for OEPC or AS/PMB signature.

B. Service Environmental Coordination Activities. Specific Service redelegations to the Assistant Directors and Regional Directors are described in 032 FW. DHC has been delegated the responsibility for assigning lead

within the Service for review and comment on OEPC-controlled documents. If it appears that an error in assignment has been made, or that another Service office has more expertise and should have been assigned lead, DHC should be contacted immediately. DHC will make all to reassignments. Reassignments will be coordinated with the Service's Regional Environmental Coordinators (REQ and other appropriate Service entities. OEPC-controlled documents received in DHC will normally be processed and mailed to the Region and field office within one working day's time. Environmental documents which require a response in less than two weeks are normally transmitted to the Region and field offices by "overnight" mail, fax, or by an appropriate form of electronic transmission.

C. Lead Bureau.

(1) The DOI bureau having either greatest expertise or jurisdiction by law for an action proposed by another Federal agency is designated lead bureau. The lead bureau is determined by OEPC. When OEPC designates the Service as lead bureau, it has responsibility for preparing DOI's response. Either the Regional Office or the Director of the Fish and Wildlife Service (Director) can be responsible for collating-comments, as described in 505 FW 3.2. This responsibility is indicated in the OEPC memorandum and/or the Ecological Services (ES) transmittal. The ES transmittal will provide the necessary instructions. DHC or another designated Division will collate bureau comments when the Director is assigned lead by OEPC.

(2) If conflicting bureau positions cannot be resolved on a proposed project, resolution will be made by either the Department's REO or by OEPC, in consultation with the Service and the other involved bureau(s). When the Service, as lead bureau, prepares the collated DOI response for the REO's or OEPC's signature, the original of each bureau's comments and/or notes of phoned comments or "no comments must accompany the letter.

D. Lead Service Region. When projects cross Regional boundaries or otherwise involve more than one Region, the Assistant Director - Ecological Services (through DHQ will collate and submit the Service's response. If a proposed action has potential site-specific impacts, the document is sent for review to the responsible Region and Service field office. If two or more field offices are involved, lead is assigned to the one responsible for the geographic area in which the greatest potential impact may occur. Unresolved differences on the Service position between Regions will be resolved by the Director.

E. Programmatic or National Reviews. For proposed actions having national impacts or for programmatic statements, DHC will assign review and comment responsibility to the Service's Washington Office division or unit with the necessary expertise.

F. Noncontrolled Reviews. Environmental documents and other project reviews prepared by other DOI bureaus may be received by Service field

offices directly from the preparing bureau or from DHC. If the preparing bureau sends a copy to DHC, DHC will control it with an "EC" number. Other site-specific bureau-prepared environmental documents received directly by Service field offices may be commented on directly from the field level or as per Regional Office instructions. Copies of noncontrolled review comments should be sent to DHC. OEPC does not control bureau-prepared environmental documents and other project reviews, with the exception that it has review and approval responsibilities over all non-delegated EISS. DOI Environmental Statement Memorandum 85-2 describes these procedures (refer to Service NEPA Reference Handbook).

G. Advance Copies. Regional and field offices often receive courtesy or advance copies of official draft or final EISs, project plans, section 4(f) statements from non-DOI agencies, or other documents which are being circulated for formal review. The advance copy will allow additional review time between receipt of the official controlled copy and transmittal from DHC. ES transmittal instructions for review and comment should come from DHC in approximately one week (to allow for OEPC and DHC processing and mail delay). If such instructions are not received, or if the reviewer has reason to believe the action agency has failed to submit the document to DOI for review, DHC should be notified immediately. The field and Regional Office review should continue and the comments should be processed as if they were controlled.

H. Technical Assistance.

(1) Other agencies and bureaus are encouraged to consult with Service field offices during early planning for technical assistance to help ensure full consideration of fish and wildlife resources. Requests for technical assistance and planning documents received as part of cooperating or scoping efforts are to be reviewed at the field level with comments sent directly to the agency. This includes review of preliminary or working draft EISs, other draft environmental documents, and other draft project reviews. DHC should be advised, by copy, of significant or controversial issues.

(2) When reviewing documents that may become part of an EIS or project plan, the agency should be reminded that such informal coordination is rendered as technical assistance, and does not represent the final position of DOI. Some requests for technical assistance are routed through DOI and controlled by OEPC. These requests are generally responded to directly by the Service field office.

I. Processing Environmental Review Documents.

(1) Environmental documents received by OEPC from other Federal agencies are processed in the following manner.

(a) OEA assigns an "ER" control number to the document and routes it to DOI bureaus, via an OEPC memorandum.
(b) DHC receives the OEPC memorandum and prepares an ES environmental Review Distribution transmittal and routes the transmittal and the document to reviewers, with information copies, as appropriate.
(c) ES field office (or other appropriate office) does site specific review and prepares a comment letter for Regional Director's signature (unless otherwise directed by ES transmittal).
(d) Regional Directors review field office comments, sign comment letters, and forward comment letters to lead bureau, REO, OEPC, or Service Washington Office, as indicated in the ES transmittal, with copy to DHC.
(e) DHC coordinates comments directed through the Washington Office with other appropriate Service entities.
(f) Lead bureau prepares consolidated DOI letter for REO's signature.
(g) OEA prepares consolidated DOI letter for OEPC or A/S PMB signature.
(h) Lead Federal agency receives DOI comments.

(2) Service comments on DOI (bureau) environmental documents received by DHC are generally signed at the Regional or field office level and are processed as follows.
(a) DHC assigns an "EV control number, prepares ES transmittal, and routes to the Service reviewer.
(b) ES field office (or other appropriate office) prepares site-specific review and prepares a comment letter for the Regional Director's signature, unless otherwise instructed.
(c) Regional Directors review field office comments, sign comment letters, and forward comments directly to lead bureau, with copy to DHC.
(d) Lead bureau receives Service's comments.

J. Signature Levels. In general, OEPC's instructions for processing review comments are duplicated on the ES transmittal. Unless instructed otherwise by the Department, signature levels are consistent with 032 FW and 505 FW 1.6.

K. Review Deadlines/No Comments.

(1) EISs and some other environmental documents have time periods set by law or regulation during which other agencies and the public may provide comments. CEQ's NEPA regulations (40 CFR 1506.10) require a minimum of 45 days for review and comment on draft EISs and a 30-day waiting

period following release of final EISs. However, Federal agencies may choose to adopt longer, but not shorter, routine time periods. The time period is calculated from the date the Notice of Availability (NOA) is published by the Environmental Protection Agency (EPA) in the Federal Register. The comment due date is provided in these notices. Time periods for draft and final revised or supplemental EISs are calculated the same as for draft EISs and final EISs. CEQ's NEPA regulations require agencies with jurisdiction by law or special expertise to comment or reply that they have no comments, within the time period specified (40 CFR 1503.2). The action agency is under no legal obligation to consider comments received after the established time period expires. To ensure that other agencies give full consideration to Service concerns and comments, reviewers must meet the deadlines given in the ES transmittal.

(2) If the Service is a cooperating agency, or if the Service has otherwise been a participant in the scoping process for a proposed action, review of the draft EIS is needed only to the extent that it ensures our concerns have been correctly addressed.

(3) When controlled documents arrive for review, they should be quickly scanned to determine deadlines and relative priority, and the review should be assigned immediately. If the immediate determination indicates a low priority and a potential for a "no comment" response, the reviewer should follow through with a quick reply.

(4) "No Comments" on draft EISs and on proposed Chief's Reports must be made in writing.

(5) Field office review schedules should ensure that intermediate offices such as the Regional Office, lead collating bureau, REO, OEPC, DHC, and other appropriate Washington Office entities are allowed adequate time to briefly review proposed comments. Potential mail delays and holiday and weekend "down time" should be factored in both DHC's mail schedule and the reviewer's schedule, to the extent possible. DHC shall ensure that the most expeditious mailing system is used, to include routine use of daily bulk "overnight" mail to the Regions, faxed copies, and other appropriate electronic mail transmission, as warranted.

L. Extensions of Time. Organizational responsibilities for meeting deadlines and for requesting extensions of time are described in 505 FW 1.6.

(1) Extensions of review deadlines will occasionally be needed because of unusual routing or mail delays, required field studies, necessary coordination with other Federal or State

agencies, or the discovery of unforeseen problems with the proposed action. The need for any extension must be determined early in the review process and should be requested not later than three days after receipt of the controlled document. The nearer the deadline, the more difficult it is to obtain extensions. An extension should be requested only when it is expected that substantive comments will be made, or substantive field inspection or coordination is needed. It is usually not appropriate or possible to get an extension on a final EIS unless needed in an attempt to avoid CEQ referral.

(2) Extensions of time on OEPC-controlled documents must be made in a request to the lead Federal agency. Unless otherwise directed, this is done by DOI (OEPC or REO, as appropriate).

(3) Extensions of time will be negotiated by the REC with OEPC or the REO, as appropriate. Extensions of one week or less can generally be requested and confirmed verbally. Requests for extension in excess of two weeks must be made in writing for DOI confirmation to the action agency. This letter request will be prepared and processed by DHC. However, the requesting field office must be prepared to offer explicit justification for lengthy extensions. Some examples of good reasons are the need to attend public meetings scheduled after the comment due date or the need for additional coordination with State resource agencies. The Washington Office Environmental Coordinator will notify the REC as soon as the extension ~as been granted or denied.

(4) To obtain an extension of the date due to a DOI lead bureau, such as the National Park Service, the REC should request an extension directly from the lead bureau.

(5) The REC will negotiate extensions through the REO when the Regional Office has the lead in collating bureau's comments for the REO's signature.

M. DOI Comment Letters. DOI review comments are signed by OEPC or AS/PMB in the Washington Office or by the appropriate REO.

(1) Copies of signed letters are forwarded to DHC. DHC provides the appropriate Regional and field offices with copies of Departmental letters signed at the Secretarial level in Washington. It is important that Service offices retain these letters for future use, as they indicate the Service and/or DOI position on the project. DHC maintains the Service's administrative record of all Service responses to DOI and Federal agencies on controlled environmental reviews. Regional and field offices should maintain similar

files for controlled environmental reviews within the scope of the Region.

(2) Service personnel should compare these letters with t * he comments submitted. The preparer and/or REC should question any substantial changes in Service comments made by OEPC or a lead bureau that were not coordinated.

3.3 How to Review Environmental Documents.

A. Service personnel responsible for reviewing an environmental document will normally have had previous experience with the proposed action by participating in the scoping process, representing the Service as a cooperating agency, authoring planning aid letters or formal Fish and Wildlife Coordination Act (FWCA) Reports, or through consultation under the Endangered Species Act.

B. Service reviewers must be extremely careful not to foreclose future options by declining to review and comment on environmental documents. Failure to review and comment on other agencies' draft EISs and other environmental documents can be interpreted by those agencies as meaning the Service has no concerns or believes that the proposed action will not have significant impacts on fish and wildlife resources. It can further be interpreted to mean that the Service will have no objections to issuance of any permits required for project construction.

C. **Major Areas of Concern to be Addressed in Service Reviews of Environmental Documents.**

(1) Service comments and advice on environmental documents should be confined to items of Service jurisdiction and expertise and should be based on facts, published research, or professionally supported opinion.

D. **Tiering.** CEQ's NEPA regulations (40 CFR 1502.20) encourage tiering EISs. Tiering, however, is not a substitute for the adequate assessment of site specific environmental effects. For example, a programmatic EIS must consider cumulative, direct, and indirect impacts; however, this may result in less detailed assessments of impacts than would be addressed on a site specific EIS.

E. **Discussion of Inconsistencies with State and Local Plans.** CEQ's NEPA regulations'140*CFR 1506.2(d)] require an EIS to discuss any inconsistencies the proposed action may have with an approved State or local plan or law, and to address the extent to which the lead agency plans to reconcile its proposed action with the plan or law. Service comments on EISs should address key State and local planning efforts which have Service involvement in development, review, and/or approval. Some of these are listed below.

(1) Management and habitat acquisition plans funded by Dingell-Johnson (D-J).and Pittman-Robertson (P-R),

Land and Water Conservation Act, section 6 (Endangered Species Act) cooperative agreements, or through other grant programs.

(2) Coastal Zone Management Plans.

(3) State and local wetland and flood plain management plans.

(4) Coastal Barriers Resources Act, as amended.

(5) Habitat conservation planning under section 10(a)(1)(B), recovery plans, and recovery actions, pursuant to the Endangered Species Act.

(6) State water quality standards.

F. **Service Reviews should be Total and Comprehensive.**

(1) EIS reviews should include consideration of total, long-term ecological impacts, including any direct and secondary (or indirect) impacts. Also, Service reviewers should consider any cumulative effects, or possible project segmentation which could mask cumulative effects.

(2) The Service should provide consistent positions. Do not contradict earlier statements unless project alternatives, impacts, or conditions have substantially changed; or significant new data are available. Any significant change in Service position must be substantiated (justified) in writing.

(3) Service reviews must represent the views of all Service program areas. Any uncompleted or unresolved reviews or consultations under other statutes must be indicated/summarized in the Service's comments.

3.4 Comments on Draft EISs. The Service should review and comment on an agency's draft EIS to ensure that fish and wildlife resources are adequately considered in their programs and plans. A sample DOI letter commenting on a draft EIS is found in the Service NEPA Reference Handbook. The following points should be considered.

A. If a draft EIS is so inadequate as to preclude meaningful analysis, but it appears that there may be significant adverse effects on fish and wildlife resources, Service comments should state explicitly what would be required to make the document adequate. The action agency should be requested to prepare and circulate a revised draft EIS, in accordance with 40 CFR 1502.9(a).

B. The Service should indicate which alternative is environmentally preferred from a fish and wildlife standpoint. The Service should make recommendations regarding each alternative to ensure that, whichever is selected, the lead agency is aware of necessary fish and wildlife measures that should be incorporated therein.

C. Service comments on a draft EIS may request the action agency to prepare a supplement to the EIS if such an analysis will help to satisfy Service concerns. Requests for supplemental documents must be consistent with the criteria set forth in 40 CFR 1502.9(c).
D. If there is any possibility that the Service may refer a project to CEQ (40 CFR 1504), that fact must be pointed out to the agency at the earliest possible time in their planning process. This normally occurs within the comment period for the draft EIS. 505 FW 4 provides specific guidance on CEQ referrals.
E. Submit all comments to the appropriate collating office. Do not bypass DOI by submitting comments directly to the requesting Federal or State agency.
F. Service comments should not be released prior to DOI's release of the official Departmental position.

3.5 Coments on Final EISs. CEQ's NEPA regulations [40 CFR 1502.9(b)] require lead agencies to respond to comments made on the draft EIS-and require discussion of responsible opposing views at appropriate points in the final EIS rather than merely appending comments to the document.

A. The Department does not normally comment on final EISs. In other words, the quality review of the document itself should be completed prior to release of the final EIS. "No Comment" responses are not normally required, unless requested on the ES transmittal. The Service comments on final EISs when there are major, unresolved issues about the project itself. For example, the Service may oppose the project or a feature of major importance relative to fish and wildlife resources. A sample DOI letter commenting on a final EIS is found in the Service NEPA Reference Handbook. Generally, comments on a final EIS are justified when one or more of the following criteria occur.
    (1) The Service strongly objects to the selected alternative because it is environmentally unacceptable from the Service's expertise or jurisdictional standpoint, or it fails to incorporate Service recommendations for mitigation or monitoring requirements as an integral part of the project.
    (2) Project modifications proposed since the draft EIS require further comment. This is especially important if the modifications significantly affect the impacts or the analysis of those impacts on fish and wildlife resources, will effect endangered species, or if new permit activities could be involved.
    (3) There is a need to correct the record because there has been a serious failure on the part of the action agency to understand significant Service comments on the draft EIS and that failure is the basis for our opposition to the project or specific project features.

(4) Important new information which would be consequential to the decision making process is available, or erroneous or obsolete data are presented in the final EIS which could significantly affect fish and wildlife resources.

B. If DOI's comments on the draft EIS included "may refer to CEQ" language, but the Service/DOI decided not to refer, DOI's comments on the final EIS should address the reasons for not referring (e.g., major issues were resolved).

C. Service comments on a final EIS should state what the Service specifically wants the lead agency to address in its Record of Decision to rectify the Service's concerns. For example, the Service could ask that specific mitigation measures or the results of section 7 consultation be addressed in the Record of Decision, if not previously included in the selected alternative.

3.6 Format for Comments on Draft and Final EISs.

A. Service comments should be organized to reflect the different statutory review requirements on the document being reviewed. For example, Service comments should be separated as follows: "Environmental Impact Statement Comments," "Section 4(f) Statement Comments," ENDANGERED Species Act Comments," (Fish and Wildlife Coordination Act Comments." The latter two sets of comments should only address statutory requirements, such as section 7 consultation or the FWCA report.

B. Regarding Service comments on a draft EIS, the comments should generally be organized in two sections: "General Comments" and "Specific Comments." A "Summary Comments" section may also be included when the review comments are lengthy. When commenting on final EISs, these sections are usually not indicated since the comments generally address only major unresolved issues regarding the project. The sections are described below.

C. General Comments.

(1) This section should summarize Service concerns with the adequacy and accuracy of the document and present comments of a general nature. The comments in this section should concentrate on the recommended or selected alternative and its impacts. Any previous technical assistance, reports, or planning aid letters provided by the Service on the project should be noted in this section (and attached), if appropriate. For example, Service comments should note any potential reviews that it may make in conjunction with section 10/404 Corps of Engineers permits, any further consultation requirements under section 7 of the Endangered Species Act, and whether the Service may refer the project to CEQ. Other project reviews are addressed in 505 FW 4. CEQ referrals are discussed in 505 FW 5.

(2) If the document is complete in its analysis of potential impacts on fish and wildlife resources of the proposed action and reasonable alternatives, and if the proposed action is acceptable, a simple statement of that fact should be made.

D. **Specific Coments.**

(1) Specific comments should support each of the major concerns raised in the "General Comments." In other words, the action agency should be able to locate and identify the specific justifications for the major problems addressed in the "General Comments" section. Other comments to rectify inadequacies on how fish and wildlife resources are addressed in the EIS are also covered in this section.

(2) The format of this section should follow the organization of the document being reviewed. Page and paragraph numbers should be cited to improve the usability of the comments. The comments Should be written in a constructive tone to help the author of the document modify the next draft or final work. State the problem with specificity rather than a general description of inadequacy. Most importantly, specifically state what needs to be done to rectify the deficiency. Give your precise recommended additions and deletions. As 40 CFR 1503.3 points out, when we choose to criticize a lead agency's predictive methodology we should describe not only the methodology we prefer, but why.

(3) Comments should address significant impacts of the proposed action that may have been overlooked or downplayed. The comments should also be made to assure that alternatives that would benefit or have fewer adverse impacts on fish and wildlife resources be included and adequately presented. Comments on the description of the environment or environmental setting should be made only if a particular component of the environment that will be significantly impacted is not described.

E. **Summary Comments.** When the review comments are lengthy, it may be ,useful to summarize the Service's major concerns and recommendations for rectifying those concerns in this section. Whenever appropriate, this section should close with an offer by the Service to meet with the agency to discuss the Service's comments and concerns. This offer of continued cooperation and assistance is especially important if significant resources are involved or if there are extensive Service comments too difficult to

thoroughly describe in a letter. Specific contacts by titles, addresses, and telephone numbers should be provided.

F. **Collated Responses.** The above format should be used when collating' comments from other bureaus into a Departmental response. However, if lengthy comments are provided by more than one bureau, the comments by the other bureaus can be presented separately within the Departmental response, as long as there are no inconsistencies or differing positions. Differing positions should be resolved between the bureaus. Unresolved issues between bureaus will be resolved at the RED or OEPC level, as appropriate. The Departmental response should be a unified, single consistent response.

3.7 Style for Comments on Draft and Final EISs. Service comments must be clear, specific, succinct, and based on facts, published literature, and expert opinion. Literature sources should be referenced when possible.

A. Presenting a complete, factual analysis is important to convincing the action agency to adopt the Service's recommendations. The tone of the comments should be constructive, objective, and professional. Comments should not contain extraneous information or excessive quotes from the document, have unnecessary descriptions of the proposed action, or give detailed descriptions of the affected environment, or offer unsupported conclusions. Further studies or information should only be requested when necessary for adequate evaluation of the proposed action or alternatives.

B. Do not use a question when commenting. Instead, clearly state the problem and the recommended solution.

C. If the comments are to be ultimately signed by the Secretary, RED, or another official in DOI, do not refer to the Service in the first person. Never use the word "I." You may use phrases such as "The Service suggests," "the Service has advised the Department," etc. Also, be careful not to preempt the Secretary's signature prerogatives. Be clear as to whose position you are referring to. For example, state whether it is a DOI position or a Service position. If you are unsure, assume the latter.

4.1 General Requirements.

A. Interrelated Reviews.

(1) The Council on Environmental Quality's (CEQ) National Environmental Policy Act (NEPA) regulations (40-CFR 1502.25) require to the fullest extent possible, that Federal agencies prepare draft environmental impact statements concurrently with and integrated with environmental impact analyses and related surveys and studies required by the Fish and Wildlife Coordination Act (FWCA), National Historic Preservation Act, Endangered Species Act (ESA), other environmental review laws, and executive orders (ED). Most Federal projects or activities require compliance with these laws and EOs. Similarly, a non-Federal project may require Federal permits, such as section 404 permits for private development in waters of the United States, a Bureau of Land Management (BLM) or Refuge permit or easement for a transmission line crossing, or an Environmental Protection Agency (EPA) point discharge permit under the National Pollution Discharge Elimination System. In any such case, where a private applicant or the State prepares the environmental document, the Federal agency approving the permit or issuing a grant remains responsible for complying with NEPA and other Federal laws, regulations, and EOs. Other project reviews should be reviewed and processed in the same manner, unless-otherwise directed, as environmental reviews.

(2) The Fish and Wildlife Service (Service) has the opportunity and duty to review these documents and others prepared under various environmental protection laws (e.g., 40 CFR 1503.2, section 4(f) of the Department of Transportation Act of 1966). However, even though the Service has additional review opportunities, the Service uses early involvement and coordination to ensure that all interrelated reviews are incorporated within the environmental document. All Service review and approval functions should be coordinated. If the Service fails to point out ESA requirements or neglects to comment on other project involvements, such as section 10/404 permits, the project sponsors and lead Federal agency may have a false impression of our concerns.

B. Segmentation.

(1) The issue of segmentation can involve many different types of proposed Federal projects or permits. However, it has frequently been raised with regard to highway projects. An important

precedent-setting case on highway segmentation is *River v. Richmond Metropo7itan Authority (1973).* The court ruled that the requirements of Federal law may not be avoided by segmentation of a project. The court established three criteria to "prove" segmentation that subsequently have been incorporated into Federal Highway Administration (FHWA) and Corps of Engineers (Corps) NEPA regulations relative to "scope of analysis."

(2) To "prove" segmentation, the following conditions must be shown:

(a) the project was originally perceived as unified and interdependent:

(b) the segments do not have independent utility, and

(c) the segments are not reasonable when considered alone.

(3) One or more of these criteria may be sufficient, although, when all three apply, a better case can be made. If these criteria can be established and if there is sufficient Federal involvement in the planning and construction of the project, segmentation may occur. In this instance, the Service may be able to argue, for example, the need for an environmental impact statement (EIS) for the entire or larger interconnected project. The same logic and approach can be taken if Federal permits are required for some or all of the segments.

4.2 Fish and Wildlife Coordination Act. See also 502 FW.

A. General.

(1) Under provisions of the FWCA (16 U.S.C. 661-667e; 48 Stat. 401, as amended), the Service has the authority to investigate and report on all proposals for work and/or other activities in or affecting the waters of the United States that are sanctioned, permitted, assisted, or conducted by the Federal government. Service comments on an EIS should be consistent with and in support of impact and mitigation analyses provided in FWCA reports, and should reference the FWCA report as appropriate. Ideally, the draft and final FWCA report should be available to the Federal agency prior to its preparation of the draft and final EIS, respectively. However, in unusual circumstances, where the EIS is circulated for review prior to completion of the FWCA reporting process, anticipated impacts and tentative mitigation needs should be identified to the extent possible. A statement should be included in the Service's NEPA comments stating that a more detailed FWCA report is forthcoming.

(2) The FWCA requires Federal construction agencies proposing works to impound, divert, or otherwise modify water bodies to consult with the Service. FWCA reports stem from field

investigations for such water projects as proposed or under study by the Corps and Bureau of Reclamation (BR), as well as for other Corps maintenance and construction activities in navigable waters. Under the Corps and BR procedures to implement the NEPA Regulations, EISs have become an integral part of their planning documentation.

(3) Although EISs are often included with other planning documents, the Service and Department of the Interior (DOI) normally respond to each document separately. This obligation can be met in one letter, provided the comments for each document are presented in separate sections. Due to their unique or complex planning procedures, guidance is provided on the following Federal agency actions.

B. Corps of Engineers Projects

(1) The Corps of Engineers defines their policy and procedures for implementing NEPA in 33 CFR 230. Under these procedures, the Corps integrates NEPA requirements with other planning and environmental review and consultation requirements. NEPA review activities generally occur during Feasibility Studies, which follow Reconnaissance Studies, in the Corps planning process. When an EIS is required, it will occur as a separate section bound in the Feasibility Report. When commenting on these combined documents, which are "ERN-controlled, the FWCA response to the planning document should be separated from the EIS comments, but may be presented in the same letter.

(2) Comments to the Department's Office of Environmental Policy and Compliance (OEPQ should also include the Service's opinion as to the environmental acceptability of the proposed action, and make note of previous Service assistance and comments. Any Service reports or documents referenced must be attached, unless previously submitted to the lead agency. Service comments to OEPC should close with an offer of continued coordination with +he field office (address and telephone number should be provided).

(3) At the termination of Feasibility Studies, the Chief of Engineers prepares a proposed report based on findings of the District Engineer and Division Engineer, which recommends the plan the Chief will propose to Congress for authorization. The proposed Chief's Report is generally two or three pages and summarizes and approves or disapproves the findings and recommendations of the Division and District Engineers. The supporting documents to the proposed Chief's Report vary but usually include the reports of the Division Engineer as well as the District Engineer's Feasibility Report and final EIS.

(4) The Service is required to complete the review of the final EIS within 30 days, but has 90 days to complete the Federal/State agency review of the proposed Chief's Report. These comments are normally contained in one letter, but must be in separate sections. The comments for both reviews should normally be submitted to the Corps within the 30-day period. Should the Service need to make comments on ESA compliance, these comments should be in a separate section of the letter.

(5) Review of the proposed Chief's Report and final EIS should determine whether Service recommendations are included in the Chief's recommendations. Service comments on the proposed Chief's Report should, at a minimum, address the following concerns.

(a) Whether the proposed Chief's Report adequately addresses Service concerns and recommendations (i.e., mitigation, ESA compliance).

(b) Whether the Service supports the Chief's recommended plan.

(6) Comments should present a definite Service position on the proposed Chief's Report and on the project. Where the Service has major unsatisfied concerns, a concise and complete justification of our position, consistent with the FWCA Report, should be provided. Service comments should clearly and forcefully urge the Chief to include modifications deemed necessary to provide for fish and wildlife concerns. When commenting, the Service should recommend specific language changes. "No Comments" on proposed Chief's Reports must also be made in writing to OEPC.

C. **Soil Conservation Service Activities.** See also 504 FW 1.

(1) Soil Conservation Service (SCS) projects also require similar consultation with and reporting requirements by the Secretary of the Interior. This authority was provided in the 1958 amendments to the FWCA, which added a new section (section 12) to the Watershed Protection and Flood Prevention Act of 1954 (P.L. 566).

(2) In December 1979, the Service and SCS signed Channel Modification Guidelines to be used in the planning of all SCS projects or measures where channel modification may be proposed. Respective Service and SCS responsibilities and guidelines for the resolution of issues are defined.

(3) The current edition of the SCS Watershed Protection Handbook outlines SCS procedures to be used to integrate NEPA into their planning process. Like the Corps, SCS now combines documents, in this case, the Watershed Plan and draft EIS. Comments on SCS Watershed Plans combined with EISs should be addressed like those for the Corps of Engineers, as outlined above.

D. **Corps of Engineers/Coast Guard Permits and Licenses Activities.**

(1) The Corps NEPA regulations (33 CFR 230) and Department of the Army regulatory program regulations (33 CFR 320 and 330) should be reviewed. The following guidance is provided regarding the interrelationship of NEPA with permits and licenses.

(a) Where the need for Federal permits or licenses has been identified in an EIS, comments to planning agencies should indicate which permits would require Service review and the likely Service position based on available information. If the Service's comments outline serious concerns or if the Service's likely position would be to recommend denial, the Service should urge the applicant to consult as early as possible with the appropriate Service office (address and telephone number should be provided). Mitigation measures, including project modifications, or proposed permit conditions should be identified in Service comments on the draft EIS.

(b) Despite efforts to have permit requirements identified early in the NEPA process or when site-specific information is lacking, an EIS may still lack an indication of possible permits. If this inadequacy is identified, Service comments on the draft EIS could contain a statement s1milar to the following: "The statement lacks a discussion of (i.e., the requirement for permits) and evaluation of how these actions may affect fish and wildlife resources. Accordingly, these comments do not preclude separate evaluation and comments by the Fish and Wildlife Service, pursuant to the FWCA (16 U.S.C. 661, et seq), if project implementation requires a permit from the U.S. Coast Guard (CG) and/or the Corps, pursuant to sections 9 and 10 of the Rivers and Harbors Act of 1899 and section 404 of the Clean water Act oi 1972, as amended. Please consult with the Field Supervisor, U.S. Fish and Wildlife Service (provide address and telephone number)."

(c) If permits are required for the proposed action, the Service may concur, with or without stipulations, or recommend denial depending on the effects on fish and wildlife resources. For example, for a CG permit for a major bridge replacement, the Service could require features to reduce turbidity during project construction, or that the shoreline area be stabilized with planting suitable for wildlife utilization.

(d) The following general guidance applies to the Service's review of section 10/404 permit applications with regard to NEPA compliance.

(i) Integrating NEPA effectively into the section 10/404 process is a question of "timing." The key elements of the NEPA document (proposal, alternatives, impact assessment) are of little value to the decision maker if it is not prepared and publicly reviewed simultaneously with the permit document.

(ii) The requirements for identifying alternatives under NEPA and section 404 are similar. However, the section 404(b)(1) guidelines require selection of the "least environmentally damaging practicable alternative." NEPA does not require the selection of any particular alternative, only that all reasonable alternatives be identified and analyzed.

(iii) Permit applicants should be made aware early-on of the Corps requirement to comply with NEPA and the section 404(b)(1) guidelines. This should be done through pre-application consultation.

(iv) When an EIS is required, the section 404 process, including the identification of potential alternatives, should commence with the NEPA scoping process.

(v) Ideally, to fulfill the purpose of NEPA, the Corps should receive sufficient information from the applicant to either prepare a draft NEPA document for inclusion with the public notice, or provide public notice for review of the draft environmental document prior to the final decision. Following public review, the final NEPA document and compliance with the section 404(b)(1) guidelines would be completed and the permit decision made.

(2) Bridges on federally-funded highways require the approval of both the FHWA and the CG. Procedures coordinating the actions of these two agencies are found in a 1972 FHWA/CG Memorandum of Agreement (MOA) (refer to DOI Environmental Review Memorandum ER 73-2, April 11, 1973, in the Service NEPA Reference Handbook). The 1972 FHWA/CG MOA assigns the responsibility for preparing the environmental documents to the FHWA. The CG considers the environmental documents and other information in their decision to approve

(with or without conditions) or deny a bridge permit, pursuant to 33 U.S.C. 401, 491, 511 et seq., 525, and acts of Congress.

4.3 Department of Transportation Act of 1966 Activities.

A. Authorities.

(1) The Service and Department review federally-funded activities under the jurisdiction of the Department of Transportation (DOT) under several authorities, including NEPA. These authorities are listed below.

(a) 49 U.S.C. 1653(f), Department of Transportation Act of 1966, section 4(f).

(b) 23 CFR 771 and 777, Federal Highway Administration regulations for implementing section 4(f) of the Department of Transportation Act of 1966. Terms particular to section 4(f) are found in 23 CFR 771.107.

B. **Section 4(f) responsibilities.**

(1) Section 4(f) of the DOT Act declares that the Secretary of DOT shall not approve any program or project requiring use of any publicly-owned land from a public park, recreation area, wildlife or waterfowl refuge, or historical site of national, State, or local significance, unless there is no feasible and prudent alternative, and such program or project includes all possible planning to minimize harm.

(2) Section 4(f) of the Department of Transportation Act of 1966 applies to all DOT activities, including activities under-the purview of the Federal Highway Administrations, the Federal Aviation Administration, Urban Mass Transportation Administration, and the Coast Guard, as well as the Interstate Commerce Commission.

(3) The Secretary of DOT must cooperate and consult with the Secretary of the Interior in developing transportation plans and programs that include measures to maintain and enhance the natural beauty of the lands traversed. DOI procedures for reviewing comments on FHWA proposals are found in DOI Environmental Review Memoranda ER 75-2 and 75-3, July 21, 1975, and August 15, 1975, respectively (refer to Service NEPA Reference Handbook).

(4) Airport projects are subject to provisions of section 4(f), as well as section 16 of the Airway Development Act of 1983 (refer to Service NEPA Reference Handbook). Both Acts address consultation requirements with the Secretary. In general, Service comments relative to section 4(f) and FAA's NEPA document suffice in meeting both requirements.

C. **How to Comment on Section 4(f) Statements.** Section 4(f) statements are generally accompanied with an environmental

document. The Service comments on each document separately, but includes the responses together in the transmitted response to the action agency.

(1) Service section 4(f) comments must indicate the Service position on the adequacy of the statement as it relates to the two provisions.

(a) Does the Service concur that there are no feasible and prudent alternatives to the use of the section 4(f) property? Or should DOI's comments be deferred until additional information is provided?

(b) Does the Service concur that the project includes all possible measures to minimize harm to the section 4(f) property? If not, we should identify the inadequacy and provide any additional measures we feel are needed (i.e., land replacement, landscaping, fencing, facility replacement and/or relocation, and wetland drainage prevention).

(2) The Service's detailed analysis of the two provisos and the propriety of any section 4(f) approval by DOT should be outlined in a separate section of the Service's comments on the EIS or environmental assessment (EA). The separate section should be titled "Section 4(f) Comments The "Summary Comments" section should specifically state that the Service either: does not object, does not object with conditions, or objects to section 4(f) approval at this time because DOT would not consider and/or implement Service recommendations of a reasonable and prudent nature to comply with one or both provisos. A sample DOI letter commenting on a section 4(f) statement/EIS is found in the Service NEPA Reference Handbook.

(3) Service section 4(f) comments should address any inadequacies in the following:

(a) identification of section 4(f) properties in the project's zone of adverse impact; and

determination of the significance of these properties [all Service lands, including hatcheries and refuges, and land acquired with Federal Aid funds and FWCA mitigation lands, are significant in the context of section 4(f)].

(4) identification and evaluation of alternatives to the use of section 4(f) properties;

(5) assessment of environmental impacts;

(6) identification of circumstances where "constructive use" may occur;

(7) mitigation measures; and

(8) consultation and coordination with the Service in the assessment of impacts and in the resolution or tentative

agreement on measures to minimize harm to any Service properties.

D. **When Applicability of Section 4(f) is in Question.**

(1) In some situations, FHWA may question whether section 4(f) is applicable because of the nature of the section 4(f) area or because of the nature of "use." In such situations, Service comments should furnish facts and information, express our opinion, and request a formal opinion relative to the applicability of section 4(f). DOI's position is that section 4(f) applies to the following lands within the jurisdiction of the Service:

(a) all lands authorized, established, or administered as part of the National Wildlife Refuge System;

(b) all lands established or administered as part of the National Fish Hatchery System;

(c) all waters and lands acquired for mitigation purposes under the FWCA; and

(d) all State lands acquired, or developed, or improved for fish and wildlife conservation, restoration, or management with grants under Pittman-Robertson (P/R)-Dingell-Johnson (D/J), section 6 of ESA, and the Anadromous Fish Act of 1965.

(2) DOI Enviro6mental Review Memorandum ER 80-2, June 25, 1980, provides additional information on the applicability of section 4(f) (refer to Service NEPA Reference Handbook).

E. **"Constructive Use."** FHWA and Urban Mass Transit Authority joint regulations define the circumstances under which "constructive uses of certain protected resources would or would not occur (23 CFR 771.135). For example, "constructive use" could mean adverse proximity (indirect) effects of the construction of a highway or airport to a nearby refuge or public park. In such cases, section 4(f) would apply. Service reviews of highway and airport proposals should be aware of this circumstance. If "constructive use" applies, the Service should fully describe the probable impacts ("use") of the section 4(f) properties.

F. **Relationship of Section 4(f) to Grant-in-Aid Programs.**

(1) Fish and wildlife resources managed by the States using P-R or D-J grant-in-aid funds also come under the provisions of section 4(f). The Service is assigned section 4(f) commenting responsibility for DOT-funded projects potentially affecting State and local wildlife management lands (publically-owned) that do not come under the direct management jurisdiction of the Service. If these State-managed lands or streams will be impacted by a federally-funded or permitted highway or airport project, it constitutes a "diversion of funds" as outlined in 50 CFR 80.4 and 80.14, if P-R or D-J funds were used by the State to enhance fish or wildlife resources on these areas. The State DOT is responsible for replacing any P-R/D-J impacted lands

according to these provisions. Service reviewers of such highway or airport projects should be mindful of possible impacts to these lands.

(2) If the Service determines no impact, its comments should state that no lands are involved which were acquired or are managed with Federal grant-in-aid assistance under the Wildlife Restoration Act (P-R Act, Public Law 75-415) or the Fish Restoration Act (D-J Act - Public Law 81-681). Therefore, the Secretary of the Interior's regulations in 50 CFR 80.4 and 80.14 are not applicable. If it is determined that there may be impacts to P-R/D-J lands, the Service's comments should clarify the State's responsibility for diversion of funds.

G. When Service Lands are Involved in Transportation Projects.

(1) National Wildlife Refuge System Lands.

(a) service Refuge Managers should be aware that it is improper to issue a permit for a transportation project granting use of 4(f) lands under our jurisdiction, or in which we have grant-in-aid interest, until the Service, through DOI, has reviewed and commented on the section 4(f) statement, and section 4(f) approval has been granted by DOT. These reviews are either controlled through OEPC and are signed at that level, or they may be controlled and signed at the Service Regional Director level, depending upon the level of impact on section 4(f) lands (see 4.3.K).

(b) In coordinating with a transportation agency relative to proposed use of section 4(f) lands under Service jurisdiction, the Service should determine if there may be feasible and prudent alternatives to use of those lands. The compatibility of the proposed use with the purposes for which the lands were acquired and are being managed must also be determined under the National Wildlife Refuge System Administration Act of 1966. Assuming both findings are satisfactory, the next step is to determine measures to minimize harm that could occur as a result of the proposed action. These required steps should be made known to the transportation agency as early as possible so they may be included in the section 4(f) statement and any NEPA documentation.

(2) National Fish Hatchery System Lands. The words "wildlife" and "refuge" under the DOT Act of 1966 have broader meaning than under the National Wildlife Refuge System Administration Act *[Brooks v. Vo7pe, 460 F.2d 1193, 1194 (9th Cir. 1972)].* It is DOI's position that all lands and interests therein authorized, established, or administered as part of the National Fish Hatchery System are subject to the provisions of section 4(f). However,

such lands are not part of the National Wildlife Refuge System, unless so specified by Congress. This is stated in a DOI Solicitor's Opinion, December 24, 1975; and in a letter from the Secretary, DOI, to Secretary, DOT, June 20, 1980 (refer to Service NEPA Reference Handbook). The protection provided by this Act, and others, such as the Refuge Recreation Act, are extended by regulation to the National Fish Hatchery system (50 CFR 25-29, 31-36, 60, and 70-71).

H. **Protection of Wetlands on Section 4(f) Properties.** See also 507 FW 2, regarding the protection of privately-owned wetlands affected by federally aided highway projects.

(1) The FHWA has agreed that components of the National Wildlife Refuge System (i.e., national wildlife refuges and waterfowl production areas), recreational (but not scenic) segments of Federal wild and scenic rivers, and national parks usually require section 4(f) approval by DOI if any use is required of such lands. This also applies to any Federal or State park or recreation lands acquired under section 6(f) of the Land And Water Conservation Act, section 6 of the ESA, Anadromous Fish Act of 1965, lands acquired or managed under the P-R or D-J grant-in-aid program, and under several other wetlands funding legislation.

(2) In practice, based on section 4(f) and related case law, wetlands that occur on section 4(f) lands usually are afforded a higher degree of protection for proposed use by FHWA than privately-owned wetlands. Mitigation, including the replacement of such lands, generally must be acceptable to the Service before DOI will provide section 4(f) concurrence to FHWA.

I. **Minor Involvement with Public Parks, Recreation Lands, Wildlife and Waterfowl Refuges, and Historic Sites.**

(1) On August 19, 1987, FHWA implemented a nationwide 4(f) evaluation and approval process for federally-aided highway projects with minor involvement with public parks, recreation lands, wildlife and waterfowl refuges, and historic sites (52 FR 31111). For a project to qualify under this streamlined, programmatic approach, the project must entail an improvement to an existing highway, have minor impacts, and have agreement from officials with jurisdiction over the property with regard to the assessment of impacts and proposed mitigation.

(2) DOI has determined that the point of coordination on these proposed projects between the FHWA and the bureaus is at the Regional Director level. The Service Regional Director will coordinate the Service response (i.e., collate field office views) to FHWA on any projects addressed under the nationwide section 4(f) evaluation.

4.4 Endangered Species Act. See also 734 FW.

A. The presence of listed or proposed threatened or endangered species and/or designated or proposed critical habitats in the area to be impacted and the potential impacts of the proposed project on those species or habitats should be fully discussed in agency's environmental documents (i.e., EAs and EISs). Service comments on draft environmental documents should identify potential impacts to those species or habitats which have not been adequately addressed.

B. It is to all parties' benefit that the Service identify potential endangered species and critical habitat conflicts early in the project planning process, such as scoping.

C. The joint Service-National Marine Fisheries Service Interagency Cooperation regulations [50 CFR 402.12(c)] state that consultation, conference, and biological assessment procedures under section 7 may be consolidated with interagency cooperation procedures required by other statutes, such as NEPA. However, satisfying the requirements of NEPA does not in itself relieve a Federal agency of its obligations to comply with their responsibilities under section 7. The following guidance is provided.

   (1) During scoping, the Service should provide the Federal agency with all relevant information on endangered and threatened species. However, this does not relieve the Federal action agency of its requirement to submit a written request for a list of any listed or proposed species or designated or proposed critical habitats, or to develop its own list for Service approval [50 CFR 402.12(c)]. The list should be included in the draft and final environmental document as supporting documents.

   (2) Similarly, where section 7 requires a Federal agency to prepare a biological assessment [50 CFR 402.12(f)], the assessment should be part of the draft and final environmental document.

   (3) Formal section 7 consultation is required when a Federal action may affect listed species or destroy or adversely modify designated critical habitat (50 CFR 402.14). The results of such consultation should be addressed in the draft and final environmental document, or, as appropriate, in the record of decision for an EIS.

D. The Service should ensure that the Federal action agency is also aware of other ESA activities in the area to be impacted, such as recovery plans, recovery actions planned or underway, and any existing or proposed habitat conservation plans, pursuant to section 10(a)(1)(B) of ESA. These activities should be addressed in the action agency's environmental document.

4.5 **Executive Orders 11988 (Flood plain Management) and 11990 (Protection** of Wetlands).

A. EO 11988 affirms that it is national policy to protect and enhance the natural and beneficial values of flood plains and to actively discourage noncompatible development. EO 11990 recognizes that the remaining U.S. wetlands are a valuable national resource. These EOs caution all Federal agencies to do everything possible to preserve remaining wetlands and flood plains by avoiding direct or indirect support of new construction in wetlands wherever there is a practicable alternative.
B. It is Service policy to provide Federal leadership in preserving and restoring the natural and beneficial fish and wildlife values of flood plains and wetlands. Whenever there is a practicable alternative, the Service should not undertake, support, or permit activities under its authorities that would adversely impact flood plains or wetlands. The Service should be-alert during the NEPA planning process for opportunities to protect, restore, and/or enhance fish and wildlife resources values in flood plains and wetlands.
C. Service comments on an EIS should identify and discuss impacts to Flood plain and/or wetland resources. Alternative project elements with less impact to these resources should be suggested, and steps that could be taken to minimize impacts or to restore or enhance natural Flood plain/wetland values should be recommended.
D. If the proposed action does not appear to be in compliance with the EOs, Service comments should state so and recommendations should be made for modifying or abandoning the project.

4.6 Federal Energy Regulatory Commission (FERC). See also 503 FW.

A. For a project license or exemption, FERC regulations require applicants to consult with appropriate State and Federal agencies and affected tribes before submitting an application to FERC. FERC's regulations for implementing NEPA are found in 18 CFR 2, 157, and 380.
B. When FERC decides the application is ready for environmental analysis, it requests public and agency review and comment within 60 days. The Service, through a controlled Departmental process, may issue comments, section 10(j) recommendations, section 4(e) terms and conditions, and section 18 prescriptions for the license. FERC, which has adopted CEQ's NEPA regulations, then prepares a NEPA document for the action.
C. Most licensing decisions are based on EA's. In many cases, FERC provides the public and the Service the opportunity to review and comment on draft EAs. The final EA and finding of no significant impact is issued with the license order.
D. In instances where an EIS is prepared, the Service, DOI, and the public are invited to scoping meetings and have an opportunity to comment on the draft EIS. If Section 4(e), 10(j) or 18 terms, conditions, prescriptions or recommendations are to be revised or submitted along

with NEPA comments, they should-be clearly labeled and separated from the main body of the comment letter.

E. Applicants seeking a preliminary permit do not have to consult with State and Federal agencies prior to filing an application. In these cases, agencies are given 60 days by FERC regulations to provide comments on the Notice of Application. This review is controlled by OEPC. Additional procedures are found in DOI's Environmental Review Memorandum No. ER 90-2, October 3, 1990.

4.7 Other Related Review Procedures. The Service review of environmental documents is often in conjunction with other planning documents. The environmental review procedures should be conducted jointly with the review requirements of the other planning documents. In addition to the other related reviews addressed above, the following Service procedures should be reviewed.

A. Presidential Permits (see 507 FW).

B. Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) (see 507 FW).

C. Review of Regulations. Service comments on proposed regulations will be collated by the Service Washington Office, unless otherwise directed by the Service or OEPC. Such comments will be coordinated and consistent with Service comments on the environmental document or other project reviews associated with the proposed rule.

5.1 Criteria.

A. Council on Environmental Quality (CEQ) referrals are a formal, third party arbitration process initiated when two or more executive departments of the Federal government come to a total impasse on a major national environmental issue. It is CEQ's policy that referrals reflect an agency's careful determination that a proposed action raises significant and environmental issues of national importance that may be precedent-setting. Determinations of the kinds of proposals that are appropriate for referral will be based on meeting one or more of CEQ's six criteria:
   (1) possible violation of national environmental standards or policy,
   (2) severity,
   (3) geographical scope,
   (4) duration,
   (5) importance as precedents, and
   (6) availability of environmentally preferable alternatives.

B. CEQ referrals are only made after all other concerted attempts at resolution have been made and failed. The nature of CEQ's treatment of a referral is not only commensurate with the significance of the proposed action and its impacts, but with the quality of agency-to-agency attempts at resolution. Procedural agreements, if they exist, with other agencies for resolution of issues (such as memoranda of agreements or consultations) must be utilized first.

C. Action agencies generally allow an extension of the 25-day referral period to permit use of the interagency resolution procedures. The Fish and Wildlife Service (Service) can request extensions at the Regional and/or Washington level. However, if an extension cannot be agreed to, the referral must be completed in the time frame specified in 40 CFR 1504.3(b).

D. When the Service seeks to refer an agency's action to CEQ, the Service must first convince the Department of the Interior (DOI) that the referral is needed to solve the fish and wildlife problem. Ultimately, it is the Secretary who refers the project to CEQ. However, the Service is expected to prepare the referral documents and conduct the briefings within DOI and at CEQ.

E. The agency's action, not the environmental impact statement (EIS), is referred to CEQ. Also, whether the agency's EIS is adequate or not adequate has no particular bearing on the decision to refer. The Service may seek to refer a project when the following conditions occur:
   (1) the action is environmentally unacceptable,
   (2) the action raises significant and major environmental issues of national importance, and
   (3) when reasonable, implement able alternatives (including no action) to the proposed action exist.

5.2 **Procedures.**

A. Service offices proposing referral of an agency's actions to CEQ must comply with the following.
   (1) CEQ NEPA regulations (40 CFR 1504).
   (2) DOI NEPA procedures (516 DM 7.5).
   (3) DOI Environmental Review Memorandum ER 77-2, September 7, 1977.

B. Tentative decisions on the Service's intent to recommend referral should be made as early as possible to allow resolution of the issues. Formal notification of the possibility of referral normally occurs in the Department's comments on the draft EIS to the lead agency.

C. Service Regional offices proposing "may refer to CEQ" language in Service comments on draft EISs must advise the Assistant Director - Ecological Services in accordance with 505 FW 1.6. The Assistant Director - Ecological Services will advise the Department's Office of Environmental Policy and Compliance (OEPQ and the lead agency's Washington Office'. The purpose of advance notification is to facilitate resolution of the issues to avoid referral.

D. Every effort must be made at the field, Regional, and Washington Office levels to resolve fish and wildlife concerns during planning stages of the proposal before elevating the referral issue to the next level in the chain-of-command. All attempts to resolve the problem with the lead agency must be fully documented.

E. Field and Regional Office personnel must be available to come to the Washington Office on short notice to work with Washington Service and Departmental personnel as the referral is being developed for acceptance by the Secretary and DOI.

F. Field installations are responsible for tracking release of a final EIS for a project that may be referred, and shall request advance copies direct from the lead agency. This is an important requirement. By waiting until the final EIS is received through official channels, the 25-calendar day countdown could be too close or passed.

G. The 25-day countdown commences with the Environmental Protection Agency's (EPA) publication of the notice of availability of the final EIS in the Federal Register. In addition, the Division of Habitat Conservation (DHQ will notify the Regional Office by phone as soon as the final EIS is received through OEPC channels.

H. Not later than five calendar days after the notice of availability of the final EIS has been published by EPA in the Federal Register, the Regional Office will notify the Assistant Director - Ecological Services and DHC by telephone as to whether or not they will recommend referral on an action previously identified as potentially referable. DHC shall immediately notify OEPC and appropriate Service Washington Office entities.

I. Not later than ten calendar days after the notice of availability of the final EIS,

the Regional Director shall provide the following referral package to the Assistant Director - Ecological Services:

(1) transmittal memorandum signed by the Regional Director;
(2) draft referral letter to the Federal agency being referred to CEQ;draft
(3) referral letter to CEQ;
(4) supporting statement [refer to 40 CFR 1504.3(2)]; and
(5) chronology of steps taken to resolve issues (to avoid referral), including a list of all meetings with the affected parties, showing coordination with affected parties in attempting to resolve the issues (copies of pertinent letters and memoranda, including comments on environmental documents, should be attached).

J. The referral letter and/or supporting statement must address the six referral criteria (or as many as apply) outlined in 40 CFR 1504.3(c)(2). The Service NEPA Reference Handbook contains samples of the abovementioned items of the **referral package.**
K. The referral package should be sent by overnight express mail or other "fast" method of communications to the Washington Office. The package should include the computer disk for revisions.
L. Immediately upon receipt of the materials, DHC, will coordinate the referral with other affected Service Washington Office entities (e.g., Endangered Species, Fisheries, Refuges, Environmental Contaminants), other affected bureaus in the Department, and any other Federal departments.
M. The Assistant Director - Ecological Services will make recommendations to the Director.
N. Service field and Regional Office personnel will likely be directly involved in briefing the Director and the Office of the Secretary (if the matter is referred to the Department).
O. Upon the Director's acceptance of the referral, approval from the Assistant Secretary for Fish and Wildlife and Parks will be sought.
P. If the Service Washington Office or DOI decision is not to refer, the Regional Director will be informed by the Director, as soon as possible, outlining why the referral was not made.
Q. When DOI concurs in the recommendation to refer a proposed action, the Secretary then signs letters to CEQ and to the lead agency, as outlined in 40 CFR 1504.3(c). The letter to CEQ and a copy of the letter to the lead agency must be delivered not later than the 25th calendar day after EPA's notice of availability of the final EIS in the Federal Register.
R. Negotiations should be underway between the Service/DOI and the Federal agency prior to and during the 25-day period. After delivery of the referral letters to CEQ and the lead Federal action agency, higher level negotiations then commence between the referring and lead agencies and CEQ.

5.3 CEQ Actions.

A. Usually within one month, CEQ will hold a hearing among the affected

agencies. Within one to thee months following the hearing, a written decision will be rendered by letter from-CEQ to the two agencies.

B. CEQ may take a variety of interim measures between the first hearing and their final decision in writing. These measures could include more meetings between the agencies to get more facts, field trips, or public meetings in the affected area. In extremely unusual situations, they may elevate the issue to the President. Exhibit I is a chart showing the chronology of the CEQ referral process.

5.4 Referral of Federal Energy Regulatory Commission (FERC) Activities.
Although FERC contends that referral of its trial-type proceedings may not necessarily conflict with FERC's obligation to provide a fair hearing, FERC states that it reserves the right not to participate in a CEQ referral. On potential CEQ referrals, DOI may or may not agree with FERC. In any event, the decision to refer a FERC activity to CEQ is up to the referring agency. Resolution of disputes could involve CEQ. FERC's NEPA procedures (52 FR 47897, December 17, 1987, and 18 CFR 380) provide additional guidance on resolving conflicts on FERC matters.

Exhibit 1 is available from the Division of Habitat Conservation (703) 358-2183.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Washington, D.C. 20240

DIRECTOR'S ORDER NO. 127, Amendment 1

Subject: National Environmental Policy Act Compliance Checklist

Director's Order No. 127, September 1, 2000, is changed as follows:

1. Section 5 is amended to read:

Sec. 5 What is the policy?

a. You must prepare a NEPA Compliance Checklist (Form 3-2185) for most Federal financial assistance actions (including major amendments) that we administer (concur or approve) within the scope of Sections 6, 7, and 8 of this Order. Include the Checklist in the administrative record for the Federal financial assistance action.

b. Modifications to the use of the NEPA Compliance Checklist and modifications pertaining to this policy (e.g., Regional agreements to streamline the review of NEPA Compliance Checklists by the Regional Environmental Coordinators for categorically excluded actions) require prior approval by the Assistant Regional Director for Ecological Services and the Assistant Director for Fisheries and Habitat Conservation.

2. Section 12, subparagraph a, is amended to read:

a. The Service signature approval blocks must include the Regional or Washington Office Environmental Coordinator, as appropriate, for any Federal financial assistance actions for which a Checklist was prepared pursuant to Section 6, subject to Regional modifications as described in Section 5b.

3. Section 14 is amended to extend the termination date to September 30, 2002.

K Adams

Acting Deputy DIRECTOR

Date: September 28, 2001

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Washington, D.C. 20240

DIRECTOR'S ORDER NO: 127

Subject: National Environmental Policy Act Compliance Checklist

Sec. 1 What is the purpose of this Order? This Order establishes policy and procedures for the preparation of an administrative record for complying with NEPA by Service personnel who administer (concur or approve) Federal financial assistance programs that may be categorically excluded or require the preparation of an environmental document (environmental assessment or environmental impact statement).

Sec. 2 Does this Order supersede other guidance? This Order supersedes guidance in 550 FW 3.3C concerning the discretionary preparation of an environmental action statement for NEPA-related actions when applicable to Service Federal financial assistance actions. All other Service actions remain subject to the administrative record guidance in 550 FW 3.3C for NEPA-related matters.

Sec. 3 To whom does this Order apply? This Order applies to all Service personnel who administer (concur or approve) Federal financial assistance programs that may be categorically excluded or require the preparation of an environmental document pursuant to NEPA.

Sec. 4 What are the authorities for taking this action?

a. National Environmental Policy Act (42 U.S.C. 4321-4347).

b. Council on Environmental Quality regulations (40 CFR 1500-1508) and other CEQ guidance.

c. 516 DM 1-6.

Sec. 5 What is the Policy? You must prepare a NEPA Compliance Checklist for most Federal financial assistance actions (including major amendments) that we administer (concur or approve) within the scope of Sections 6, 7, and 8 of this Order. To meet the requirements of this Order, you may use Form 3-2185 (NEPA Compliance Checklist) or, with prior approval of the Assistant Director for Fisheries and Habitat Conservation, you may use a similar checklist. Include the Checklist in the administrative record for the Federal financial assistance action.

Sec. 6 When should I prepare the NEPA Compliance Checklist? Submit the Checklist to the Service decision maker when:

a. The proposed action is not completely covered by a categorical exclusion (e.g., the proposal cannot meet the qualifying criteria in the categorical exclusion, and "is not" will be checked on the Checklist);

NEPA COMPLIANCE CHECKLIST

State: **Federal Financial Assistance Grant/Agreement/Amendment Number:**

Grant/Project Name:

This proposal ☐ is; ☐ is not completely covered by categorical exclusion No(s). _____, 516 DM 6 Appendix 1.
(check (✓) one) (Review proposed activities. An appropriate categorical exclusion must be identified before completing the remainder of the Checklist. If a categorical exclusion cannot be identified, or the proposal cannot meet the qualifying criteria in the categorical exclusion, an EA must be prepared.)

Exceptions:
Will This Proposal *(check (✓) yes or no for each item below)*:

Yes	No		
☐	☐	1.	Have significant adverse effects on public health or safety.
☐	☐	2.	Have adverse effects on such unique geographic characteristics as historic or cultural resources, park, recreation or refuge lands, wilderness areas, wild or scenic rivers, sole or principal drinking water aquifers, prime farmlands, wetlands, floodplains, or ecologically significant or critical areas, including those listed on the Department's National Register of Natural Landmarks.
☐	☐	3.	Have highly controversial environmental effects.
☐	☐	4.	Have highly uncertain and potentially significant environmental effects or involve unique or unknown environmental risks.
☐	☐	5.	Establish a precedent for future action or represent a decision in principle about future actions with potentially significant environmental effects.
☐	☐	6.	Be directly related to other actions with individually insignificant, but cumulatively significant environmental effects.
☐	☐	7.	Have adverse effects on properties listed or eligible for listing on the National Register of Historic Places.
☐	☐	8.	Have adverse effects on species listed or proposed to be listed on the List of Endangered or Threatened Species, or have adverse effects on designated Critical Habitat for these species.
☐	☐	9.	Have material adverse effects on resources requiring compliance with Executive Order 11988 (Floodplain Management), Executive Order 11990 (Protection of Wetlands), or the Fish and Wildlife Coordination Act.
☐	☐	10.	Threaten to violate a Federal, State, local or tribal law or requirement imposed for the protection of the environment.

(If any of the above exceptions receive a "Yes" check (✓), an EA must be prepared.)

Concurrences/Approvals:
Project Leader: _____ Date: _____

State Authority Concurrence: _____ Date: _____
(with financial assistance signature authority, if applicable)

Within the spirit and intent of the Council of Environmental Quality's regulations for implementing the National Environmental Policy Act (NEPA) and other statutes, orders, and policies that protect fish and wildlife resources, I have established the following administrative record and have determined that the grant/agreement/amendment:

- ☐ **is a categorical exclusion as provided by 516 DM 6, Appendix 1. No further NEPA documentation will therefore be made.**
- ☐ **is not completely covered by the categorical exclusion as provided by 516 DM 6, Appendix 1. An EA must be prepared.**
- ☐ **includes other attached information supporting the Checklist.**

Service signature approval:

RO or WO Environmental Coordinator: _____ Date: _____

Staff Specialist, Division of Federal Aid: _____ Date: _____
(or authorized Service representative with financial assistance signature authority)

FWS Form 3-2185
08/00

(3) Joint public involvement.

(4) Joint preparation of environmental documents.

b. Provide assistance and guidance to the States and other applicants on the preparation of environmental documents and implementation of environmental streamlining measures (516 DM 6, Appendix 1.2 and 1.3).

Sec. 14 What is the effective date of this Order? This Order is effective immediately and is applicable to new grants, amendments, or renewals submitted to the Service on or after this date. Any grant actions currently under review by the Service are subject to the existing guidelines in 550 FW 3.3C. The Order will expire September 30, 2001, unless amended, superseded, or revoked. We will include the provisions of this Order in Part 550 of the Fish and Wildlife Service Manual.

DIRECTOR

Date: September 1, 2000

c. The NEPA Compliance Checklist will document our decision as to whether or not the Federal financial assistance action:

(1) Meets the requirements for coverage under an existing categorical exclusion, in accordance with 516 DM 2, Appendix 1; 516 DM 6, Appendix 1; and the exceptions to categorical exclusions in 516 DM 2, Appendix 2; or

(2) Requires the preparation of an EA or EIS. Exhibit 1 is an Overview of the NEPA Process and Documentation (flow chart).

Sec. 10 When should I prepare and process the Checklist? Ensure that the applicant or Service personnel prepare the Checklist and that appropriate authorities sign it prior to project (e.g., Federal financial assistance) approval. In some cases, the applicant may prepare the Checklist; in other cases, Service personnel. However, we are responsible for the accuracy of the Checklist, final concurrence of the Checklist, and compliance under NEPA. The Checklist is part of the administrative record for a Federal financial assistance action, and you must include it with any documents undergoing public review and ensure that it is available to the public upon request.

Sec. 11 How should differences of opinion regarding NEPA matters be resolved between the State and the Service? Try to resolve differences of opinion between the State and Service regarding the NEPA Compliance Checklist and other NEPA matters informally at the lowest level (e.g., between the State Project Leader and the Service Federal Aid Staff Specialist or Regional Federal Aid Chief). If any issues remain unresolved, refer them to the Assistant Regional Director or Regional Director for resolution with higher level State officials.

Sec. 12 Are there any additional instructions for preparing the NEPA Compliance Checklist?

a. The Service signature approval blocks must include the Regional or Washington Office Environmental Coordinator, as appropriate, for any Federal financial assistance actions requiring the preparation of a Checklist within the scope of Section 6 of this Order.

b. You may attach other supporting documentation and/or an explanation of the "checked" responses, if necessary, to the NEPA Compliance Checklist.

Sec. 13 How can the Service work with State and local governments, local agencies, Indian tribes, and private applicants to reduce paperwork and delays for Federal financial assistance actions?

a. Cooperate with State and local agencies to the fullest extent possible, consistent with 40 CFR 1506.2, to reduce duplication between NEPA and State and local requirements. Such cooperation will include:

(1) Joint planning processes.

(2) Joint environmental research and studies.

b. The proposed action cannot be categorically excluded because an exception to the categorical exclusion applies (e.g., a "Yes" will be checked on the Checklist);

c. Environmental conditions at or in the vicinity of the site have materially changed, affecting the consideration of alternatives and impacts (applicable to amendments and renewals);

d. There is a need to document a normally categorically excluded action that may be controversial; or

e. Additional internal review and/or documentation of the NEPA administrative record are desirable.

Sec. 7 To which Federal financial assistance programs does this policy apply? This Order applies to Federal financial assistance programs using appropriated funds and permanent indefinite appropriated funds through the Federal Aid Program that we administer (concur or approve) through the:

a. Division of Federal Aid (e.g., Pittman-Robertson and Dingell-Johnson Acts, Clean Vessel Act, Endangered Species Act, National Coastal Wetlands Conservation Grant Program, etc.).

b. Division of North American Waterfowl and Wetlands (e.g., North American Wetlands Conservation Act and coastal grants authorized by the Coastal Wetlands, Planning, Protection, and Restoration Act).

c. Division of Fish and Wildlife Management Assistance (e.g., Partners for Fish and Wildlife Program assistance and fisheries grants).

Sec. 8 Are there programs where this policy does not apply? This Order does not apply to Federal financial assistance actions in foreign countries, except as appropriate, under Executive Order 12114, January 4, 1979, and the Council on Environmental Quality's guidance, July 1, 1997, on the application of NEPA to proposed Federal actions in the United States with transboundary effects.

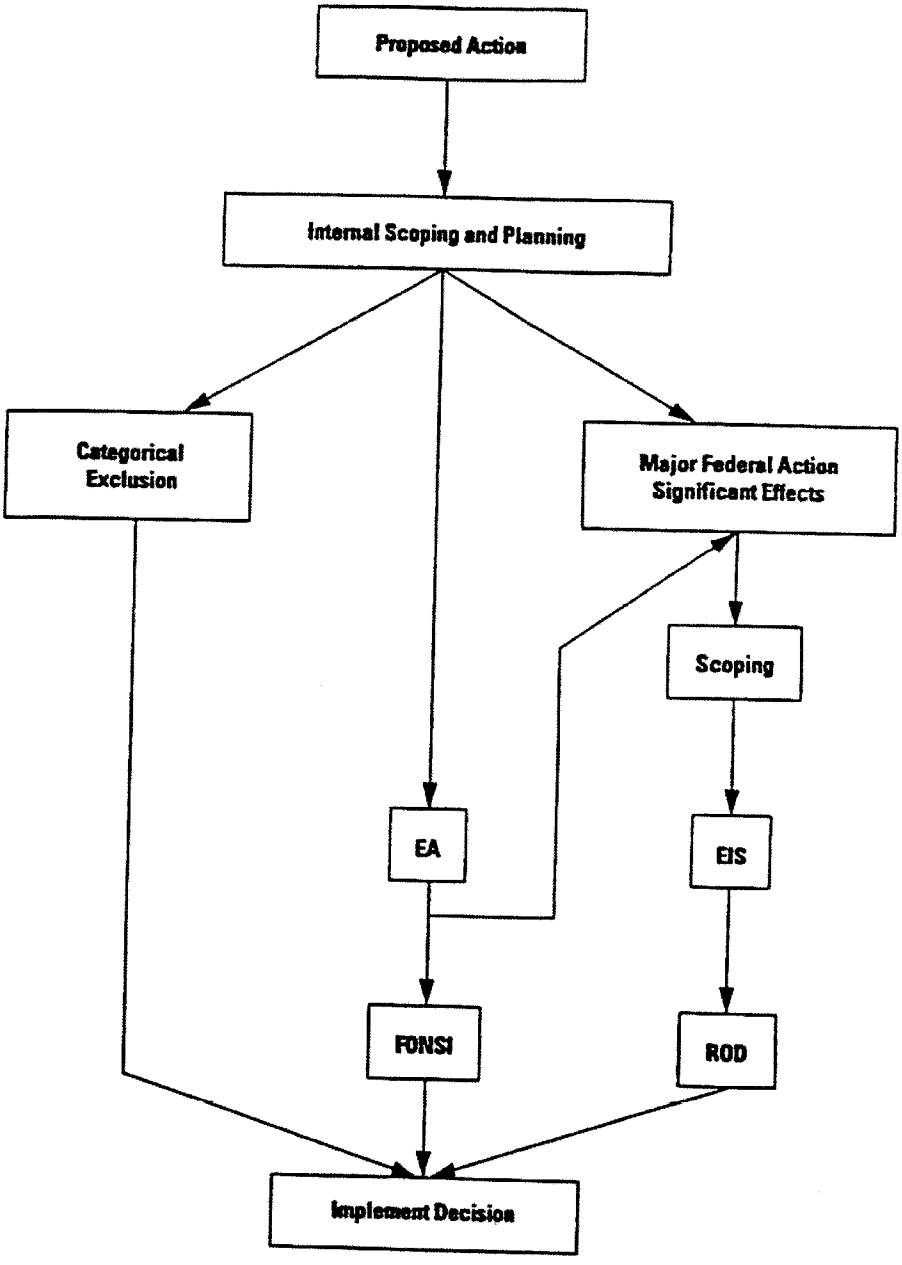
Sec. 9 How do I determine the level of NEPA compliance for Federal financial assistance actions?

a. To ensure compliance with NEPA, initiate early coordination and consultation with other Federal and State agencies, Indian tribes, and private parties seeking Federal financial assistance from the Service, in accordance with 516 DM 2.2 and 516 DM 6, Appendix 1.3.

b. We may require applicants seeking Federal financial assistance to provide additional information on the proposal and on its environmental effects as necessary to satisfy our requirements to comply with NEPA, other Federal laws, and executive orders, in accordance with 40 CFR 1506.6 and 516 DM 6, Appendix 1.3A.

Overview of the NEPA Process and Documentation

NEPA Process



Chapter 1 National Environmental Policy Act - Policy and Responsibilities – 550 FW 1

1.1 What is the purpose of this Manual Chapter? This chapter establishes policy and provides uniform guidance to Fish and Wildlife Service (Service, we, or our) personnel on responsibilities for implementing the National Environmental Policy Act of 1969, as amended, and related authorities (550 FW 1.4) in planning and implementing our actions and preparing NEPA.

1.2 What is the scope of this Manual Chapter? This chapter applies to all of our divisions and offices involved in planning and implementing our actions and preparing documents in accordance with NEPA. This chapter is to be read in conjunction with documents cited in 550 FW 1.5, which are included in full text in the NEPA Reference Handbook. This chapter does not address our review of actions proposed by other Federal agencies and other related reviews, which are addressed in 505 FW 1-5.

1.3 What are the purposes of NEPA? The purposes of NEPA are stated in section 2 of the preamble of NEPA: "to declare a national policy which will encourage productive and enjoyable harmony between man and his environment, to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man, to enrich the understanding of the ecological systems and natural resources important to the Nation, and to establish a Council on Environmental Quality." Two of the purposes have special meaning to us. NEPA's purpose, "to enrich the understanding of the ecological systems and natural resources important to the Nation," is only one of a few such purposes in law that recognizes the

importance of ecological systems to Federal planning and decision making. Further, NEPA's purpose, "to promote efforts which will prevent or eliminate damage to the environment," complements our mission (550 FW 1.4).

1.4 What are our policies regarding NEPA?

(A) We will strive to implement the policy in section 101(a) of NEPA, that is: ". . . it is the continuing policy of the Federal Government, in cooperation with State and local governments, and other concerned public and private organizations, to use all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans."

(B) We shall integrate, in an efficient and reasonable manner, the NEPA purposes (section 2 of NEPA), the NEPA policy (section 101 of NEPA), and the NEPA decisionmaking process (section 102 of NEPA) into the planning and implementation of our actions. Our NEPA goal is to make better environmental decisions in a cost and time-efficient manner to further our mission to conserve, protect, and enhance fish and wildlife and their habitats for the continued benefit of the American people.

1.5 What are the authorities for complying with NEPA? Major authorities, regulations,

procedures, and guidance that establish and promulgate the above purpose are listed below.

A. 42 U.S.C. 4321-4347, National Environmental Policy Act of 1969, as amended.

B. 40 CFR 1500-1508, Council on Environmental Quality Regulations for Implementing the Procedural Requirements of NEPA, July 1, 1986.

C. 48 FR 34263, CEQ's Guidance Regarding NEPA Regulations, July 28, 1983.

D. 46 FR 18026, CEQ's Forty Most Asked Questions Concerning CEQ's NEPA Regulations, March 23, 1981.

E. 516 DM 1-6, Department of the Interior's (Departmental) Manual, particularly Chapter 6, Appendix 1.

F. Environmental Memoranda Series, Department of the Interior, Office of Environmental Policy and Compliance (Environmental Statement and Environmental Compliance Memoranda).

G. Designation of Non-Federal Agencies to be Cooperating Agencies in Implementing the Procedural Requirements of the National Environmental Policy Act, CEQ Memorandum, July 28, 1999.

H. Environmental Justice Guidance Under the National Environmental Policy Act, CEQ, 1998.

I. Application of the National Environmental Policy Act to Proposed Federal Actions in the United States with Transboundary Effects, CEQ, July 1, 1997.

J. Considering Cumulative Effects Under the National Environmental Policy Act, CEQ, January 1997.

K. Incorporating Biodiversity Considerations Into Environmental Impact Analysis Under the National Environmental Policy Act, CEQ, January 1993.

1.6 Where can you find the definitions of terms used in this Manual Chapter? Terms associated with the NEPA process are defined in the Council on Environmental Quality's NEPA regulations in 40 CFR 1508.

1.7 What are our organizational responsibilities for complying with NEPA?

40 CFR 1507.2(a) and 516 DM 6.2B. Overall NEPA responsibilities for the Director, Assistant Director - Fisheries and Habitat Conservation; other Assistant Directors; Regional Directors; Chief, Division of Federal Program Activities; and Washington and Regional Office Environmental Coordinators are defined in 516 DM 6, Appendix 1.1 and 032 FW 5. We have listed additional specific responsibilities relative to 550 FW 1-2 below.

A. Assistant Director - Fisheries and Habitat Conservation. Responsible to the Director for overall management and guidance of Service NEPA-related involvement.

B. Chief, Division of Federal Program Activities.

(1) Carries out the responsibilities for the Assistant Director for Fisheries and Habitat Conservation for providing management and guidance of Service NEPA-related involvement.

(2) Informs the Department's Office of Environmental Policy and Compliance of agreements to assume cooperating status or any declinations pursuant to 40 CFR 1501.6(c) and 516 DM 2.5.

(3) Maintains a record of our notices for the preparation and public review of each environmental impact statement, the record of decision, and a copy of each draft and final EIS.

C. Washington Office Environmental Coordinator.

(1) Provides staff support to ensure NEPA responsibilities delegated to the Assistant Director - Fisheries and Habitat Conservation, and Chief, Division of Federal Program Activities, are carried out in accordance with CEQ's NEPA regulations, DOI's NEPA procedures, and our NEPA guidance.

(2) Serves as our liaison to CEQ, OEPC, and other Federal agency NEPA staff on NEPA

matters, pursuant to 516 DM 6.2 and 516 DM 6, Appendix 1.1D.

(3) Conducts training and ensures quality control of technical input into NEPA-related training materials for Washington, Regional, and field office personnel, including the Regional Environmental Coordinators, on NEPA compliance matters, in coordination with our National Conservation Training Center.

(4) Obtains the statement control number from OEPC for Washington and Regional Office personnel preparing to release draft and final EISs for the purpose of filing with the Environmental Protection Agency and for intra-Departmental distribution.

(5) Prepares the Quarterly Report on EISs, with input from the Regional Environmental Coordinators, in accordance with Departmental procedures in ESM96-3.

(6) Provides technical assistance, quality control, and overview regarding Servicewide compliance with NEPA for our proposals.

D. Regional Director.

(1) Designates an individual in the Regional Office, pursuant to 516 DM 6.2 and Appendix 1.1E, who provides staff assistance to the Regional Director, Assistant Regional Directors, divisions and field offices on NEPA compliance matters.

(2) Ensures quality control of all Service environmental documents submitted by offices and divisions under his/her control.

(3) Ensures that our Regional and field office personnel are adequately trained in NEPA compliance matters.

(4) Submits notices of intent to prepare an EIS to the Federal Register for actions under his/her authority. Provides a copy of the notice to OEPC in accordance with DOI ESM98-2, and a copy to our Washington Office Environmental Coordinator.

(5) Has signature authority to file EISs with EPA in accordance with Departmental procedures in ESM98-2. This responsibility cannot be delegated below the Regional Director or Acting Regional Director level. Non-delegated EISs must be coordinated with OEPC, and cannot be printed, numbered, or distributed until approved for printing by OEPC.

(6) Designates the EIS Team Leader and approves membership on the interdisciplinary planning team to prepare an EIS.

E. Regional Environmental Coordinator.

(1) Provides staff support to the Regional Director by providing technical assistance to the Assistant Regional Directors, divisions, and field offices on NEPA-related matters, including

internal compliance and coordinating environmental reviews. Provides technical assistance in accordance with CEQ's NEPA regulations, DOI's NEPA procedures, and our NEPA guidance.

(2) Coordinates significant Regional NEPA-related issues on an interagency and intra-Service level. This includes assuring that all of our affected or interested offices are advised of our proposals and their need to provide technical input and assistance.

(3) Coordinates with counterparts in other agencies to resolve Regional NEPA-related conflicts.

(4) Serves as liaison to OEPC on non-delegated EISs, pursuant to Departmental procedures (ESM98-2).

(5) Requests statement control number from our Washington Office Environmental Coordinator prior to filing draft and final EISs with EPA and prior to intra-Departmental distribution.

(6) Participates in conducting training of Regional and field office personnel on NEPA compliance matters, in coordination with the Regional Training Officer and our National Conservation Training Center.

(7) Tracks and logs EISs prepared at the Regional level and provides input on a quarterly basis to our Washington Environmental Coordinator for the preparation of the Quarterly Report of EISs, pursuant to Departmental procedures in ESM96-3. To the extent practical, tracks and logs

environmental assessments prepared at the Regional and field office level.

F. Service Divisions and Offices.

(1) Obtains training on NEPA compliance matters whenever involved in the planning of our proposals requiring the preparation of environmental documents. Contacts the Washington or Regional Environmental Coordinator or the National Conservation Training Center for available courses.

(2) Advises our Washington or Regional Environmental Coordinator, as appropriate, whenever an EIS is proposed, and whenever an EA or EIS is prepared. Consults with the Washington or Regional Environmental Coordinator, as appropriate, for guidance and technical assistance on the scoping, preparation, and public review of environmental documents.

1.8 What is the Departmental Quarterly EIS Report, and how do we prepare it? OEPC's ESM96-3 requires each bureau to prepare and submit a quarterly report on EISs to OEPC on January 1, April 1, July 1, and October 1. The Regional Environmental Coordinators will provide input to our Washington Office Environmental Coordinator no later than one week before the above dates. The Washington Office Environmental Coordinator will prepare and submit the report to OEPC through appropriate channels.

1.9 What is the Service NEPA Reference Handbook? The Service NEPA Reference

Handbook, which includes the full texts of various NEPA authorities and related documents cited in this part and in 505 FW 1-3 (Interagency Activities - Environmental Review), is an integral part of and will be read in conjunction with this guidance. Also refer to 505 FW 1.7. You can obtain our NEPA Reference Handbook by accessing http://www.fws.gov/r9esnepa.

Chapter 2 National Environmental Policy Act - Compliance Guidance – 550 FW 2

2.1 What is the purpose of this Chapter? This chapter provides uniform guidance to Fish and Wildlife Service (Service, we, or our) personnel on complying with the procedural requirements for preparing environmental impact statements and environmental assessments and for making categorical exclusion determinations in accordance with the National Environmental Policy Act and pertinent regulations, policy, procedures, and guidance.

A. Service NEPA Goal. Refer to 550 FW 1.4.

B. You can find the objectives of the procedural requirements of NEPA in section 102 of the Act. These objectives were reconfirmed in the Supreme Court Decision, Robertson vs. Methow Valley Citizens Council (1989), which stated:

(1) In reaching its decision, the agency shall carefully consider detailed information concerning every significant environmental impact on the human environment.

(2) The public shall play a role in the decisionmaking process and the implementation of that decision, such as ensuring that monitoring and mitigation plans are executed as prescribed.

C. Relationship to the Council on Environmental Quality's NEPA Regulations and Department of the Interior's NEPA Procedures. This chapter is consistent with CEQ's NEPA regulations (40 CFR 1500-1508) and Departmental NEPA procedures (516 DM 1-6). This guidance supplements and clarifies, but does not duplicate, the aforementioned regulations and procedures as they relate to our activities.

D. Total Service Internal NEPA Compliance Guidance. For a full understanding of NEPA compliance matters for internal Service activities, use this guidance in conjunction with the CEQ NEPA regulations, Departmental NEPA procedures, references cited in the Service's Manual in 550 FW 1.5 and 550 FW 1 and 3. Refer to our NEPA Reference Handbook, authorized in 550 FW 1.9, for full texts of various NEPA authorities and related documents.

2.2 How does the NEPA process apply to the Service?

A. Initial Service Planning and NEPA Decisions. The NEPA process focuses on our decisionmaking process. We must make several critical early and mid-course decisions at the beginning of our NEPA decisionmaking process. Making early NEPA decisions can be critical to our success and efficiency in implementing an action and can reduce delays and costs. Our major decision points are listed below.

(1) Develop the Proposed Action. 40 CFR 1501.2 and 516 DM 2.2. Developing the proposed action is an early planning activity that precedes the initiation of the NEPA process. Before we can make a determination whether or not an action is categorically excluded, requires the preparation of an EIS, or requires an EA, we must develop a proposed action. The proposed action is not a list of goals, strategies, or objectives. The proposed action is a plan of action, identifying specific actions to be taken and decisions to be made. Quantify the specific actions (e.g., location of facilities, size of facilities, capacity projections, etc.). When developed, our proposed action will considered in the NEPA process (40 CFR 1508.23). When permits or grants are proposed by applicants, we should coordinate early with them to develop the purpose, needs, and proposed action. As a result of the public scoping process (550 FW 2.3), revise the proposed action, as appropriate.

(2) Determine Type of NEPA Compliance. The basic question under NEPA is: "Is the action a major Federal action significantly affecting the quality of the human environment?" If the answer is "yes," then we must prepare an EIS. If the action is covered by a Service/Departmental categorical exclusion, we require no documentation under NEPA, except as required by our NEPA guidance in 550 FW 3.3C. If the action does not require the preparation of an EIS, and is not covered by a Service/Departmental categorical exclusion, or if the impacts of the action are uncertain, you must prepare an EA. **Exhibit 1** is a NEPA decisionmaking flowchart showing the options and pathways for NEPA compliance for an action.

(a) Categorical Exclusion. 40 CFR 1508.4 and 516 DM 2.3A. Actions that are categorically

excluded do not require the preparation of an EA or EIS. Our actions that are categorically excluded are found in the Departmental Manual in 516 DM 2, Appendix 1 and 516 DM 6, Appendix 1.4. If circumstances exist in which a normally categorically excluded action may result in significant impacts on the human environment, or if the action is covered by an exception under 516 DM 2.3A(3) and 516 DM 2, Appendix 2, we must prepare an EA or EIS. If a determination is made that our proposed action is a categorical exclusion and the exceptions to the categorical exclusions do not apply, we can implement the action immediately. Refer to 550 FW 3.3C for guidance on establishing an administrative record of a decision to categorically exclude an action and how to prepare an environmental action statement that documents that decision.

(b) Environmental Impact Statement. 40 CFR 1508.11 and 516 DM 4. Our proposed actions that normally require the preparation of an EIS prior to their implementation are listed in 516 DM 6, Appendix 1.6. Also refer to 550 FW 3.3B for criteria to assist in determining when to prepare an EIS for purposes of NEPA compliance, such as when the original proposed action contains mitigation measures to reach a finding of no significant impact that would otherwise require the preparation of an EIS. Circumstances may exist in which an action normally requiring the preparation of an EIS would not require one. In such circumstances, prepare an EA in accordance with 40 CFR 1501.4(e)(2) and will circulate the FONSI to the affected public for a minimum of 30 days before we sign it and implement the action (516 DM 6, Appendix 1.6B). Normally, we will circulate the final EA with the unsigned FONSI at the same time. Refer to 550 FW 3.3A for guidance on preparing and distributing the record of decision (ROD).

(c) Environmental Assessment. 40 CFR 1508.9 and 516 DM 3. The purposes of the EA are to determine if the action will have significant impacts, address unresolved environmental issues, and to provide a basis for a decision on the proposal. Any Service action not fitting (a) or (b) above, or when the impacts of the action are uncertain, or when there are unresolved environmental issues, requires the preparation of an EA. In addition, you may prepare an EA if you determine that it would aid in the planning or decisionmaking, serve as a vehicle to gain public input or to facilitate interagency coordination, simplify permit approval, or gain other necessary legal clearances. Examples of our actions normally requiring preparation of an EA are also listed in 516 DM 6, Appendix 1.5. If an EA determines that the proposal is a major Federal action significantly affecting the quality of the human environment, we must prepare an EIS. Refer to 550 FW 3.3B for guidance on preparing and distributing the FONSI.

(d) Programmatic Document. 40 CFR 1500.4(I) and 1502.20. A programmatic EIS or EA addresses a group of similar or related actions as a whole, rather than one at a time in separate EISs or EAs. A programmatic document can be an effective means for addressing broad cumulative issues and impacts. These documents can address a group of different actions occurring in the same place, or a single action occurring in many different places. Addressing programs, policies, or plans of broad scope, rather than those of narrow scope, can eliminate repetitive discussions of the same issues. Programmatic NEPA documents do not relieve us of our responsibility to prepare site-specific NEPA documents.

B. Lead and Joint Agency. Refer to 40 CFR 1501.5, 1506.2(c), and 516 DM 2.4. A State or

local agency shall be a joint lead agency with the Service if it has State laws or local ordinances promulgating environmental requirements comparable and not in conflict with NEPA and CEQ's NEPA regulations.

C. What are the Benefits and Requirements of a Cooperating Agency? 40 CFR 1501.6 and 1608.5, 550 FW 1.4D and G, and 516 DM 2.5. Also refer to 032 FW and 505 FW 2.2.

(1) Benefit to the Service. The benefits of early coordination in our planning cannot be over-emphasized. A cooperating agency, in the case when we prepare an EIS, can provide meaningful assistance to us through early coordination and cooperation in the planning and implementation of our proposals. A cooperating agency may have jurisdiction by law (40 CFR 1508.15) that requires it to approve, veto, or finance all or part of the proposal; or it may have special expertise (40 CFR 1508.26) that may benefit our planning and implementation of the proposal. Any Federal agency with jurisdiction by law that requests, or is asked by us, to be a cooperating agency, shall be a cooperating agency (40 CFR 1501.6). We encourage our personnel to request other agencies to be a cooperating agency on our proposals to expedite the planning and implementation process by reducing time and costs when other Federal, State, or local planning and decisions are required. The participation of a cooperating agency does not affect our responsibilities as a lead agency or our review and consultation responsibilities, pursuant to other environmental requirements.

(2) Applicability and Eligibility. This guidance applies when we request another agency to be

a cooperating agency on the planning and implementation of our proposal, or when another agency makes a request to us to be a cooperating agency on our proposal. Cooperating agencies should be made aware of our role as lead agency and the role of a cooperating agency, as defined in 40 CFR 1501.5 and 1501.6, respectively. CEQ's NEPA regulations in 40 CFR 1501.6 allow State and local agencies and Indian tribes to be cooperating agencies when such entities have "jurisdiction by law" or "special expertise" on environmental issues addressed in the EA/EIS. These terms are defined in 40 CFR 1508.15 and 1508.26, respectively. We will consider any requests from State and local agencies and Indian tribes to be a cooperating agency, subject to these regulations.

(3) Cooperating Agency Agreements. An agreement should be established in writing between the cooperating agencies and us that specifically states the role of the cooperating agency, including specific tasks to be accomplished, time schedules for completing the tasks, and funds available to the cooperating agency, if appropriate, for the agreed upon product. CEQ's regulations in 40 CFR 1501.6(b)(5) encourage, but do not require, Federal agencies to fund part or all activities performed by a cooperating agency under the agreement. Service funds used for cooperative agency involvement should normally be expended during the scoping stage and not during review and subsequent stages. Refer to 550 FW 1.5G for CEQ's guidance on non-Federal agencies as cooperating agencies.

(4) Reporting. Copies of approved cooperating agreements are maintained by our Regional and Washington Office Environmental Coordinators.

D. Interdisciplinary Planning Team. 40 CFR 1502.6 and 1502.17; and 550 FW 1.7D(6). We will prepare EISs and EAs (if necessary) using an inter-disciplinary approach. Preparers of the document should represent appropriate biological, physical, and economic disciplines necessary to adequately address the key issues and impact analysis. Determine the composition of the team on the basis of significant issues and impacts identified in the early scoping process. The team members can include Federal, State, or other persons with expertise necessary to assist us prepare the EIS or EA.

2.3 What is scoping and how is it used? 40 CFR 1501.7 and 1508.25, and 516 DM 2.6. Scoping is a crucial step in the early planning stage of an environmental document. The objectives of scoping are to identify significant issues and to translate these into the purpose for the action, the needs for the action, the action or actions to be taken, alternatives to be considered in detail, alternatives not to be considered in detail, and impacts to be addressed. Use scoping to design the EIS or EA. Effective scoping should reduce paperwork, delays, and costs; and improve the effectiveness of the NEPA process.

A. Scoping Process. Scoping is a public participation process that begins with the publication in the Federal Register of our notice of intent to prepare an EIS. The scoping process ends with the publication of the Environmental Protection Agency's notice of availability of the draft EIS in the Federal Register. Scoping can be informal or formal, as in the case of an EIS. Scoping is required for an EIS. We encourage public scoping for an EA since it helps satisfy NEPA's purposes in section 101(b). The result of scoping is to streamline our analysis and

decisionmaking process by ensuring that we address all important issues are that unimportant issues are eliminated from analysis. Among the issues to consider, our EISs and EAs should also address Indian trust resources and environmental justice concerns, when appropriate. The result of scoping is to focus and streamline the NEPA process. Scoping ends when we issue the draft EIS or EA.

B. Public Participation in Scoping. Initiate public participation in scoping through a number of techniques, such as notices in local newspapers, direct mailings, Federal Register notices, etc. We should carefully consider the affected public and provide reasonable advance notice of public meetings and comment due dates to facilitate effective public participation in our proposal. Include preliminary scoping information in the notice and at the scoping meeting to solicit meaningful public participation. The scoping information should state the objectives of scoping, our proposal (actions), the purpose and needs for the action, and list preliminary alternatives and impacts. We should strive to understand the public concerns, accurately record their comments, and allow adequate time for involvement by the affected public.

C. Scoping Results. The results of scoping shall be available to the affected public. Include a report of the scoping process and results as an appendix to the EIS or EA. Include a summary of the scoping process and results as a separate section at the beginning of our EIS or EA. We should briefly explain in the scoping results any issues and alternatives raised during the scoping process, but eliminated from detailed analysis in the EIS or EA, should briefly be explained in the scoping results. Most importantly, we should incorporate the results of scoping into the design of and analysis in the EIS or EA.

2.4 What is the content of environmental documents?

A. Content of EA and EIS. 40 CFR 1502.10 and 1508.9, and 516 DM 3 and 4. **Exhibit 2** is a sample outline of an EA/EIS. Additional guidance on selected components of the outline is provided below.

(1) Purpose. 40 CFR 1502.13 and 516 DM 4.9. We define purpose as a goal or end to be obtained.

(2) Needs. 40 CFR 1502.13 and 516 DM 4.9. We define need as a lack of something required, desirable, or useful. Needs can be identified as our needs, as well as the needs of other Federal agencies, States, or private parties. Needs help define and design alternatives. Thus, needs help our decisionmakers achieve our NEPA goal in 550 FW 1.4 by encouraging the selection of the alternative that best satisfies the identified needs.

(3) Scoping/Public Participation. Summarize the results of scoping and public participation in a separate section in the EA/EIS. We should attach a full report of scoping as an appendix to the EA/EIS. Although we do not require public scoping for the preparation of an EA, we encourage it.

(4) Alternatives, Including the Proposed Action. 40 CFR 1502.14 and 1508.23, and 516 DM 4.10. The CEQ NEPA regulations state that this section is the heart of the EIS. Ensure

that the alternatives selected for detailed analysis are reasonable and implementable, are given equal treatment, and provide clear choices for the decisionmaker. Each alternative, including the proposed action, must identify the specific actions, operations, and measures to be taken by the Service, the permit applicant, or grantee. Avoid describing alternatives solely on the basis of strategies, goals, or objectives, unless they identify specific actions, operations, and measures. Develop alternatives in consideration of scoping comments, purpose, and needs. The EIS and EA shall include an alternative comprising the proposed action, a no action alternative, and reasonable alternatives that satisfy the purpose and need(s), to the extent practicable.

(a) No Action Alternative. Describe in detail the specific actions that would take place as a result of not taking the proposed action. The actions can be projected linearly to the planning (future) target date or, the actions can be projected non-linearly to the target date based on reasonably-anticipated projects and activities planned or proposed without the proposed action. In unusual circumstances, we may consider a no-action alternative that is not reasonable when its implementation is otherwise restricted or prohibited by a court decision or legislative statute. In such unusual cases, the no action alternative may still be used as the baseline for comparing the proposed action and other alternatives. Explain the basis for the no action alternative in the EA/EIS.

(b) Preferred Alternative. To avoid confusion, we should normally use the term "preferred" alternative in conjunction with applicant-driven permit or grant actions. For example, we normally consider the applicant's proposal as the proposed action. However, in some instances,

we may identify our "preferred" alternative in the draft/final EA or EIS, to distinguish it from the proposed action and other alternatives. For other than applicant-driven permit and grant actions, the recommended approach is that the final EA or EIS should identify our "proposed" decision. In some cases, the proposed decision could include components of one or more alternatives and/or a combination of several alternatives. This term should not be confused with the requirement to identify the "environmentally-preferable" alternative in the record of decision in 40 CFR 1505.2(b).

(c) Mitigation and Monitoring Measures. Include mitigation and monitoring measures, as appropriate, in each alternative, except the no action alternative.

(d) Summary of Actions by Alternative. Include a brief, concise table at the end of the Alternatives chapter that summarizes the actions by alternative. The table allows the decisionmaker and the affected public to compare changes in the level of actions between alternatives with the no action alternative. Consider differences in actions when you conduct the analysis of impacts in the subsequent Environmental Consequences chapter of the EIS or EA.

(5) Affected Environment. 40 CFR 1502.15. The description of the affected environment establishes the current environmental conditions we consider to be affected or created by the alternatives, including the proposed action. Focus on the biophysical, social, and economic environments pertinent to the actions addressed in the proposed action and alternatives, and on those impacts addressed in the Environmental Consequences chapter in the EIS or EA, as

determined through the scoping process. Although an Affected Environment chapter is not required by CEQ's regulations as a separate chapter in the EA, we suggest that it be included in our EAs. The Affected Environment chapter should include enough information relative to the proposed actions to assist us to develop the analysis contained in the Environmental Consequences chapter. If necessary, lengthy information or data should be included in an appendix, although you should summarized the results in this chapter.

(6) Environmental Consequences. 40 CFR 1502.15 and 1508.8. This chapter addresses the net difference between the environmental impact of the alternatives, including the proposed action, to the no action alternative. An environmental impact is an effect, not a cause (action). For the purposes of NEPA, the terms "impact" and "effect" mean the same. Address both beneficial and adverse direct and indirect (secondary) impacts in the analysis. We should present the analysis in specific terms, such as number of ducks produced reflected as an increase or decrease, number of fishing visits increased or decreased, tons of soil lost or saved per year, etc. Use the best available science in the analysis of impacts. A conclusion should follow the analysis of each impact topic, particularly when the analysis is extensive or complex. The scope and depth of information in the EA must be sufficient for the decisionmaker to reach a conclusion based on the significance of the impacts. Address all significant impacts in detail in the EIS, even if we do not have the in-house expertise to conduct the analysis. In such cases, we may obtain additional expertise from other Federal, State, or local government agencies or from the private sector to adequately address significant impacts. Refer to 550 FW 2.2D regarding necessary expertise on the interdisciplinary planning team.

(a) Impacts to be Addressed. Address direct, indirect, and cumulative impacts, as appropriate. Determine the extent and breadth of impacts to be addressed through formal or informal public scoping, as appropriate. Through scoping, identify impact topics for analysis in each of the alternatives, including the proposed action, and the rationale for their selection should be described. Examples of impact topics are impacts on white-tailed deer, impacts on wetlands habitat, etc. When applicable, other impacts to consider may include minority and low-income populations (ECM95-3 and ECM98-2), Indian trust resources and sacred Indian sites (ECM97-2), transboundary environmental impacts (ESM97-2), and CEQ's guidance on biological diversity cited in 550 FW 1.4K.

(b) Scope of Analysis of Impacts. The scope of analysis of impacts to be addressed in the EIS or EA should be dependent upon whether or not a reasonable, significant link can be established between our proposed action and the impact. This determination should be made during the scoping process and analyzed in the Environmental Consequences chapter.

(c) Cumulative Impact Analysis. In an EIS, prepare a cumulative impact analysis that addresses the proposed action, and a separate analysis for each alternative (if possible). This analysis can be included within each alternative or as a separate analysis at the end of the Environmental Consequences chapter. In an EA, a cumulative impact assessment should be conducted if it is deemed necessary through scoping to make a determination of significance of the proposed action. Refer to CEQ's guidance on considering cumulative effects cited in 550 FW 1.5J.

(d) Impacts of Mitigation. Mitigation measures may also cause impacts, both positive and negative. Analyze any impacts resulting from the mitigation measures in the Environmental Consequences chapter.

(e) Summary of Impacts by Alternative. Insert a brief, concise table should be inserted at the end of the Environmental Consequences chapter that summarizes the impacts by alternative. The table allows the decision maker and the affected public to compare changes in the level of impacts between alternatives with the no action alternative. This table may be useful when making presentations to the decisionmaker and the public.

B. What are the differences Between an EA and EIS? 40 CFR 1501.3 and .4, 516 DM 3.2, 516 DM 6 Appendix 1.5 and 1.6, and 550 FW 3.3B(2). The purposes of an EA are described in 550 FW 2.2A(2)(c). We encourage, but do not require, public scoping for an EA. The content of the EA is reduced by design. The Affected Environment chapter in an EA is suggested, but not required. Otherwise, the format of an EA is similar to that of an EIS. Normally, the text of a final EIS will be less than 150 pages, and for proposals of unusual scope or complexity, will normally be less than 300 pages (40 CFR 1502.7). The text of an EA should normally be 10-15 pages, unless we combine the EA with other planning requirements. The scope and depth of the EA should be "sufficient" for the decisionmaker to reach a conclusion on the significance of impacts in order to determine if the preparation of an EIS is required. It is not necessary for the EA to address the "relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity" and "irreversible or irretrievable

commitments of resources" required in an EIS, as long as the content of the EA can lead to an informed conclusion regarding significance of impacts. Include an assessment of cumulative impacts, if applicable, in the Environmental Consequences chapter of the EA, consistent in scope and depth with the "sufficiency" requirement stated above. If the analysis of impacts in the EA leads us to an informed conclusion that the proposal may significantly affect the quality of the human environment, do not sign the FONSI. No further detailed analysis of alternatives and impacts is required in the EA. At that point, the EA can be made available to the public. We should then prepare and publish a notice of intent to prepare an EIS in the Federal Register (refer to 550 FW 2.5C).

2.5 How do we process and conduct public review of environmental documents?

40 CFR 1508.10 and 550 FW 3. This section addresses the processing and public review of EAs, NOIs, and EISs. The level of public participation can vary substantially between an EA and EIS. Coordination procedures for intra-Departmental review of environmental documents prepared by Departmental bureaus and offices are addressed in DOI ESM98-3.

A. How do we Process the EA?

(1) Our internal approval of an EA should normally be done at the same time the accompanying plan, permit, or rule is approved. If an environmental action statement is prepared, include it with the signature package for approval (refer to 550 FW 3.1C). The approval responsibilities for EAs are in accordance with 032 FW.

(2) The conclusions in the EA and subsequent FONSI or NOI to prepare an EIS should accompany the decisionmaking package for review and approval by the decision maker for our action. For example, for an EA that accompanies a document for an action to be approved at the Washington Office level, the approval of the EA, FONSI, or NOI to prepare an EIS will occur at the Washington Office level. For an EA that accompanies a document for an action to be approved at the Regional Office level, the approval of the EA, FONSI, or NOI to prepare an EIS will occur at the Regional Office level. The Regional Director may delegate the approval of our actions requiring an EA to the field office level, subject to the coordination provisions in 550 FW 1.7E and F. When finalized, the EA and FONSI are part of our administrative record for the action.

(3) We normally do not require Departmental clearances or coordination for processing our EAs. Coordinate the preparation of EAs with our Regional or Washington Office Environmental Coordinator, as appropriate.

B. What are the Requirements for Public Review of the EA? 40 CFR 1501.4(e)(1) and (2) and 1506.6(b), and 516 DM 2.2 and 3.3.

(1) CEQ NEPA regulations and Departmental NEPA procedures require public notification, where appropriate, to allow the affected public to be involved in the EA process. However, no time periods are specified in the CEQ NEPA regulations or Departmental NEPA procedures for the review of the EA. Determine specific time periods for the public review of the EA, as

appropriate.

(2) The EA shall be made available by appropriate notice and/or be circulated to the affected public. In most cases, we will prepare and circulate a draft and final EA. In such cases, the final EA should address the comments of the public, and other Federal, State and local agencies. In cases where an EA is expected to generate few if any comments, we may circulate a single EA to the affected public. In such cases, the EA would normally be referred to as an "EA," rather than a "Final EA." We should circulate the draft and final EA to the public with the accompanying draft and final project documents, such as the plan, permit, or rule. For example, circulate the draft EA with the draft plan, and the final EA with the final plan. Attach all substantive public comments and our response to those comments to the final EA.

(3) The length of the public review period for the EA should normally be the same as the public review period for the accompanying planning and/or decision document, as appropriate. For example, the Endangered Species Act requires a notice in the Federal Register, which initiates a 30-day public review of the draft habitat conservation plan. It is Service policy that this generally applies to all EAs prepared for HCPs that are not large-scale, regional, or exceptionally complex [refer to 550 FW 2.5D(3)]. If an EA was prepared for the action, the notice would also announce the availability of the EA for review in the same review period. In another example, 602 FW 2 requires a 30-day public comment period for a draft refuge comprehensive conservation plan. If we prepare an EA for the CCP, it should be circulated for public review in the same manner and time as the draft CCP, and with the final CCP if substantive changes to the

final EA are made. The public review of the EA should be integrated and concurrent with the public review requirements of the planning documents for the Service proposal. Service personnel should include public participation in the preparation, review, and implementation of the EA in parallel with other Service requirements to reduce delays, reduce costs, and to make a better environmental decision.

(4) CEQ NEPA regulations in 40 CFR 1501.4(e)(2) and subsequent CEQ NEPA guidance require a 30-day review of the FONSI under certain circumstances. Refer to 550 FW 3.3B(4) for a list of the criteria for circulating the FONSI. If an EA was not previously made available for public review, we should make it available for public review at the same time the FONSI is circulated, subject to the 30-day review period.

(5) Public notice of the EA can be made using any appropriate media means to reach the affected public. If an EA is prepared for an action having nationwide implications, you must publish a notice of availability in the Federal Register.

C. How do we Process and Provide Public Notification of the NOI? 40 CFR 1501.7, 1508.22, and 516 DM 2.3D. The NOI to prepare an EIS shall be published in the Federal Register by the Service Washington or Regional Office, as appropriate. Provide a copy of the notice to OEPC, in accordance with DOI ESM98-2, and a copy to the Washington Office Environmental Coordinator. The NOI initiates the scoping process for the EIS, which ends upon issuance of the draft EIS. The notice for the NOI in the Federal Register should indicate the

approximate release date of the draft EIS for public review. The Federal Register notice can also indicate a closing date for comments to be considered in the preparation of the draft EIS. Normally, this would be 30 to 60 days following publication of the notice. We shall consider any comments received in writing or verbally from any public scoping meetings for the EA in the preparation of the draft EIS. We will make very effort to consider comments received after the comment due date given in the NOI, depending upon the schedule for preparing the draft EIS. Where applicable, these procedures may also apply to the public notification for preparing an EA, as appropriate. **Exhibit 3** is an example of an NOI to prepare an EIS in the Federal Register.

D. What are the Requirements for Processing and Providing Public Review of the EIS? 40 CFR 1506.6, 1506.9, 1506.10, and DOI ESM94-8, 95-3, 96-2, and 98-2.

(1) Service and Departmental Clearance. DOI ESM98-2. Regional Offices and Washington Office divisions preparing EISs should contact the Washington Office Environmental Coordinator to obtain additional guidance on whether an EIS is delegated or non-delegated, and to obtain Departmental clearance for publication. Most of our EISs are delegated, meaning that signature authority for the proposed action rests by delegation only with the Assistant Secretary for Fish and Wildlife and Parks or the Service. Refer to DOI ESM98-2 for the criteria by which an EIS is non-delegated, and additional requirements, including restrictions on obtaining a control number . Non-delegated EISs must be approved and filed with EPA by the Assistant Secretary for Policy, Management and Budget. The AS/PMB has assigned this responsibility to OEPC. Evidence of Departmental clearance is required by EPA before EPA will publish their

notice of availability in the Federal Register. The Department will not provide clearance to us until we have indicated that our document has been approved by the Regional Director or Director, and has been printed or is being distributed. Clearance means that you must obtain a "DES" number for a draft EIS, and a separate "FES" number for a final EIS. Write or stamp the clearance number (it does not need to be printed) on the front outside cover of all draft and final EISs sent to EPA for filing, OEPC, and affected or interested offices or bureaus in the Department of the Interior. You are not required to mark the clearance number on EISs distributed to other Federal agencies and the public.

(2) Filing EISs with EPA. DOI ESM95-3, 96-2, and 98-2. Once the EIS has received Departmental clearance, file the EIS as soon as possible with EPA. EPA requires five copies of the EIS. File the five copies of the EIS with EPA by Express Mail to avoid any delays in the publication of the notice. EPA will prepare a notice of availability, which contains the name of the agency, name of the project, location, comment due date, and agency contact person and telephone number. The notice will appear in the Federal Register under EPA's "Environmental Statements, Availability, etc. - Weekly Receipts." EPA will publish the notice on Friday of the week following the week the notice is received. The date of EPA's notice of availability in the Federal Register is counted as the official first day of the comment period. Unless a longer due date is requested in the Service's or Department's letter to EPA, the due date EPA will list in the Federal Register will be a minimum of 45 days for a draft EIS, and a minimum of 30 days for a final EIS, respectively, from the date of publication in the Federal Register. If the last day falls on a weekend or holiday, EPA will select the next working day as the closing date. Do not

delegate the responsibility for filing an EIS below the Regional Director or Director level, as appropriate (550 FW 1.7C). Departmental statement control numbers for draft and final EISs are obtained through the Washington Office Environmental Coordinator (550 FW 1.7D). **Exhibit 4** is an example of a letter for filing a draft/final EIS with EPA.

(3) EIS Review Time Period. 40 CFR 1506.10, 516 DM 4.24, and DOI ESM94-8. This guidance incorporates Departmental procedures and CEQ NEPA regulations regarding the time period for public and agency review of a draft EIS. The time period for public and agency review of the draft EIS will be a minimum of 60 days from the date of transmittal of the draft EIS to EPA, or a minimum of 45 days from the date of EPA's notice of the draft EIS in the Federal Register, whichever is less; and a minimum of 30 days for a final EIS. Normally, EPA will indicate a 45-day time period (minimum required in the CEQ NEPA regulations) in the EPA notice, unless requested by us in writing to be longer. In some cases, the public review period may be longer than the minimal time period prescribed in the CEQ NEPA regulations. For example, a draft EIS for an HCP normally requires a minimal public review period of 90 days. This is consistent with Service policy that requires a 90-day review of a draft HCP which is large-scale, regional, or exceptionally complex.

(4) Service Notice of Availability of Supplemental Information. DOI ESM98-2. We may publish an additional, but separate, notice in the Federal Register containing supplementary information on the proposal. The due date for comments indicated in that notice must be the same as indicated in the EPA notice. **Exhibit 5** is an example of a Service NOA in the Federal

Register for a draft/final EIS.

(5) Intra-Departmental Distribution and Review of EISs. DOI ESM98-3. **Exhibit 6** is an example of a memorandum seeking intra-departmental review of an EIS. The memorandum should be addressed to any bureau in the Department of the Interior that may be affected by the proposal. The number of copies of the EIS to be sent to each bureau will be in accordance with DOI ESM98-3.

E. Who Can Prepare the EIS or EA? 40 CFR 1506.2, 1506.3, 1506.5(c), and 516 DM 4.18 and Appendix 1. An EIS can be prepared by us or a contractor, but not normally by the applicant who is seeking to receive a permit, grant, or approval from us. When a contractor prepares an EIS for us, the contractor shall prepare a disclosure statement for inclusion in the draft and final EIS to ensure the avoidance of any conflict of interest (550 FW 2.5F). Under certain circumstances, an applicant, who is a State agency or official, can be the primary preparer of an EIS if they meet the requirements of section 102(2)(D) of NEPA. Refer to 516 DM 4, Appendix 1 for a list of Department of Interior programs of grants to States in which agencies having statewide jurisdiction may prepare EISs. An EA can be prepared by us, a contractor, or the applicant.

F. What are the Requirements for Contractors who Prepare EISs? 40 CFR 1506.5(c). The Service should provide technical assistance to applicants and contractors on NEPA compliance matters. When a contractor prepares an EIS, the contractor shall prepare a disclosure statement

prepared by the Service, or where appropriate the cooperating agency, specifying that the contractor has no financial or other interest in the outcome of the project. **Exhibit 7** is an example of a disclosure statement from a contractor to be included in a draft and final EIS.

G. When should a Supplement be Prepared for an EIS? 40 CFR 1502.6 and 516 DM 4.5. Prepare a supplement for draft or final EISs if: (1) substantial changes are made to the proposed action that materially and substantially affect the analysis of impacts, and (2) significant new circumstances or information becomes available that materially and substantially affect the analysis of impacts. In such cases, you will prepare a supplement when you have determined that the changes will have a material affect on the decisionmakers choice. We can also prepare a supplement to further the purposes of NEPA.

H. What Additional Requirements should you be Aware of when Conducting Public Participation? 40 CFR 1501.7 (Scoping), 1503 (Commenting), and 1506.6 (Public Involvement). Also refer to 516 DM 1.6 and 1.7, 301 DM 2; and 550 FW 2.3 and 2.4A(3). Public participation is to be an integral and required part of the NEPA process. We shall make a reasonable and concerted effort to involve affected Federal agencies, States, government officials and agencies, non-governmental organizations, and the public in the NEPA planning, decision making, and implementation process. All substantive public comments to the draft EIS and our response to those comments shall be addressed in the final EIS and attached to the final EIS in accordance with 40 CFR 1503.4. Refer to the referenced CEQ NEPA regulations for guidance on techniques and procedures for public participation in the NEPA process.

I. How should we Handle Public Comments? Each public comment letter or electronic transmission should be numbered and logged (name of originator, date of letter or electronic transmission, and date received). Maintain the original letter and attachments, if any, in a clean manner (without pen and ink markings or marginal comments). The disposition of public comment letters on environmental documents will be in accordance with our records disposition procedures in 283 FW 1-4.

J. What are our Requirements for Addressing Freedom of Information Act Requests? 203 FW 1-2. Environmental documents, defined in 40 CFR 1508.10, should be made available to the public without cost, to the extent practical. Requests for copies of the public comments received by the Service on EAs and EISs, commenter names, home addresses, and other information will be consistent with current Service and Departmental policy. If public requests for public comments on our documents pose unusual circumstances that may outweigh the balance of the privacy interest vs. the public interest, consult the Regional Service FOIA Officer and the Regional Solicitor for advice. Insert the following language in notices of availability of environmental documents for public review.

> All comments received from individuals become part of the official public record. We will handle all requests for such comments in accordance with the Freedom of Information Act and the Council on Environmental Quality's NEPA regulations in 40 CFR 1506.6(f). Our practice is to make comments, including names and home addresses of respondents, available for public review during regular business

hours. Individual respondents may request that we withhold their home address from the record, which we will honor to the extent allowable by law. If you wish us to withhold your name and/or address, you must state this prominently at the beginning of your comments.

K. What are our Requirements for Ensuring Intra-Service Coordination? Preparers of EAs and EISs should ensure that all potentially affected Service programs and offices are coordinated with during the preparation and processing of environmental documents prior to release of such documents for public review.

L. How do we Establish and Maintain the Administrative Record for NEPA Documents? The office originating the NEPA documents for an action should at a minimum maintain the following permanent administrative record of NEPA compliance: draft and final EA, FONSI, NOI to prepare an EIS, draft and final EIS, and ROD. Also refer to 550 FW 1.7B.

2.6 How can we Improve the Effectiveness of NEPA?

A. Reducing Paperwork and Delays. 40 CFR 1500.4 and 1500.5. During the scoping process (550 FW 2.3), make every effort to reduce paperwork and delays by addressing only important or significant issues, not addressing insignificant issues, integrating the NEPA requirements with other consultation and review requirements, using incorporation by reference (40 CFR 1502.21), tiering (40 CFR 1502.20), adoption (40 CFR 1506.3, and 550 FW 2.6B), joint processing with

other Federal and State requirements, combining NEPA documents with other planning documents, and parallel processing of environmental requirements (550 FW 2.6C).

B. Adoption. 40 CFR 1506.3 and 516 DM 3.6. We can adopt another Federal agency's EA or EIS, or another Federal agency can adopt a Service EA or EIS to streamline the NEPA compliance process. The key components to streamlining the NEPA process when we adopt another agency's NEPA document are: (1) the document to be adopted must adequately comply with Departmental/Service NEPA procedures/guidance; (2) we should be a cooperating agency with the other Federal agencies in the preparation of their EA/EIS, in accordance with 40 CFR 1501.6; (3) the other Federal agency's EA/EIS must adequately address our actions and alternatives being considered; and (4) the other agency's EA/EIS must meet the NEPA standards prescribed in 40 CFR 1506.3. This requires close coordination between the involved agencies. **Exhibit 8** is a flowchart of the adoption process.

C. Parallel Processing and Integration of the NEPA Process with Other Environmental Requirements. 40 CFR 1502.25. To the fullest extent possible, the Service shall prepare environmental documents concurrently with and integrated with other environmental impact analyses, related surveys and studies, and planning and decision making requirements. For many Service proposals, parallel processing should ensure concurrent processing of the planning process for the proposal with the requirements under section 404 of the Clean Water Act, section 7 of the Endangered Species Act, NEPA, section 106 of the National Historic Preservation Act, and other requirements.

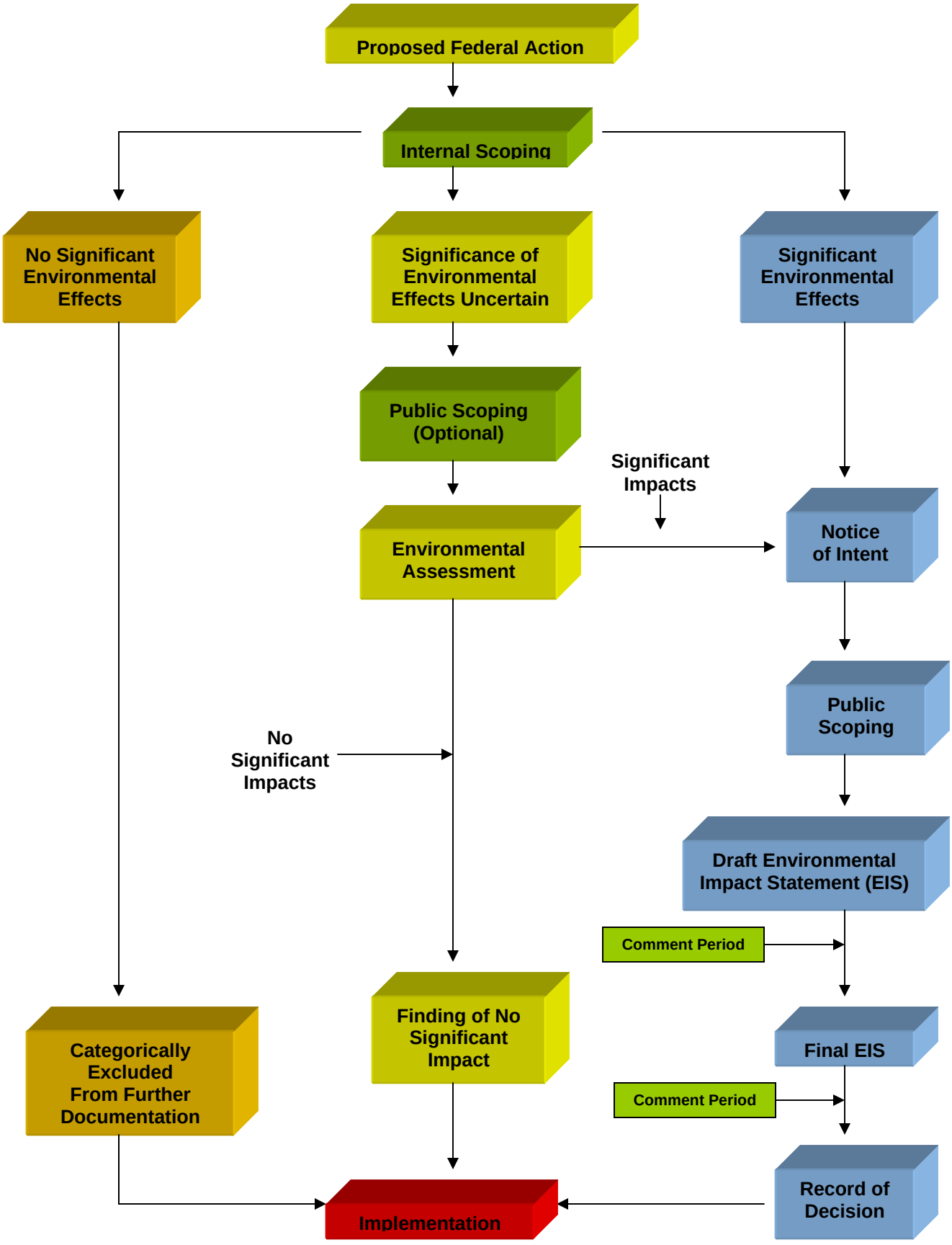
D. Assistance and Guidance to Applicants. 40 CFR 1506.5(a); 516 DM 6, Appendix 1.3; and 550 FW 2.5D(5). You should assist applicants for permits, grants, and approvals in the preparation of environmental documents for our proposals. When applicable, we may require applicants for permits, grants, and approvals to provide additional information on the proposal and on its environmental effects as may be necessary to satisfy our requirements to comply with NEPA, other Federal laws, and executive orders.

2.7 What Other NEPA-Related Guidance should we be Aware of?

A. Record of Compliance. 318 DM 1. The issuance of regulations and policy normally requires the preparation of a Record of Compliance. The ROC contains a section on NEPA compliance for the action. This section of the ROC will summarize compliance with NEPA. When a Service action is categorically excluded, the ROC should state which categorical exclusion(s) applies.

B. Emergency Actions. 40 CFR 1506.11, 516 DM 5.8, DOI ESM97-3. CEQ's NEPA regulations allow agencies to take emergency actions that would have significant environmental impact without NEPA compliance so long as the agency consults with CEQ. The use of an emergency action is very limited by design, is rarely taken by the Service , and applies only in cases where an EIS would otherwise have been prepared. The process is not applicable to an action covered by an EA.

NEPA DECISION MAKING



SAMPLE OUTLINE OF EA/EIS

Cover Sheet

Summary (optional in EA)

Table of Contents (optional in EA)

1.0 Purpose of the Proposed Action

2.0 Needs for the Action

3.0 Scoping/Public Participation (optional in EA, but suggested)

4.0 Alternatives Including the Proposed Action
- 4.1 Alternative A (Proposed Action)
- 4.2 Alternative B (No Action)
- 4.3 Alternative C (continue listing all reasonable alternatives)
- 4.4 Summary of Actions by Alternatives (compare actions in a table)

5.0 Affected Environment (optional in EA, but suggested)

6.0 Environmental Consequences (use same impact topics for each alternative)
- 6.1 Alternative A (Proposed Action)
  - A. Wetland Habitat Impacts
  - B. White-Tailed Deer Impacts
  - C. Economic Impacts
- 6.2 Alternative B (No Action)
  - A. Wetland Habitat Impacts
  - B. White-Tailed Deer Impacts
  - C. Economic Impacts
- 6.3 Alternative C
  - A. Wetland Habitat Impacts
  - B. White-Tailed Deer Impacts
  - C. Economic Impacts
- 6.4 Summary of Environmental Consequences by Alternative (compare impact topics in a table)

7.0 List of Preparers

8.0 List of Agencies, Organizations, and Persons Contacted

9.0 Appendices (optional in EA/EIS, but suggested to keep above text easily readable)

10.0 Index (optional in EA)

(greater management flexibility under a special rulemaking). Additional alternatives may be identified through the upcoming series of public scoping sessions for analysis in the draft EIS.

A scoping newsletter details the EIS process; issues and alternatives identified to date; locations, dates, and times of open houses, and how to become involved. A 16-page booklet with answers to citizens' questions about grizzly bear recovery in the Bitterroot Ecosystem is available and will be inserted in the newsletter. Individuals who previously requested information on grizzly bear recovery in the Bitterroot Ecosystem will receive copies.

Other interested persons can obtain copies of these materials and be placed on the mailing list by writing to Dr. John Weaver (see **ADDRESSES** section).

Dated: May 25, 1995.

Terry T. Terrell,

Deputy Regional Director, Region 6.

[FR Doc. 95–13488 Filed 6–1–95; 8:45 am]

BILLING CODE 4310–55–M

Notice of Intent To Prepare an Environmental Impact Statement for a Permit Application to Incidentally Take the Endangered Karner Blue Butterfly in the State of Wisconsin

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Notice of intent and meetings.

SUMMARY: The U.S. Fish and Wildlife Service (Service) is issuing this notice to advise the public that an Environmental Impact Statement (EIS) will be prepared regarding an application from the Wisconsin Department of Natural Resources (WDNR), Madison, Wisconsin, for a permit to allow the incidental take of the Karner blue butterfly *(Lycaeides melissa samuelis)* in the State of Wisconsin with an accompanying habitat conservation plan (HCP). This notice describes the conservation plan (proposed action) and possible alternatives, invites public participation in the scoping process for preparing the EIS, and identifies the Service official to whom questions and comments concerning the proposed action may be directed. Three public scoping meetings will be held in the State of Wisconsin on the following dates at the indicated locations and times:

1. June 27, 1995; Wisconsin Rapids, WI at City Hall, 444 W. Grand Ave., Council Chambers; 3 p.m. to 6 p.m.

2. June 28, 1995; Siren, WI at the Burnett County Government Center, 7410 Cty. Rd. K, Room 165; 3 p.m. to 6 p.m.

3. June 29, 1995; Eau Claire, WI at the South Middle School, 2115 Mitscher Ave., Auditorium; 3 p.m. to 6 p.m.

There will be a presentation at 3 p.m. at each meeting which will address the Karner blue butterfly, the background and history of the HCP development process, the information available on the presence of this species in Wisconsin, activities which may be affected by their presence, and strategies to conserve the species while allowing land use activities to continue. Submission of written and oral comment and questions will be accepted at the scoping meetings. Written comments regarding EIS scoping also may be submitted by August 30, 1995, to the address below.

FOR FURTHER INFORMATION CONTACT: Janet M. Smith, Field Supervisor, U.S. Fish and Wildlife Service, 1015 Challenger Court, Green Bay, Wisconsin 54311.

SUPPLEMENTARY INFORMATION: The Karner blue butterfly was listed by the Service as an endangered species in December, 1992. Because of its listing as endangered, the Karner blue butterfly population is protected by the Endangered Species Act's (Act) prohibition against ''taking.'' The Act defines ''take'' to mean: to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in such conduct. ''Harm'' is further defined by regulation as any act that kills or injures wildlife including significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering (50 CFR 17.3).

However, the Service may issue permits to carry out prohibited activities involving endangered and threatened species under certain circumstances. Regulations governing permits for endangered and threatened wildlife are at 50 CFR 17.22, 17.23, and 17.32.

The WDNR is preparing to apply to the Service for an incidental take permit pursuant to Section 10(a)(1)(B) of the Act, which authorizes the issuance of incidental take permits to non-Federal landowners. The largest populations of the Karner blue butterfly in the nation occur in this State. This permit would authorize the incidental take of the Karner blue butterfly, and, possibly, associated threatened or endangered species addressed in the HCP, during the course of conducting otherwise lawful land use or development activities on public and private land in the State of Wisconsin. Although public and private entities or individuals have participated in development of the HCP and may benefit by issuance of an incidental take permit, the WDNR has accepted the responsibility of coordinating preparation of the HCP, submission of the permit application and coordination of the preparation and processing of an EIS for Service review and approval. The action to be described in the HCP is a program that will ensure the continued conservation of the Karner blue butterfly in the State of Wisconsin, while resolving potential conflicts that may arise from otherwise lawful activities that may involve this species and its habitat on non-Federal lands in the State of Wisconsin. The environmental impacts which may result from implementation of a conservation program described in the HCP or as a result of implementing other alternatives will be evaluated in the EIS. The WDNR and more than 30 other persons or entities are involved in the process of information gathering, development and preparation of the Section 10(a)(1)(B) permit application, NCP, and the EIS, which is being developed concurrently.

Development of the HCP will involve a public process that includes open meetings of the HCP team and its advisory subcommittees. Those involved in this effort include other State and Federal agencies; counties; towns; industries, utilities, foresters, lepidopterists and biologists; and representatives of various environmental and recreational use organizations. Conservation strategies to be applied to the lands will differ depending on the landowner, ownership objective and management capability. It is anticipated that implementation of the conservation strategies will be through an implementation agreement or cooperative agreement entered into by the landowner and the WDNR.

Alternatives

I. Statewide HCP and Incidental Take Permit (Proposed Action)

This alternative, the proposed action, seeks to address all lands which constitute potential Karner blue butterfly habitat and associated land uses in the State of Wisconsin, whether publicly or privately owned or large or small in size. Such lands include utility, highway and railroad rights-of-way; private and publicly owned forest lands; other publicly owned lands such as parks, fisheries and wildlife areas, and recreational use areas; and private and publicly owned land subject to other

land uses including agriculture and development. This approach seeks to address conservation through a ''grassroots'' landowner effort. Individual conservation strategies of landowners may include:

1. Forest management and production strategies designed to assure no net loss of Karner blue butterfly habitat. However, specific areas of habitat may change;

2. Continued management of habitat through a maintenance and management scheme. Information on this species to date indicates that it is dependent on a disturbance regime, whether natural or otherwise. The species is found in such areas as tank trails on military training areas, timber sale or timber regeneration areas, highway or utility rights-of-way, and agricultural lands. There is evidence that some past and current practices in agriculture, forest management, military operations, right-of-way management, and wildlife management have been beneficial to the species. A ''protection'' strategy alone may result in the loss of habitat due to the natural maturation of other vegetation;

3. Barrens management which entails a scheme designed to maintain or restore barrens communities which may constitute habitat for a variety of species including the Karner blue butterfly;

4. Right-of-way maintenance regimes designed to minimize adverse effects on the Karner blue butterfly or enhance habitat through modification in mowing or clearing regimes, or burning;

5. Agricultural practices designed to maintain habitat; and

6. Other practices or strategies designed to maintain and, possibly, enhance habitat as science or practice confirms their effectiveness.

This alternative would incorporate the concept of ''adaptive management.'' As science and conservation strategies evolve or demonstrate a need to change, the landowners would adapt or modify the conservation strategy as needed. Therefore, as science and information progress, so may the conservation strategies and efforts under the HCP and permit.

This alternative seeks authority for a long-term incidental take permit. The HCP will assure continued conservation measures as well as monitoring and reporting procedures, as required for issuance of an incidental take permit by the Service.

Service issuance of an incidental take permit will authorize land use activities to proceed without violating the Act. Landowners may participate in the HCP through cooperative agreements, certificates of inclusion, involvement in one of the several WDNR private lands assistance programs, other cooperative programs by partners or participants in this conservation effort, or exemption from regulation based on the conservation program established under the HCP and permit. A coarse estimate of potential Karner blue butterfly habitat in the State would include about 25 percent of its acreage. About 12 percent may have a high potential to be Karner blue butterfly habitat.

II. Development of an HCP and Application for an Incidental Take Permit by one Landowner or a Consortium of Landowners or Organizations Not Constituting a Statewide Effort

This alternative may involve a single landowner, such as the WDNR or an industrial forest landowner. It may also involve a group of landowners, such as several industrial forest landowners or utilities. Any conservation strategy addressed in the proposed action alternative could be applied by the landowners involved under the same or similar facts or motives. Conservation strategies not discussed earlier could also be developed.

This alternative requires separate HCP development and application processes. Naturally, this approach would require separate permit review processes by the Service with the necessity of conducting separate environmental impact review procedures and documents.

Implementation and oversight would not likely involve the WDNR, which is the endangered resource regulatory agency for the State of Wisconsin, but would require oversight and implementation as described in the implementation agreements and permits.

III. Development of Short-term Incidental Take Permits

This alternative would seek to address the conservation program for this species for a period which is shorter than that anticipated in the proposed action alternative, which could extend for up to 30 years for willing landowners. Conservation strategies may be the same or similar as in the proposed action alternative, with the possibility of addressing the same land ownership, or some smaller element of land ownership.

IV. No Action Alternative

Under the No Action Alternative, no section 10(a)(1)(B) permit(s) would be issued and activities involving the take of the Karner blue butterfly would remain prohibited under Section 9 of the Act. Activities that would avoid the take of the butterfly could continue. Proposed activities on non-Federal land that may affect the butterfly would require submitting an individual section 10(a)(1)(B) permit application to the Service. If a Federal action (e.g., proposed roadway) would affect the butterfly, incidental take could be allowed through the Section 7 consultation process and development of an incidental take statement if the action were determined to not jeopardize the continued existence of the species.

Issue Resolution and Environmental Review

The primary issue to be addressed during the scoping and planning process for the HCP and EIS is how to resolve potential conflicts between development or land management practices and listed (Federal or State) species in the State of Wisconsin. A tentative list of issues, concerns and opportunities has been developed. There will be a discussion of the potential effect, by alternative, which will include the following areas:

(1) Karner blue butterfly and its habitat.

(2) Other federally listed endangered or threatened species in the state of Wisconsin.

(3) State listed endangered and threatened species in the State of Wisconsin.

(4) Effects on other species of flora and fauna.

(5) Socioeconomic effects.

(6) Use of state, county and local public lands for Karner blue butterfly conservation.

(7) Use of privately owned lands for Karner blue butterfly conservation.

(8) Use of Federal lands.

Environmental review of the permit application will be conducted in accordance with the requirements of the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321 *et seq.*), National Environmental Policy Act regulations (40 CFR Parts 1500–1508), other appropriate Federal regulations, and Service procedures for compliance with those regulations. This notice is being furnished in accordance with Section 1501.7 of the National Environmental Policy Act, to obtain suggestions and information from other agencies, tribes, and the public on the scope of issues to be addressed in the statement. Comments and participation in this scoping process are solicited.

The draft environmental impact statement should be available to the public in the spring of 1996.

William F. Hartwig,

Regional Director, Region 3, U.S. Fish and Wildlife Service, Fort Snelling, MN.

[FR Doc. 95–13622 Filed 6–2–95; 8:45 am]

BILLING CODE 4310–55–M

Notice of Availability of a Draft Recovery Plan for the June Sucker for Review and Comment

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Notice of document availability and public comment period.

SUMMARY: The U.S. Fish and Wildlife Service (Service) announces the availability for public review of a draft recovery plan for the June sucker *(Chasmistes lioris),* a fish inhabiting Utah Lake and the Provo River in Utah. The Service solicits review and comment from the public on this draft recovery plan.

DATES: Comments on the draft recovery plan must be received on or before August 4, 1995 to receive consideration by the Service.

ADDRESSES: Persons wishing to review the draft recovery plan may obtain a copy by contacting the Field Supervisor, Ecological Services, Lincoln Plaza, Suite 404, 145 East 1300 South, Salt Lake City, Utah 84115. Written comments and materials regarding this draft recovery plan should be sent to the Field Supervisor at the Salt Lake City address given above. Comments and materials received are available on request for public inspection, by appointment, during normal business hours at the above address.

FOR FURTHER INFORMATION CONTACT: Henry Maddox (see **ADDRESSES** above) at telephone (801) 524–4430.

SUPPLEMENTARY INFORMATION:

Background

Restoring an endangered or threatened animal or plant to the point where it is again a secure, self-sustaining member of its ecosystem is a primary goal of the Fish and Wildlife Service's (Service) endangered species program. To help guide the recovery effort, the Service is working to prepare recovery plans for most of the listed species native to the United States. Recovery plans describe actions considered necessary for conservation of the species, establish criteria for the recovery levels for downlisting or delisting them, and estimate time and cost for implementing the recovery measures needed.

The Endangered Species Act of 1973 (Act), as amended (16 U.S.C. 1531 *et seq.*), requires the development of recovery plans for listed species unless such a plan would not promote the conservation of a particular species. Section 4(f) of the Act, as amended in 1988, requires that public notice and an opportunity for public review and comment be provided during recovery plan development. The Service will consider all information presented during a public comment period prior to approval of each new or revised recovery plan. The Service and other Federal Agencies also will take these comments into account in the course of implementing approved recovery plans.

The June sucker *(Chasmistes lioris)* occurs only in Utah Lake and the Provo River in central Utah, although the species historically occupied the Spanish Fork River and possibly other tributaries of Utah Lake. This once common fish has declined in abundance due to a variety of human activities that have significantly altered the lake and river habitat in which the species occurs.

The June sucker was listed under the Act as an endangered species on March 31, 1986 (51 FR 10857), due to the precipitous decline in this once common fish. The species decline is believed to result from significant alterations in the species' lake and river habitat. Dams and water diversions constructed on the rivers flowing into Utah Lake have reduced water flows, altered flow regimes within the river, and dramatically increased fluctuations in the level of the lake. Increased pollution and nutrient inflow caused by urban development surrounding Utah Lake, have degraded water quality within the lake and destroyed shoreline vegetation. In addition, several species of nonnative predacious fish that may prey upon juvenile June suckers have been introduced into Utah Lake. The combination of these factors has apparently reduced the survival of young fish to the point that most fish found today are between 20 and 43 years old.

The goal of the recovery plan is increase reproduction and survival of young June sucker to increase population numbers and ensure the species' survival. Recovery actions recommended to facilitate recovery of the species include identification of habitat requirements, coordination of efforts to restore required water flows and other appropriate habitat conditions, and identification and amelioration of the effects of predation by nonnative fish species.

Public Comments Solicited

The Service solicits written comments on the recovery plan described. All comments received by the date specified in the DATES section above will be considered prior to approval of the recovery plan.

Authority

The authority for this action is Section 4(f) of the Endangered Species Act, 16 U.S.C. 1533 (f).

Dated: May 23, 1995.

Terry T. Terrell,

Deputy Regional Director, Denver, Colorado.

[FR Doc. 95–13572 Filed 6–2–95; 8:45 am]

BILLING CODE 4310–55–M

Klamath River Basin Fisheries Task Force; Meeting

AGENCY: U.S. Fish and Wildlife Service, Interior.

ACTION: Notice of meeting.

SUMMARY: Pursuant to section 10(a)(2) of the Federal Advisory Committee Act (5 U.S.C. App. I), this notice announces a meeting of the Klamath River Basin Fisheries Task Force, established under the authority of the Klamath River Basin Fishery Resources Restoration Act (16 U.S.C. 460ss *et seq.*). The meeting is open to the public.

DATES: The Klamath River Basin Fisheries Task Force will meet from 8:00 a.m. to 5:30 p.m. on Tuesday, June 20, 1995, and from 8:00 a.m. to 1:00 p.m. on Wednesday, June 21, 1995.

PLACE: The meeting will be held at the Oregon Institute of Technology (Shasta Conference Center), 2301 Campus Drive, Klamath Falls, Oregon 97603.

FOR FURTHER INFORMATION CONTACT: Dr. Ronald A. Iverson, Project Leader, U.S. Fish and Wildlife Service, P.O. Box 1006 (1030 South Main), Yreka, California 96097–1006, telephone (916) 842–5763.

SUPPLEMENTARY INFORMATION: The principal agenda items at this meeting of the Klamath River Basin Fisheries Task Force will be to recommend a flow study approach for the Klamath River Basin; to recommend projects for funding through Federal and State and fishery restoration grants in the 1996 fiscal year; to decide how to proceed with a draft restoration plan amendment addressing issues on the upper Klamath River Basin; to solicit nominations for awards to recognize private landowner efforts towards restoration of anadromous fish in the Klamath Basin.

EXAMPLE OF LETTER FOR FILING DRAFT/FINAL EIS WITH EPA

U.S. Environmental Protection Agency
Office of Federal Activities
EIS Filing Section
Mail Code 2252-A
401 M St., SW
Washington, D.C. 20460

Dear Sir or Madam:

In compliance with Section 102(2)(C) of the national Environmental Policy Act of 1969 and in accordance with 40 CFR 1506.9, we are enclosing five (5) copies of a *(draft/final)* environmental impact statement for *(title of proposal).*

This EIS has been transmitted to all appropriate agencies, special interest groups, and the general public. The official responsible for the distribution of the EIS and knowledgeable of its content is *(name and phone number).* [Note: If the comment period is to be longer than the minimum periods required in the CEQ regulations, please so indicate to EPA.]

Sincerely,

FWS DIRECTOR or
REGIONAL DIRECTOR *[for delegated EIS]*

or

Willie R. Taylor *[for non-delegated EIS]*
Director, Office of Environmental
Policy and Compliance

Enclosures

cc: OEPC (4 copies)
DOI Natural Resources Library (2 copies)

Note: If you are hand delivering your EIS, you will make your delivery to:

U.S. Environmental Protection Agency
Office of Federal Activities
EIS Filing Section
Mail Code 2252-A
401 M St., SW
Washington, D.C. 20460

Please check in with the building security guard and call the EIS Filing Section on 202/564-2400.

EXAMPLE OF NOA OF DRAFT/FINAL EIS

DEPARTMENT OF THE INTERIOR
(BUREAU)

Notice of Availability of *(Draft/Final)* Environmental Impact Statement

AGENCY: *(Bureau)*, Department of the Interior

ACTION: Notice of Availability of a *(draft/final)* environmental impact statement (EIS) for the proposes *(title)*

*DATE: Comments will be accepted until *(date)*

*ADDRESS: Comments should be sent to *(office and address)*

FOR FURTHER INFORMATION CONTACT: *(office and address)*

SUPPLEMENTAL INFORMATION: A limited number of individual copies of the EIS may be obtained from *(the above contact and wherever).*

Copies are also available for inspection at the following locations:

**A public *(hearing/meeting)* will be held on the proposal on *(dates and locations).*

_____ _____

Date

Willie R. Taylor *[for non-delegated EIS]*
Director, Office of Environmental
Policy and Compliance

or

FWS DIRECTOR or
REGIONAL DIRECTOR *[for delegated EIS]*

* Include only for draft EIS
** Include if appropriate to this notice

EXAMPLE OF MEMORANDUM TO DOI ENTITIES ON THE AVAILABILITY OF DRAFT/FINAL EIS

Memorandum

To: Director, Bureau of Land Management
Director, National Park Service
Commissioner, Bureau of Reclamation
[list other affected bureaus, as appropriate]

From: Director [or Regional Director, as appropriate]

Subject: Draft/Final Environmental Impact Statement for [name project]

Attached is/are [insert number] copies of the subject draft/final environmental impact statement for your review [delete the word "review" for a final EIS] and information.*

If you have any comments or questions regarding the proposal, please contact [list name, address, and telephone number].

Attachments

cc: FWS Office of Congressional and Legislative Affairs
FWS Office of Public Affairs
other affected/interested FWS offices

*The number of copies submitted to the bureaus will be in accordance with DOI ESM98-3.

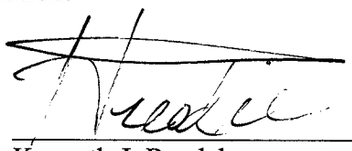
550 FW 2
Exhibit 7

EXAMPLE OF EIS DISCLOSURE STATEMENT

for Plum Creek Timber Company, L.P.,
Concerning the preparation of an EIS
For the Cascades Habitat Conservation Plan

I, **Kenneth J. Raedeke**, of **Raedeke Associates, Inc**. have made inquiry and to the best of my knowledge and belief declare that executing the contracted work of preparing the EIS for the Cascades habitat Conservation Plan does not represent an actual or potential conflict of interest and that **Raedeke Associates, Inc.** does not have any financial or other interest in the outcome of this project.

I understand the term "conflict of interest" to mean that because of other activities or relationships with other persons, the contractor is unable or potentially unable to render impartial assistance or advice to the Government, or the contractor's objectivity in performing the contract work is or might be otherwise impaired, or the contractor may have an unfair competitive advantage. I understand the phrase "no financial or other special interest in the outcome of this project" to include any financial benefits such as promise of future construction or design work on the project, as well as indirect benefits the consultant is aware of other than the enhancement of the contractor's professional reputation.

Signed: 

Kenneth J. Raedeke

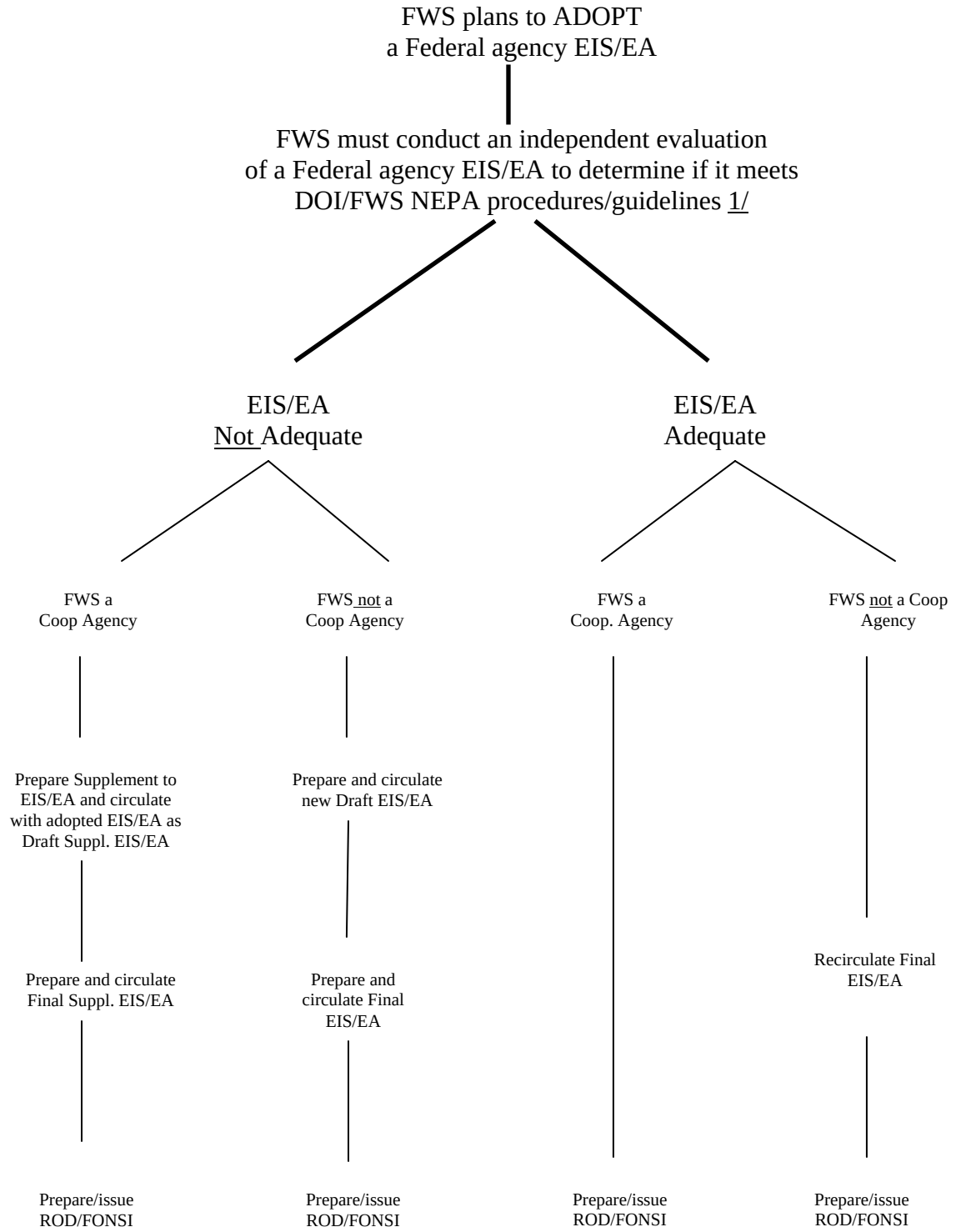
Employers Name: Raedeke Associates, Inc.

Address: 5711 NE 63rd Street
Seattle, Washington 98115

Telephone Number: (206) 525-8122

ADOPTION PROCESS

(40CFR 1506.3)



1/ The independent evaluation must ensure that the adopted and/or supplemental document meets DOI/FWS NEPA procedures and guidelines. The adopted document must (1) adequately reflect significant issues raised during scoping, (2) adequately address the public comments on the draft/final EIS/EA, (3) include FWS actions and alternatives to be considered by the FWS decision make, and (4) adequately address the impacts of the proposed action and alternatives. The independent evaluation must meet DOI/FWS NEPA requirements in 516 DM 1-6, 30 AM 2-3, and 550 FW 3.

CHECKLIST FOR THE CONTENTS OF A
RECORD OF DECISION (ROD)

Record of Decision Title: _____
_____

Final EIS Title (if different from the above ROD title): _____
_____

Reviewer: _____

Date of Final EIS:_____ Date of ROD:_____

DECISION

1. Does the ROD state what the decision was? 1505.2(a)
yes/no page(s)___

2. Does the ROD identify all alternatives considered by BPA in reaching its decision? 1505.2(b)
yes/no page(s)___

3. Does the ROD specify which alternative or alternatives were considered to be environmentally preferable and why? 1505.2(b)
yes/no page(s)___

4. Does the ROD (i)identify and (ii) discuss all relevant factors including any essential considerations of national policy which were balanced by the agency in making its decision? 1505.2(b)
yes/no page(s)___

5. Does the ROD state how those factors identified and discussed in question 4 entered into BPA=s decision? 1505.2(b)
yes/no page(s)___

6. If the chosen alternative was not environmentally preferable alternative, does the ROD state why an environmentally preferable alternative was not chosen? 1505.2(b): 15500.2(f)
yes/no page(s)___

MITIGATION

7. Does the ROD state whether all practicable means to avoid or minimize environmental harm from the alternative selected have been adopted? 1505.2(c)
yes/no page(s)___

8. Does the ROD identify all practicable means to avoid or minimize environmental harm for the

alternative selected which were identified in the EIS but which were not adopted? 1505.2 (c)

yes/no page(s)___

9. Does the ROD state the reasons why the mitigation measures identified in question 8 were not adopted? 1505.2(c)

yes/no page(s)___

MONITORING AND ENFORCEMENT

10. Does the ROD state whether a monitoring and enforcement program is applicable for any mitigation? 1505.2(c)

yes/no page(s)___

11. Does the ROD state whether any applicable monitoring and enforcement program has been adopted? 1505.2(c)

yes/no page(s)___

12. Does the ROD summarize monitoring and enforcement programs which have been adopted? 1505.2(c)

yes/no pages(s)___

MISCELLANEOUS

13. Is the ROD concise? 1505.2

yes/no page(s)___

14. Does the ROD state on its face how it will be made publically available? 1505.2

yes/no page(s)___

15. Does the ROD state on its face that no decision has been made until the later of the following dates: (1) ninety (90) days after publication of the notice for a draft EIS: (2) thirty (30) days after publication of the notice for a final EIS? 1506.10(b)

yes/no page(s)___

16. (a) Endangered and threatened species and critical habitat. If any of the alternatives have been the subject of an FWS biological opinion (which means it has been determined that one or more alternatives may or will affect an endangered or threatened species or critical habitat either adversely or beneficially), does the ROD state that the FWS will be notified of the final determination on whether to proceed with the proposed activity or program? (Proposed) 50 CFR 402.16(a)

yes/no page(s)____

(b)Heritage Conservation. If the decision is or includes taking an action which would adversely affect a property on or eligible for the National Register of Historic Places, does the ROD state (1) that a memorandum of agreement has been prepared between (i) the Federal

agency, (ii) the State Historic Preservation Officer and (iii) the Executive Director of the Advisory Council on Historic Preservation, and (2) that the terms of the memorandum of agreement will be carried out? 36 CFR 800.6(c)(3)

yes/no page(s)___

(c) A-95. If any of the alternatives include taking an action which is direct Federal development and/or Federal assistance, does the ROD (1) state how clearinghouse will be notified of actions taken (implementing, timing, postponement, abandonment, etc.), and (2) explain any actions taken contrary to Clearinghouse recommendations? OMB Circular A-95. Part II. Section 5(b)(4)

yes/no page(s)___

(d) Coastal zones. If the decision is or includes taking an action which (1) is a development project in the coastal zone, (2) directly affects the coastal zone, (3) is listed in an approved coastal management program as requiring a consistency determination, (5) is the same as or similar to actions for which a consistency determination has been prepared in the past, or (6) has been subject to a thorough consistency assessment, does the ROD state that State coastal management agencies have been provided with consistency information at least 90 days prior to the date of the decision, or that both the Federal agency and the State agency have agreed to an alternative period. 15 CFR 930.34(b) and 930.41(c)

yes/no page(s)___

(e) Flood plains. If the decision is or includes taking an action in a flood plain, does the ROD include (1) an explanation of why Athe only practicable alternative consistent with the law and with the policies set forth in (the flood plains Executive Order) requires siting in a flood plain@, and (2) a statement that the action is designed or modified ›to minimize potential harm to or within the flood plain@ (consistent with agencies implementing procedures)? Executive Order 11988, Flood plain Management, Section 2(a)(2)(42 FR 26951, May 25, 1977)

yes/no page(s)___

(f) Wetlands. If the decision is or includes undertaking or providing assistance for new construction located in wetlands, does the ROD include a finding A(1) that there is no practicable alternative to such construction, and (2) that the proposed action includes all practicable measures to minimize harm to wetlands which may result from such use@ (taking into account economic, environmental and other pertinent factors)? Executive Order 11990, Protection of Wetlands, Section 3(a) (42 FR 26961, May 25, 1977)

yes/no page(s)___

(g) Farmlands. If the decision is or includes taking an action which converts prime or unique farmlands to other uses, does the ROD include a finding that there was no practicable alternative to such conversion (taking into account economic, environmental and other pertinent factors such as the agency mission)? NEPA Section 101(b)(4): August 11, 1980 (45 FR 59189, September 8, 1980)

yes/no page(s)___

CHECKLIST FOR THE CONTENTS OF A
FINDING OF NO SIGNIFICANT IMPACT (FONSI)

FONSI Title: _____
_____

Environmental Assessment (EA) Title: _____
_____

Reviewer: _____

Date of EA;_____ Date of FONSI_____

PART 1: CEQ REGULATIONS, 1508.13

1. Does the FONSI include the EA, or a summary of the EA? !508.13
yes/no page(s)

2. If the FONSI includes the EA, does the FONSI incorporate by reference discussions in the EA rather than repeat those discussions? 1508.13
yes/no page(s)

3. Does the FONSI present the reasons why an action will not have a significant effect on the human environment? 1508.13
yes/no page(s)

4. Does the FONSI state whether any other documents are relate to it? 1508.13
yes/no page(s)

PART 2: PUBLIC AVAILABILITY

5. Does the FONSI indicate how it will be made available to the affected public? 1501.4(e)(1)
yes/no page(s)

6. Does the FONSI state whether it has been prepared on an action which
- is, or is similar to, one which normally requires the preparation of an EIS, or
yes/no page(s)

- is without precedent? 1501.4(e)(2)
yes/no page(s)

7. If the action is or is similar tom one which normally require-s an EIS, or is one without

precedent, does the FONSI state whether it will be available for public review for 30 days before the agency makes its final determination whether to prepare an EIS? 1501.4(e)(2)

yes/no page(s)

PART 3: SUBJECTIVE FONSI STANDARDS

8. Does the FONSI include only brief discussion of other than significant issues, with only enough discussion to show why more study is not warranted? 1502.2(b)

yes/no page(s)

9. Is the FONSI brief? 1508.13

yes/no page(s)

PART 4: LEGAL STANDARD OF REVIEW

10. Does the FONSI show that the agency >reasonably concluded@ that the project will have no significant adverse environmental consequences? City of Davis v. Coleman, 521 f.2d 661, 673 (9th Cir. 1975)(emphasis original). Does the FONSI show that the alternatives including the proposed action will not significantly degrade some human environmental factor?

yes/no page(s)

11. An EIS is required whenever a proposed action Amay cause significant degradation of some human environmental factors.@ City of Davis v. Coleman, 521 F.2d 661, 673 (9th Cir. 1975) (emphasis original). Does the FONSI show that the alternative including the proposed action will not significantly degrade some human environmental factor?

yes/no page(s)

12. Is the FONSI prepared according to the agency=s own guidelines? Portela v. Pierce, 650 F. 2d 210, 213 (9th Cir. 1981).

yes/no page(s)

13. Does the FONSI show that it precedes the agency=s final decision on the proposed action? (FONSI pitfall #1)

yes/no page(s)

14. Neutral facts do not support a FONSI. Do facts stated in the FONSI show how they support a finding of no significance? (FONSI pitfall #4)

yes/no page(s)

15. Mitigation measures.

-A(C)hanges in the project are not legally adequate to avoid an impact statement unless they permit a determination that such impact as remains, after the change, is not significant.@ Cabinet Mountains Wilderness/Scotchman=s Peak Grizzly Bears v. Peterson, 685 F.2d 678 (D.C. Cir. 1982). Does the FONSI show that the agency is committed to the mitigation measures reduce

impacts below the threshold of significance?

yes/no page(s)

-Agencies Ashould not rely on the possibility of mitigation as an excuse to avoid the EIS requirement.@ Cabinet Mountains Wilderness/Scotchman=s Peak Grizzly Bears v. Peterson , 685 F. 2d 678 (D.C. Cir. 1982)(emphasis added). Does the FONSI show that the agency is committed to the mitigation measures (i.e. that proposed action will not be taken without measures)? (FONSI pitfall #3)

yes/no page(s)

16. Are all alternatives which were discussed in the EA appear in the FONSI? (FONSI pitfall #2).

yes/no page(s)

17. Impacts may be both beneficial and adverse. A significant effect may exist even of the Federal agency believes that on balance the effect will be beneficial. 40 C.F.R. * 1508.27(b)(1). Does the FONSI show that beneficial, as well as adverse impacts will not be significant? (FONSI pitfall #6)

yes/no page(s)

18. Does the FONSI present the reasons why the action will not have a significant effect on the human environment? 40 C.F.R. * 1508.13. (FONSI pitfall #5)

yes/no page(s)

19. Are all effects described in the EA taken into account in the FONSI? (FONSI pitfall #7)

yes/no page(s)

20. Are all environmental standards the sole evidence of non-significance? (FONSI pitfall #8)

yes/no page(s)

END

FEDERAL AID
NEPA WORKSHEET

NOTE: THIS IS A WORKSHEET TO BE FILLED IN DURING PROJECT PLANNING. THIS IS NOT AN EA. BECAUSE THIS IS A PLANNING TOOL, YOU SHOULD HANDWRITE AND ATTACH INFORMATION.

(Applicable Section of EA Outline in which to use information)

1. What need is causing you to act? (Why do anything?) What is the purpose? (IA)

2. What is the Acontext@ for any action(s)? Background, laws, goals, directives, interrelationships which affect or force your action? (IB, ID)

3. Provide a map and general vicinity description. (IC)

4. Who cares about this kind of action? Who can help give information? Who can answer questions? What public involvement is needed? Who (groups or individuals) has expressed an interest so far? (IE)

5. What are alternative ways of accomplishing the purpose? What are all of my options. (IIB)

6. What alternatives can be eliminated? Why? (IIA)

7. What, in some detail, are the actions (activities or cause agents) of each remaining viable alternative?

8. Which resources will be affected by the specific activities of the alternatives? Answer each Ayes@ or Ano@ (IIIA)

Wildlife_____	Air Quality_____	Economy_____
Vegetation_____	Topography_____	Cultural/Historical Resources _____
Soils_____	Geology_____	Aesthetics_____
Water Quality_____	Sociology_____	Land Use_____

9. For each alternative, list the activities which would have no important effect on the environment. (IIA)

10. Will this project: (IV A, B, C)

(Yes or No)

(A) be performed in any area in which threatened or endangered species are present? _____ May it affect the endangered or threatened species. _____

(B) potentially affect flood plain or wetland area through development, modification or destruction of these areas? _____

(C) be expected to have organized opposition or generate substantial public controversy? _____

(D) include the introduction or exportation of any species not presently or historically occurring in the receiving location? _____

(E) affect any known archaeological, historical or cultural site or alter the aesthetics of subject area? _____

(F) include use of any chemical toxicant? _____

(G) impact on any designated or proposed wild or scenic rivers, trails, or wilderness areas? _____

(H) result in any discharge which will conflict with Federal or State air or water quality regulations? _____

(I) affect any prime or unique farmland, forest land or ecologically critical areas as designated by Federal, State, or local authorities _____

(J) require any Federal or State permits? _____

11. If all the answers are Ano@ in the column above, and if the alternatives are entirely within the categorical exclusions, cease the assessment and prepare a categorical exclusions statement identifying the exclusions which apply.

12. If you marked Ayes@ to any of the above, what public involvement is required? (ID)

13. What is your public involvement plan? What are state processes for obtaining public input?

14. Describe in detail the resources that would be affected in important ways by the

actions of each alternative (all marked Ayes@ in question 8). Consider only those features of each resource which would be affected by the actions. (IIIB)

15. Describe in detail the impacts on the resources which would result from the important activities under each alternative. (IVB)

Altern. A	Altern. B	Altern. C
1. activity & consequences	1.	1.
2. activity & consequences	2.	2.
3. activity & consequences	3.	3.

16. DECIDE IF ANY OF THESE CONSEQUENCES ARE AIMPORTANT ENOUGH@ TO require an EIS. If so, consult with your Federal Aid Coordinator. If not, continue with this assesment.

17. Prepare a consequence table. This will summarize (in quantified form) the impacts which you described under question 15. (IVC)

EXAMPLE

ALTERNATIVES

	Vegetation	Water Soils	Wildlife	Historic
Altern. A	_____	_____	_____	_____
Altern. B	_____	_____	_____	_____
Altern. C	_____	_____	_____	_____

---

18. List the standards or criteria you will use to make your selection among the alternatives. Standards could be such things as detrimental effects, beneficial results, technologic and economic feasibility, compatibility with goals, directives, laws, etc. (IICI)

19. Based on the standards used above, prepare a comparative matrix showing how the various alternatives will meet your chosen standards. Use the following rating system:

++exceeds standards
+meets standards
0 neutral
-does not meet standards
Bserious deficit

ALTERNATIVES	Environmental effects	Technological feasibility	State needs or goals
Alternative A			
Alternative B			
Alternative C			
Alternative D			

20. Discuss which alternative best meets the standards, and select your proposed action or preferred alternative.

THIS COMPLETES YOUR NEPA PLANNING WORK. TO PREPARE YOUR EA, PLACE THIS INFORMATION INTO THE EA FORMAT AS INDICATED BY THE EA OUTLINE SECTION NUMBER ON THE RIGHT-HAND SIDE OF THESE PAGES. IF ALL ACTIVITIES ASSOCIATED WITH THE ALTERNATIVE SELECTED ARE ELIGIBLE FOR CATEGORICAL EXCLUSION, NO EA IS REQUIRED.

REFUGES

ENVIRONMENTAL CHECKLIST

Proposed action:_____

Submitted by:_____

Field Station or Office:_____

ACTIONS	EFFECTS SHORT TERM	EFFECTS LONG TERM	EFFECTS QUANTIFIED
Wetlands			
Uplands			
T&E Species			
Other Wildlife			
Cultural Resources			
Historical Resources			
Water Quality			
Water Quantity			
Air Quality			
Social			
Economic			
Cumulative			
Controversial			

*Quantify the effects

NEPA COMPLIANCE DECISIION

_____ Action categorically excluded from NEPA
_____ Start environmental Assesment (EA)

By:_____ _____
Project Leader Date

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ENVIRONMENTAL IMPACT CHECKLIST
FOR
SOME OF THE MORE COMMON SOCIAL CONCERNS

SOCIAL CONCERN	EFFECT		COMMENTS
	POS	NEG	
Impacts ro minority and low income populations			
Changes in ethnic or racial composition			
Influx or outflow of temporary workers			
Community disruption or disintegration			
Changes in land use patterns			
Changes in lifestyles			
Changes in social interactions, family ties, kinship patterns			
Displacement/relocation of business			
Changes in the ability to provide and deliver social services			
Changes in aesthetics or perceived environmental quality			
Changes in public health, safety, or perceived well-being			
Displacement of community facilities			
Changes in public vehicular access			
Changes in public pedestrian access			
Changes in recreation			
Changes in leisure-time activities			
Changes in local employment opportunities			
Changes in community tax base			
Changes in commerce, recreation, or related services			
Impacts to Native American Trust Resources			

Other			

Fish and Wildlife Service
Department of Transportation Project
Section 4 (f) Review Checklist

	YES	NO

A. Transportation Project Impacts on 4(f) Resources

1. Will recreational resources be significantly impacted?

2. Will historic/archeological on resources be significantly impacted?

3. Does the project involve segmentation of actions?

4. Will secondary development be promoted by the project and affect section 4(f) resources?

5. Will secondary development impacts on section 4(f) resources be environmentally adverse?

6. Will there be Aconstructive use@ of any section 4(f) resources?

7. Will the project affect FWCA mitigated lands/waters?

8. Will the project affect National Wildlife Refuge System lands?

9. Will the project affect National Fish Hatchery System lands?

10. Is there segmentation of transportation projects?

11. Are there other projects now in the area, or planned, that may affect section 4(f) resources?

12. Will Scenic Byways be affected?

13. Will National Recreational Trails be affected?

14. Will the project affect Federal Aid acquired or managed lands?

B. General Comments

		YES	NO
1.	Do the Service comments identify that feasible and prudent alternatives to the use of section 4(f) resources have been identified and evaluated by FHWA?		
2.	Do the Service comments indicate the adequacy of the section 4(f) statement?		
3.	Do the Service comments indicate whether FHWA has identified proper mitigation measures for the project?		
4.	Do the Service comments identify existing planning inadequacies and provide additional mitigating measures, if needed?		
5.	Do the Service comments address inadequacies in the FHWA's document?		
6.	Are all section 4(f) resources in the project area identified by FHWA?		
7.	Has the project's significance on section 4(f) resources been properly determined?		
8.	Has FHWA consulted/coordinated with the Service to minimize harm to any affected Service property?		
9.	Is a Presidential Permit required?		
10.	If required, has the Presidential Permit been issued?		
11.	Has compliance with section 106 of the National Historic Preservation Act been completed?		
12.	Has compliance with E.O.13007 concerning Indian Sacred Sites been completed?		

C. Summary Comments Concerning Section 4(f) Approval

1. Service concurs that there are no feasible and prudent alternatives to the use of section 4(f) resources [or the converse].

2. Service concurs that the project includes all possible measures to minimize harm to the use of section 4(f) resources [or the converse].

ENVIRONMENTAL IMPACT CHECKLIST
FOR
ECONOMIC CONCERNS

ECONOMIC VALUE	EFFECT		COMMENTS
	YES	NO	
Recreation Value			
Ecological Value			
Commercial Value			
Subsistence Value			
Intangible Value			
Economic Impact Values			
Employment			
Consumer Income			
Business Income/costs			
Private Property Values			
Tax Revenues			
Distribution of Effects			
Types of Businesses			
Population Affected			
Tribal Governments			
Other Affected Agencies			
Local			
County			
State			
Federal			

Other			

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A Comprehensive Assessment of Red Wolf Reintroduction Sites

By Shane O'Neal

Advisor: Dr. Nicolette Cagle

Client: Dr. Ron Sutherland, Wildlands Network

April 27, 2018



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Cover photo: Madeleine McMillan

Executive Summary[1]

The red wolf (*Canis rufus*) is the world's rarest wild canid, with fewer than 60 wolves living in the wild, and likely even fewer than 40. After being declared extinct in the wild in 1980, the wolf was reintroduced to Alligator River National Wildlife Refuge in North Carolina in 1987 and successfully established itself, with the small initial population growing to 150 within two decades. Recent increases in mortality have reduced the wolf's numbers to their current low levels, and the Fish and Wildlife Service now faces the difficult decision of where else to reintroduce the red wolf within its historic range.

This Masters Project is an attempt to analyze the current landscape of the Southeast from both an ecological and sociological perspective to determine the best possible places for red wolves to successfully establish a new population. I first conducted a literature review to identify key variables that affect the suitability of an area and found five such factors: available habitat, available prey, concentrations of livestock, recreational hunters, and the age of local residents. The reintroduction effort has to begin on federally owned and protected land, and so I next set out to select a suite of potential sites for the reintroduction to take place, establishing a list of 21 such locations.

The relationship between all of the variables I considered is complex, so to properly weight them against each other I surveyed 14 experts in red wolf biology and management. I received responses from 10 of the experts and used this information to construct models in ArcGIS to determine the overall suitability of a site. After assembling a Weighted Sum model based on available data and calculating descriptive statistics, the sites all received a suitability score. The highest-scoring sites were Croatan National Forest in North Carolina and Okefenokee National Wildlife Refuge in Georgia. Fish and Wildlife should focus future reintroduction efforts on these locations, which strike the best available balance between suitable ecology and low chances of human-wolf conflict.

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[1] For more information, contact the author at sfoneal14@gmail.com.

Introduction

I. The Issue

The world's most endangered wild canid species lives only a three-hour drive from Duke University in the coastal wetlands of North Carolina. The red wolf (*Canis rufus*) once covered a geographic range that encompassed much of the land east of the Mississippi River[2], but today is limited to only a series of National Wildlife Refuges on the Albemarle Peninsula of North Carolina. As a recovery criterion of the US Fish and Wildlife Service's Red Wolf Species Survival Plan (SSP), the Fish and Wildlife Service ("USFWS" or "the Service") aimed to reintroduce the wolves and establish wild populations in three locations within the historic range of the red wolf.[3] Recent research has focused mostly on the status and habits of the wolves living in their limited current range, but managers will need to consider a broader range of issues if they hope to see future reintroductions succeed elsewhere.

This Masters Project aims to lay out a set of suggestions for where red wolves could be reintroduced successfully. I sought to understand what drives the success or failure of such a project, both ecologically and socially, in order to take a comprehensive look at the benefits or drawbacks of all possible sites. The literature on red wolves has not sufficiently dealt with this question, and to avoid a failed reintroduction that could cripple the entire program it is worthwhile to fully address the site selection process before moving any animals back into the wild in a new location.

II. History and Controversy

North Carolina is home to a diverse array of wildlife living in habitats ranging from the coastal plains to the piedmont and the mountains. The red wolf was among the many species driven to the brink of extinction by habitat loss and hunting during the widespread development of the United States, and in 1980 the species was declared extinct in the wild.[4] The last remaining wild individuals were captured from swampy forests along the Louisiana-Texas border between 1973-1980, and those that were

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[2] Ronald M. Nowak, "The Original Status of Wolves in Eastern North America," *Southeastern Naturalist* 1, no. 2 (June 1, 2002): 95–130, https://doi.org/10.1656/1528-7092(2002)001[0095:TOSOWI]2.0.CO;2.; U.S. Fish and Wildlife Service, "Endangered Red Wolves," October 1997, https://digitalmedia.fws.gov/cdm/singleitem/collection/document/id/1940/rec/1. ; International Wolf Center, "North Carolina." http://www.wolf.org/wow/united-states/north-carolina/.

[3] U. S. Fish and Wildlife Service, "Red Wolf Recovery/Species Survival Plan" (U.S. Fish and Wildlife Service, Southeast Region, 1989).

[4] *Id* at Executive Summary.

determined to be pure examples of the red wolf phenotype were captured and moved into captivity to initiate captive breeding programs.[5]

This breeding program began at Point Defiance Zoo in Tacoma, Washington and grew rapidly, starting with a small population of 15 breeding individuals. Following American Zoological Society (AZA) approval of the Species Survival Plan in 1984, it gradually expanded to more facilities and became one of the most successful captive breeding programs in the country.[6]

The reintroduction effort took the next step in September of 1987 when four pairs of adult red wolves were released into Alligator River National Wildlife Refuge (NWR) in northeastern North Carolina as a non-essential experimental population.[7] These wolves on the Albemarle Peninsula were able to successfully establish themselves and founded a truly wild population that grew to number approximately 151 individuals by 2005.[8] They have expanded their range into neighboring Pocosin Lakes National Wildlife Refuge as well, along with other parcels of federal land and private property.

A second reintroduction took place in Great Smoky Mountains National Park, where a family of red wolves was released into the wild in 1991.[9] This project lasted less than a decade however and was terminated in 1998 after wolves dispersed widely outside of the Park and experienced high mortality. Most remaining wolves were recaptured, and scientists posited that the project likely failed due to a lack of food and a preference for the less mountainous habitat outside the Park.[10] This left the wolf population centered around Alligator River NWR as the only successful reintroduction site, and this remains the case to this day despite the Red Wolf Recovery Plan's goal of establishing three sites.

The recovery effort has been hampered by political and scientific controversy in recent years. This turmoil and the management decisions it has spurred have led to a severe rise in mortality of wolves and a subsequent decline in their population in the wild, dropping to approximately 45-60 wolves by 2016, when the USFWS last updated their mortality numbers.[11] These numbers likely overestimate the

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[5] *Id* at 12.
[6] *Id* at 12.
[7] *Id* at 17.
[8] Joseph W. Hinton et al., "Survival and Population Size Estimates of the Red Wolf," *The Journal of Wildlife Management* 81, no. 3 (March 28, 2017): 417–28, https://doi.org/10.1002/jwmg.21206.
[9] U.S. Fish and Wildlife Service, "Notice of Termination of the Red Wolf Reintroduction Project in the Great Smoky Mountains National Park," *Federal Register* 63, no. 195 (October 8, 1998): 54151. https://www.fws.gov/redwolf/Reviewdocuments/1998_FR(63)54151-54153.pdf
[10] *Id*.
[11] U.S. Fish and Wildlife Service, "Table 1. Causes of Mortality in Wild Red Wolves." (June 13, 2016). https://www.fws.gov/redwolf/Images/Mortalitytable.pdf; Hinton et al., "Survival and Population Size Estimates of the Red Wolf."

number of wolves currently remaining in the wild, as in the spring of 2017 only 29 individuals were known by the USFWS to have functioning radio collars.[12]

One of the reasons for the controversy surrounding the program is the current debate over the genetic status of the red wolf as a true species.[13] This report will not attempt to address these issues as they are outside the purview of selecting a new reintroduction site, but it would be remiss to not acknowledge these concerns. The questions of genetic purity and what makes a "true" red wolf have been enough to hamper the management of the species and create a modest amount of public opposition to the continued protection of the red wolf in recent years.

An example of the impact of this pressure is the decision by the USFWS to suspend its Adaptive Management Plan in 2015, which had been designed "to study, monitor and adaptively manage hybridization with coyotes, which was identified as the existential threat to the red wolf at the time the plan was developed."[14] This decision was followed up by the issuance of several "take" permits, allowing the killing of red wolves by private landowners, as well as the removal of wolves from private land by the Service.[15]

Even more recently, in September of 2016 the USFWS announced significant changes to the Red Wolf Recovery Plan.[16] The most relevant components of this new strategy were 1) to remove many of the wild red wolves from their current habitat and place them back in captivity indefinitely in order to bolster the captive breeding stock, and 2) to identify other potential project areas where they might establish new "Non-essential Experimental Populations," as described in the Endangered Species Act (ESA).[17] The Service does not intend to completely eliminate the current "non-essential experimental" wild population,

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[12] Ron Sutherland, "By Night, Hunters Would Blast Red Wolves into Extinction," *The News & Observer*, March 4, 2017, sec. Op-Ed, http://www.newsobserver.com/opinion/op-ed/article136432798.html.

[13] Selection of relevant papers: Bridgett M. von Holdt et al., "Whole-Genome Sequence Analysis Shows That Two Endemic Species of North American Wolf Are Admixtures of the Coyote and Gray Wolf," *Science Advances* 2, no. 7 (July 1, 2016): e1501714, https://doi.org/10.1126/sciadv.1501714; Bridgett M. von Holdt et al., "Admixture Mapping Identifies Introgressed Genomic Regions in North American Canids," *Molecular Ecology* 25, no. 11 (May 12, 2016): 2443–53, https://doi.org/10.1111/mec.13667; Linda Y. Rutledge et al., "Conservation Genomics in Perspective: A Holistic Approach to Understanding Canis Evolution in North America," *Biological Conservation* 155 (October 1, 2012): 186–92, https://doi.org/10.1016/j.biocon.2012.05.017; Justin H. Bohling and Lisette P. Waits, "Factors Influencing Red Wolf–coyote Hybridization in Eastern North Carolina, USA," *Biological Conservation* 184 (April 1, 2015): 108–16, https://doi.org/10.1016/j.biocon.2015.01.013.

[14] U.S. Fish and Wildlife Service, "Red Wolf Adaptive Management Plan, FY13-FY15," February 2013.; Group Solutions, Inc., "Red Wolf Recovery Team Final Recommendations," September 6, 2016.

[15] Heidi Ridgley, "The Long and Winding Road," *Defenders Magazine*, January 26, 2017, https://defenders.org/magazine/winter-2017/long-and-winding-road.

[16] Cynthia K. Dohner to Regional Director, Southeast Region, "Recommended Decisions in Response to Red Wolf Recovery Program Evaluation," September 12, 2016.; U. S. Fish and Wildlife Service, "Science Leads Fish and Wildlife Service to Significant Changes for Red Wolf Recovery," Press Release, September 12, 2016, https://www.fws.gov/news/ShowNews.cfm?ref=science-leads-fish-and-wildlife-service-to-significant-changes-for-red-&_ID=35794.

[17] *Id.*

but will restrict their protected territory solely to Alligator River NWR, removing them from private lands and attempting to keep them solely within Dare County.[18] This decision has been challenged in court by a number of conservation organizations who believe restricting the territory of the wolves so dramatically will lead to increased mortality and doom them in the wild,[19] and has also been called into question by the scientists whose Population Viability Analysis the Service relied upon when making their decision to declare the captive population to be at-risk.[20]

The original deadline for the Service to announce their final determination on this matter, along with the new potential locations to establish a wild population, was October of 2017. Despite issuing an Advanced Notice of Proposed Rulemaking in May of 2017,[21] the Service has not published a final report or decision on the matter at this time and declares on the website of the Southeast Regional Office that the "Service must first secure the captive population before establishing any new populations in the wild."[22]

III. Importance of Wolves: Why Reintroductions Matter

The idea of reintroducing wolves and other apex predators to environments where they formerly roamed is not just a flight of fancy by wildlife-loving biologists, or part of an effort by government agencies to increase their control over lands. After centuries of persecution and removal, the loss of wolves is reflected clearly in ecosystems throughout their historic range. Species such as coyote that formerly were confined to the West of the United States have moved into the East in several waves, filling in the niche formerly occupied by wolves and mixing with many other canid species they encounter.[23] This expansion of geographic range and ecological function is known as "mesopredator release," and can have far-ranging effects.[24] The populations of other species such as white-tailed deer

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[18] *Id.*
[19] Ridgley, "The Long and Winding Road."
[20] Lisa Faust et al. to Cynthia K. Dohner, "PVA Team Response to USFWS," October 11, 2016.
[21] U.S. Fish and Wildlife Service, Advance notice of proposed rulemaking; notice of intent to prepare a National Environmental Policy Act document, "Endangered and Threatened Wildlife and Plants; Nonessential Experimental Population of Red Wolves (Canis rufus) in North Carolina," *Federal Register* 82, no. 98 (May 23, 2017): 23518. https://www.gpo.gov/fdsys/pkg/FR-2017-05-23/pdf/2017-10551.pdf
[22] U.S. Fish and Wildlife Service, "Red Wolf Recovery Program Review," Southeast Region of the U.S. Fish and Wildlife Service, November 28, 2017, https://www.fws.gov/southeast/faq/red-wolf-recovery-program-review/.
[23] Elizabeth Heppenheimer et al., "Demographic History Influences Spatial Patterns of Genetic Diversity in Recently Expanded Coyote (Canis Latrans) Populations," *Heredity* 120, no. 3 (March 2018): 183–95, https://doi.org/10.1038/s41437-017-0014-5; IUCN, "Canis Latrans: Gese, E.M., Bekoff, M., Andelt,W., Carbyn, L. & Knowlton, F.: The IUCN Red List of Threatened Species 2008: E.T3745A10056342" (International Union for Conservation of Nature, June 30, 2008), https://doi.org/10.2305/IUCN.UK.2008.RLTS.T3745A10056342.en.
[24] William J. Ripple et al., "Widespread Mesopredator Effects after Wolf Extirpation," *Biological Conservation* 160 (April 1, 2013): 70–79, https://doi.org/10.1016/j.biocon.2012.12.033.

have also exploded without the pressure of predation from wolves in the East, resulting in increases in car accidents with deer and associated costs for humans.

The reintroduction of wolves into an area can help reverse some of these trends and can have remarkable restorative effects on entire ecosystems. This has been demonstrated by the success of the reintroduction of wolves to the Greater Yellowstone Ecosystem. Since wolves were brought back over two decades ago, elk numbers have declined, various types of vegetation have greatly increased in size and distribution due to decreased browsing pressure, songbirds have returned to former territories, and beavers have increased in both number and activity, changing the hydrological profile of certain areas.[25]

These effects are dramatic, and have demonstrated the impact that restoring large, high-trophic-level predators such as wolves to an ecosystem can have for native flora and fauna. Restoring the red wolf to a wider range of territories could have a similar impact on its historic range, possibly alleviating some of the changes brought on by wide-scale development and land change in the Eastern United States.

IV. Goals of the Study

This study is therefore aimed to provide useful information for the Service to consider when making their future selection for a recovery site, and can be used by my client, Wildlands Network, to advocate for adherence to the Recovery Plan in accordance with the best available science. Previous efforts to identify suitable sites for reintroduction have focused primarily on ecological characteristics, and the most comprehensive previous effort in the public literature was conducted in the year 2000 focusing on general geographic areas rather than particular parcels of government-owned land.[26] This study aimed to consider both ecological and social factors that can affect the success of a reintroduced population, as the human element can override even the best of biological fits. I also started with an open-ended search for specific sites, including both state and federal lands to allow for the consideration of locations where the government would have legal authority to introduce species.

While the genetics and politics of red wolves may both be highly controversial, the species remains listed as Endangered under the Endangered Species Act[27] and deserves the full protection of the

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[25] Robert L. Beschta and William J. Ripple, "Riparian Vegetation Recovery in Yellowstone: The First Two Decades after Wolf Reintroduction," *Biological Conservation* 198 (June 1, 2016): 93–103, https://doi.org/10.1016/j.biocon.2016.03.031; Robert L. Beschta and William J. Ripple, "Large Predators and Trophic Cascades in Terrestrial Ecosystems of the Western United States," *Biological Conservation* 142, no. 11 (November 1, 2009): 2401–14, https://doi.org/10.1016/j.biocon.2009.06.015.

[26] Frank T. van Manen, Barron A. Crawford, and Joseph D. Clark, "Predicting Red Wolf Release Success in the Southeastern United States," *The Journal of Wildlife Management* 64, no. 4 (2000): 895–902, https://doi.org/10.2307/3803197.

[27] U.S. Fish and Wildlife Service, "Species Profile for Red Wolf (Canis Rufus)," ECOS: Environmental Conservation Online System, accessed April 8, 2018, https://ecos.fws.gov/ecp0/profile/speciesProfile?spcode=A00F.

law. This study provides a useful method to evaluate locations as potential sites for reintroduction and gives Wildlands Network and the Service data that they can use to make choices in the very near future about where to continue the wild population of red wolves.

Methods

I. Identifying the Issue

Due to prior work with red wolves based on other projects and work at a summer internship, I had already collected and read a great deal of literature on red wolves. I decided to continue working with the species in a new and potentially useful capacity. After deciding in July of 2017 to analyze potential reintroduction sites, I began this new independent project in earnest.

I approached Wildlands Network and Dr. Ron Sutherland with my idea for the Masters Project, as I had worked with him previously on my prior red wolf project. They were interested in supporting and guiding my work, because according to Dr. Sutherland "Wildlands Network is very interested in promoting the recovery of red wolves across the former range of the species, and is interested in using the best available data for identifying the most logical places to start new recovery programs." He said that they are "excited to look at the data and inform advocacy and scientific efforts to steer the course of Fish and Wildlife Service and encourage them to start new programs."

II. Methods Overview

The first step in predicting which sites are the most suitable for red wolf reintroduction was to identify the factors that predict their success or failure. This was achieved through a literature review and produced a list of five key variables, both social and ecological, that influence the likelihood of a successful reintroduction. I then identified the sites that I would analyze for suitability and surveyed a group of experts to determine the relative importance of each variable. Using this information, I produced data layers in ArcGIS and calculated a weighted sum, producing suitability scores for each potential site. Finally, I calculated additional statistics to examine the similarity of various sites and identify how each variable contributed to the overall scores.

III. Literature Review for Variable Identification

The first step was to conduct a thorough literature review on red wolf biology and on the social factors that can affect individual attitudes and feelings towards wolves. This was conducted using the Duke University Library Summon search engine, as well as specific databases such as Web of Science. I

also was provided with a database of relevant articles by Dr. Sutherland, along with a similar cache of documents provided by my summer employer, the Center for Biological Diversity.

The number of studies on red wolves is relatively limited, and this is made more difficult by the fact that there has not been a substantial wild population since the early 20th Century, which was never fully studied. All studies conducted in the wild in the last 30-40 years have looked at very limited and artificially selected settings, mainly in their current range in eastern North Carolina. This may not present true representations of the wolves' preferences and habits, as it is unknown how they behaved in a truly natural state before their elimination by humans. Similarly, given their limited geographic range, the amount of studies done on social attitudes towards red wolves is fairly limited. Therefore, I used a number of studies that dealt with social surveys related to grey wolves, as the subtle distinctions between the two species are probably not widely known or understood by the general public.

A number of trends and themes emerged during the search, and these formed the basis for my variables moving forward. The key ecological factors that determined the success of red wolves appeared to be the type of suitable habitat available[28] and the amount of prey available.[29] The sociological factors that appeared to be the most consistent in shaping views towards wolves were the age of an individual,[30] their ownership of livestock,[31] and their pursuit of recreational hunting.[32] I also identified several sources

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[28] Joseph W. Hinton and Michael J. Chamberlain, "Space and Habitat Use by a Red Wolf Pack and Their Pups During Pup-Rearing," *The Journal of Wildlife Management* 74, no. 1 (December 13, 2010): 55–58, https://doi.org/10.2193/2008-583; Justin A. Dellinger et al., "Habitat Selection of a Large Carnivore, the Red Wolf, in a Human-Altered Landscape," *Biological Conservation* 157 (January 1, 2013): 324–30, https://doi.org/10.1016/j.biocon.2012.09.004; Joseph W. Hinton et al., "Space Use and Habitat Selection by Resident and Transient Red Wolves (Canis Rufus)," *PLOS ONE* 11, no. 12 (December 21, 2016): e0167603, https://doi.org/10.1371/journal.pone.0167603; Joseph W. Hinton, "RED WOLF (CANIS RUFUS) AND COYOTE (CANIS LATRANS) ECOLOGY AND INTERACTIONS IN NORTHEASTERN NORTH CAROLINA" (University of Georgia, 2014).

[29] Justin A. Dellinger et al., "Food Habits of Red Wolves during Pup-Rearing Season," *Southeastern Naturalist* 10, no. 4 (December 1, 2011): 731–40, https://doi.org/10.1656/058.010.0412; Michael K. Phillips, V. Gary Henry, and Brian T. Kelly, "Restoration of the Red Wolf," *USDA National Wildlife Research Center - Staff Publications*, January 1, 2003, 272–88.

[30] Christopher K. Williams, Göran Ericsson, and Thomas A. Heberlein, "A Quantitative Summary of Attitudes toward Wolves and Their Reintroduction (1972-2000)," *Wildlife Society Bulletin (1973-2006)* 30, no. 2 (2002): 575–84; Alistair Bath, "The Public and Wolf Reintroduction in Yellowstone National Park," *Society & Natural Resources* 2, no. 1 (January 1, 1989): 297–306, https://doi.org/10.1080/08941928909380693; Tulchin Research, "Polling Finds North Carolina Voters Strongly Back Red Wolf Recovery," August 17, 2016, https://defenders.org/publications/Defenders-of-Wildlife-Red-Wolf-Public-Memo.pdf.

[31] Meredith S. Berry, Norma P. Nickerson, and Elizabeth Covelli Metcalf, "Using Spatial, Economic, and Ecological Opinion Data to Inform Gray Wolf Conservation," *Wildlife Society Bulletin* 40, no. 3 (September 21, 2016): 554–63, https://doi.org/10.1002/wsb.687; Jennifer Pate et al., "Coloradans' Attitudes toward Reintroducing the Gray Wolf into Colorado," *Wildlife Society Bulletin (1973-2006)* 24, no. 3 (1996): 421–28; Williams, Ericsson, and Heberlein, "A Quantitative Summary of Attitudes toward Wolves and Their Reintroduction (1972-2000)"; Bath, "The Public and Wolf Reintroduction in Yellowstone National Park."

[32] Berry, Nickerson, and Metcalf, "Using Spatial, Economic, and Ecological Opinion Data to Inform Gray Wolf Conservation"; Pate et al., "Coloradans' Attitudes toward Reintroducing the Gray Wolf into Colorado."

that delineated the historic range of red wolves before their widespread removal from the environment, which will be explored in more depth in the next section.[33]

IV. Selecting Sites

With these potential variables in mind, I began moving my work into ArcGIS and downloading data to form the backbone of my analysis. This included state boundaries from The National Map program at the U.S. Geological Survey (USGS).[34] Using the historic ranges provided in the literature, which are in general agreement, I drew a line representing the boundary of my study area that extended from Eastern Texas across Oklahoma and Missouri, then northeast to Pennsylvania and New Jersey (Figure 1). I also drew a second line to complete the circle and create a polygon that I could use to clip the extent of other data files so they only covered the historic range.

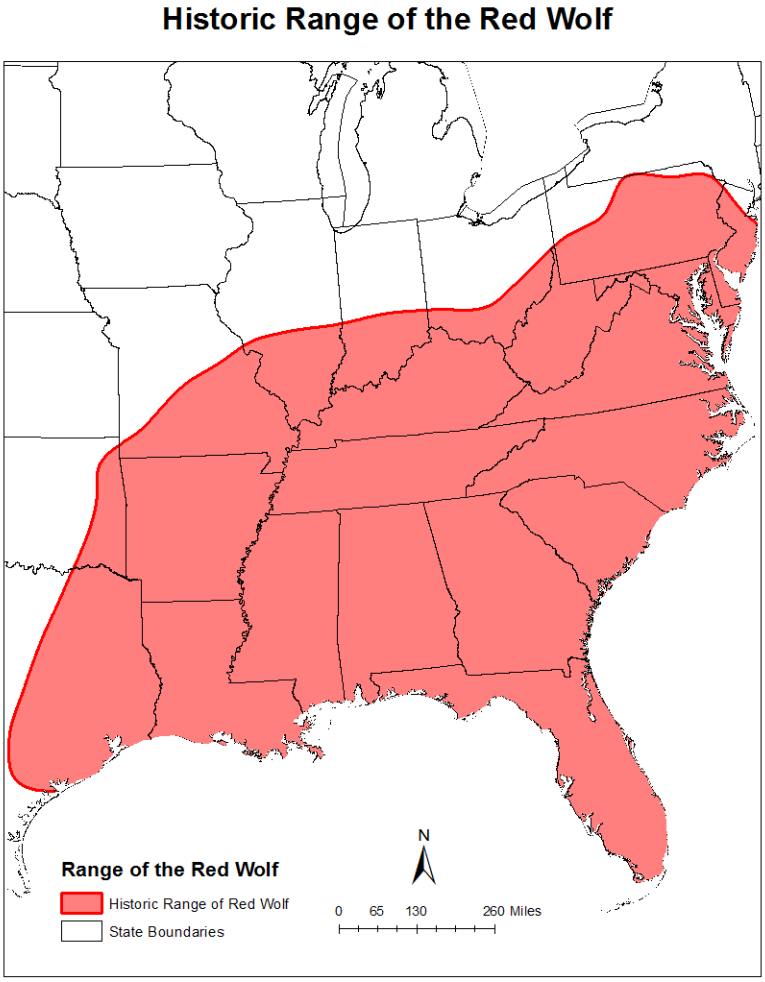


Figure 1. This area was used to represent the historic range of the red wolf across the Eastern United States before their extirpation by humans. The western boundary was drawn based on the average extent from numerous historical sources.

[33] Nowak, "The Original Status of Wolves in Eastern North America"; U.S. Fish and Wildlife Service, "Endangered Red Wolves."; International Wolf Center, "North Carolina."
[34] U.S. Geological Survey, The National Map. July 2017. Small-Scale Data Download. https://nationalmap.gov/small_scale/atlasftp.html

To identify which sites should be the focus of my analysis, I had to determine a set of parameters by which to evaluate sites. I initially decided that the sites must be located within the historic range of the wolves and have some level of protected status at either the state or federal level. This is necessary because in order for the federal government to implement their Species Survival Plan and introduce the wolves, they must have the authority to introduce animals onto the piece of land in question. This would be too difficult to manage if attempting to balance a number of private land owners, and so the core introduction areas must be protected and managed by a governmental authority. Beyond that, I determined that a site must be at least as large as Alligator River National Wildlife Refuge, or 152,000 acres in size.[35] As the wolves have already run into opposition from abutting land owners in their current location, it would seem prudent to ensure that any future sites have at least as much available, contiguous land for them to utilize.

The largest available database of public and protected lands is the Protected Areas Database of the United States (PAD-US), which is maintained by the National Gap Analysis Project (GAP) within USGS.[36] I downloaded data for four different regions, the Midwest, Northeast, Southeast, and Southcentral, then combined them all into a single Shapefile and clipped it to only keep the sites that were within the historic range polygon. From there, I selected only the protected sites that met the minimum size requirement of 152,000 acres. This reduced the data from thousands of potential choices to fewer than 100.

I then proceeded to remove sites that were owned by the Department of Defense and Department of Energy, because although these are well-protected they are also often enclosed and would severely limit the ability of wolves to disperse naturally. The remaining sites included several in southern Florida that were primarily marine and/or coastal protected areas, and so I removed those as well (e.g., Everglades National Park and Biscayne National Park). I also removed Great Smoky Mountains National Park, due to the prior failed reintroduction effort in that Park.

Finally, areas that either overlapped entirely or shared significant amounts of border were merged together into a single file. These include two parcels of Ouachita National Forest divided only by the Arkansas-Oklahoma border, Tate's Hell State Forest and Apalachicola National Forest in Florida, and Nantahala National Forest and Chatahoochee-Oconee National Forest across the North Carolina-Georgia state line. This left me with a set of 21 protected areas to serve as core sites for potential reintroductions (Figure 2, Table 1).

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[35] U.S. Fish and Wildlife Service, "Alligator River National Wildlife Refuge," n.d., https://www.fws.gov/southeast/pdf/fact-sheet/alligator-river-national-wildlife-refuge.pdf.

[36] U.S. Geological Survey, Gap Analysis Program (GAP). May 2016. Protected Areas Database of the United States (PAD-US), version 1.4 Combined Feature Class. https://gapanalysis.usgs.gov/padus/data/download/.

I also created shapefiles for Alligator River and Pocosin Lakes National Wildlife Refuges, the federal protected areas that form the core of the current Red Wolf Recovery Area, and joined them together to form one site for the "current" range. I conducted all of the analyses on these sites as well in order to compare the potential sites to the suitability of their present range.

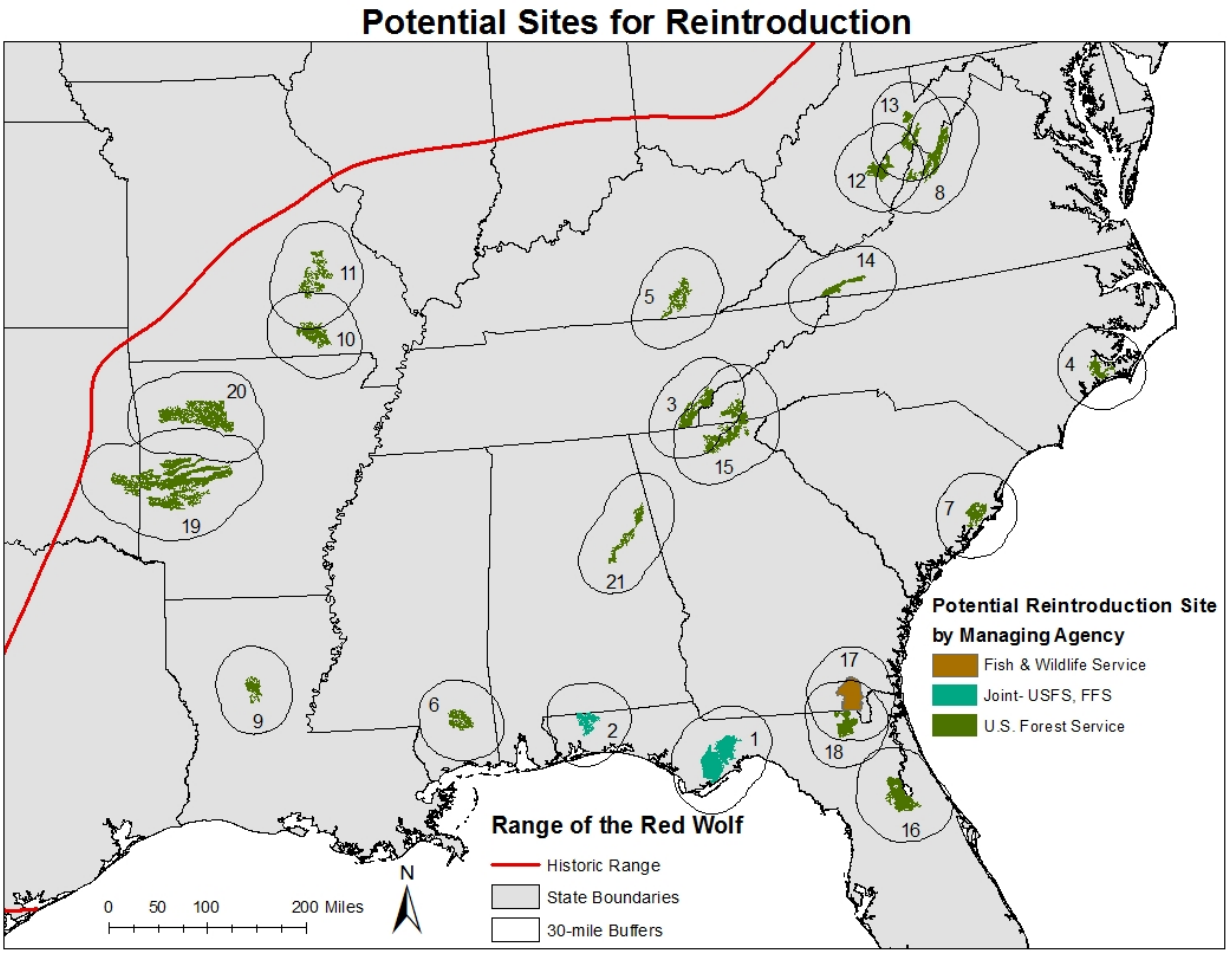


Figure 2. The final set of 21 possible sites for the reintroduction of red wolves within their historic range. All sites are classified by their managing agency, 18 of which are managed exclusively by the U.S. Forest Service with one owned by U.S. Fish and Wildlife Service and two jointly managed by Florida Forest Service and other agencies. Names for each site are provided in Table 1.

Table 1. Key to the potential reintroduction sites as labeled in Figure 2. When not provided in the PADI-GAP dataset, names were obtained from the U.S. Forest Service website.[37]

Number	Site
1	Apalachicola National Forest (FL)/Tate's Hell State Forest (FL)
2	Blackwater River State Forest (FL)
3	Cherokee National Forest (TN)
4	Croatan National Forest (NC)
5	Daniel Boone National Forest (KY)
6	De Soto National Forest (MS)
7	Francis Marion and Sumter National Forests (SC)
8	George Washington and Jefferson National Forest (VA)
9	Kisatchie National Forest (LA)
10	Mark Twain National Forest (1) (MO)
11	Mark Twain National Forest (2) (MO)
12	Monongahela National Forest (1) (WV)
13	Monongahela National Forest (2) (WV)
14	Mount Rogers National Recreation Area (VA)
15	Nantahala National Forest /Chatahoochee-Oconee National Forest (NC/GA)
16	Ocala National Forest (FL)
17	Okefenokee National Wildlife Refuge (GA)
18	Osceola National Forest (FL)
19	Ouachita National Forest (AR/OK)
20	Ozark-St. Francis National Forest (AR)
21	Talladega National Forest (AL)

V. Locating Data

The wide geographic range across which sites were located, encompassing states from Oklahoma to Florida to West Virginia, made finding data at the appropriate scale and of acceptable quality a challenge. Based on the literature review, the five variables that I considered were: Age of local residents, the amount of livestock owned by people in the area, the amount of hunting that takes place around the site, the amount of prey available for red wolves to consume, and the type of land cover and habitat available to them.

Determining the age of residents around a site was relatively straightforward, as the United States Census Bureau puts out their data in easily accessible formats. Their TIGER products (Topologically Integrated Geographic Encoding and Referencing) are available in formats that are easily integrated into ArcGIS, and I was able to download shapefiles that included the median age of residents on a county-by

[37] U.S.D.A. Forest Service, "FSTopo Map Products," FS Geodata Clearinghouse, accessed April 12, 2018, https://data.fs.usda.gov/geodata/rastergateway/states-regions/states.php.

county basis for the entire study area. These were available as "TIGER/Line with Selected Demographic and Economic Data" from the Census Bureau website, and I used the data from the 2010 Census.[38]

When considering the availability of prey, the issue for the study became availability of data. Species such as rabbits, nutria and raccoons can be a large component of a red wolf's diet,[39] but there is very limited data available about their relative ranges and local concentrations. Deer are also a frequent source of food for red wolves[40] and due to the presence of range-wide data for white-tailed deer I chose to use them as the proxy for food availability.

A team at the University of Minnesota's Forest Ecosystem Health Lab and the U.S. Department of Agriculture, Forest Service-Northern Research Station digitized a dataset of white-tailed deer density estimates for the Eastern United States in 2016.[41] The data used in their digital product came from a 2009 report by the Quality Deer Management Association (QDMA), and was compiled with information supplied to them from 2001-2005 by state wildlife agencies.[42] In conversation with Dr. Sutherland, we agreed that this represented the best and most recent estimate of deer densities over such a wide range. The data were downloaded from the University of Minnesota's website and clipped to only cover the study area.

Data on livestock abundance was obtained from the Food and Agriculture Organization of the United Nations. Their Agriculture and Consumer Protection Department has produced data on the spatial distribution of many forms of agricultural activity, including a project known as "Gridded Livestock of the World," which estimates global distribution of a variety of livestock animals.[43] I downloaded their global dataset for cattle, which was updated in 2014 for higher resolution and accuracy than their 2007 version.[44]

The choice to use cattle as representative of livestock conflict was based on a number of factors. First, there is a long history of cattle ranchers being opposed to wolves and favoring their hunting and

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[38] United States Census Bureau, TIGER Products. 2010. TIGER/Line with Selected Demographic and Economic Data, 2010 Census, Counties. https://www.census.gov/geo/maps-data/data/tiger-data.html

[39] Glynn A. Riley and Roy T. McBride, "A Survey of the Red Wolf (Canis Rufus)" (U.S. Department of the Interior, Fish and Wildlife Services, 1972), http://hdl.handle.net/2027/mdp.39015077581356.

[40] Phillips, Henry, and Kelly, "Restoration of the Red Wolf"; Dellinger et al., "Food Habits of Red Wolves during Pup-Rearing Season."

[41] Brian F. Walters, Christopher W. Woodall, and Matthew B. Russell, "White-Tailed Deer Density Estimates across the Eastern United States, 2008," March 13, 2016, http://dx.doi.org/10.13020/D6G014.

[42] Kip Adams, Joe Hamilton, and Matt Ross, "QDMA's Whitetail Report" (Quality Deer Management Association, 2009).

[43] Food and Agriculture Organization of the United Nations, Agriculture and Consumer Protection Department. 2007. "Gridded Livestock of the World." http://www.fao.org/ag/againfo/resources/en/glw/home.html

[44] Timothy P. Robinson et al., "Mapping the Global Distribution of Livestock," *PLOS ONE* 9, no. 5 (May 29, 2014): e96084, https://doi.org/10.1371/journal.pone.0096084.

persecution.[45] Further, considering the specific circumstances of the Eastern United States, there is a pervasive low level of sheep and goat abundance, making the data so sparse as to be uninformative. The practices of keeping hogs and chickens in this part of the world typically involve keeping the animals indoors in dense, largely self-contained enclosures, reducing the likelihood of potential conflict with predators. After making this decision and acquiring the FAO data, I clipped the Raster files to just cover the extent of the study area.

The data to evaluate land cover and habitat type came from the National Land Cover Database (NLCD) from 2011.[46] This is developed by the Multi-Resolution Land Characteristics Consortium from Landsat imagery and is available freely online in Raster format. I clipped this data to the extent of the wolves' historic range as well.

The final variable to consider was hunting, which does not have a single national database to draw from. Instead, I decided to use harvest of white-tailed deer as a proxy for the intensity of hunting at the county level. Every state has an agency that regulates hunting, sets the opening and closing dates for each season, and issues permits to hunt various species based on their management strategy. These agencies also put out annual reports that include the statistics on hunting for the previous year, including total harvest and typically a breakdown by county.

I acquired the best available data for each state in the range of the red wolf that had a potential reintroduction site within it and joined that data as tables to shapefiles of all the counties in the respective state. Many of the states had data online in highly inaccessible formats, and so I created a series of scripts in the Python coding language to scrape the data either from websites or PDFs, when the data came in that format. A sample of these scripts and a table of sources for the hunting data is available in the Appendix (Figure 6 & Table 6).

Data was available on a county-by-county basis for every state in question except for Mississippi and Louisiana. I contacted the Louisiana Department of Wildlife and Fisheries and the Mississippi Department of Fish and Game to inquire about what data they may have available at the county level, and I was told that Mississippi does not have a harvest reporting system at the county level.[47] Louisiana did have such data available and provided it to me via email.[48]

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[45] Berry, Nickerson, and Metcalf, "Using Spatial, Economic, and Ecological Opinion Data to Inform Gray Wolf Conservation"; Pate et al., "Coloradans' Attitudes toward Reintroducing the Gray Wolf into Colorado"; Williams, Ericsson, and Heberlein, "A Quantitative Summary of Attitudes toward Wolves and Their Reintroduction (1972-2000)."

[46] Homer, C.G., et al., "Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information." 2015. *Photogrammetric Engineering and Remote Sensing* 81, no. 5, p. 345-354.

[47] R. Hamrick, MS DWFP, personal communication. January 11, 2018.

[48] J. Bordelon, LA DFW, personal communication. January 11, 2018.

To account for the lack of county-level data in Mississippi, I used the total estimated harvest from their statewide phone survey of hunters and averaged that across all counties in the state. Additionally, several states only have "reported harvest" numbers available, which they emphasized were different from the actual harvest data. For example, in Alabama it is estimated that only 35% of deer harvest is reported.[49] Georgia's county-by-county data[50] only totaled about 58% of their estimated total harvest for the state[51], and in Louisiana they estimate that only about 50% of deer killed are reported to the agency.[52] Based on these statistics, I adjusted all counties in each of those states by their state's respective proportion in order to bring the total level of harvest closer to reality.

VI. Surveying Experts

One of the most difficult parts of designing a model that accounts for multiple variables is deciding how to weight them. For this project, I turned to the experts to help make the decision for me. I developed a list of 14 experts on the topic of red wolf biology, based on their published research, involvement with the red wolf recovery team, or work in the field with the experimental population in North Carolina. The experts were promised anonymity for their participation in the survey, and so I cannot include a list of their names in this report.

I created the survey using software available to Duke students through Qualtrics, and a copy of this survey may be found in the Appendix (Figure 7). The questions asked the experts to assign weights from 0-100 for all five of the variables described above, assessing each independently. The experts were also asked to estimate how far away from the core protected areas these variables should be evaluated (choosing from a multiple-choice list). This second question aimed to set zones of a certain distance around the sites, within which I could evaluate the variables. Dr. Sutherland provided edits before the survey was distributed. Additionally, Dr. Cagle and I conferred with the Duke Internal Review Board (IRB) and were told the survey did not meet the baseline for human subject research and so was exempt from IRB approval.

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[49] The Associated Press, "More than 82,000 Deer Killed in Alabama during 2016-17 Hunting Season," AL.com, March 8, 2017, https://www.al.com/news/birmingham/index.ssf/2017/03/more_than_82000_deer_killed_in.html.
[50] Georgia Department of Natural Resources, "Georgia Hunter Resources (WRD Harvest Data)," 2018, https://gamecheckresults.gooutdoorsgeorgia.com/DeerByCounty.aspx.
[51] Georgia Wildlife, "2016-17 Georgia Deer Harvest Summary," 2017, http://georgiawildlife.com/sites/default/files/wrd/pdf/harvest-summaries/deer/16-17_Deer_Harvest_Summary.pdf.
[52] J. Bordelon, LA DFW, personal communication. February 12, 2018.

VII. Assembling the Final Model

With all of the data collected and the weights elicited from the experts, I put everything together in a series of ArcGIS models and scored each potential site. This first involved putting all data layers into the same Datum (WGS84) and Projection (Albers Equal Area). Then, for each variable I reclassified the previous values into scores that represent their suitability for the red wolves. These tables are available in the Appendix (Tables 7-11). These scores were based off of the literature for the land cover variable, as a number of studies have looked at the preferred habitat of red wolves (in this case, grasslands and longleaf pine savannahs with a tolerance for hardwood forests and wetlands).[53] For the other variables, it was simply assumed that the response was along a roughly linear gradient from negative to positive.

Once all variables had been reclassified onto a scale of 1-10, with 10 being the best or most suitable conditions, I converted the data in polygon format to Raster format with 30-meter cell size. After conferring with John Fay about the differences between a Weighted Sum and Weighted Overlay tool in ArcGIS, I decided to proceed with the Weighted Sum tool, which provides a more granular look at the results and does not re-scale things to a predetermined range. In order to run this tool, I had to input all five variable Raster files with their reclassified values and their assigned weights (Table 2).

Once this tool had run, the result was a Raster image with the suitability score calculated for every pixel in the historic range (Figure 3). To evaluate the suitability of each individual site, I drew buffer zones of 30 miles around each of the proposed locations (Figure 3) and calculated the Zonal Statistics for each of these zones. However, due to a quirk of ArcGIS, this method could not handle the areas where zones overlapped and produced only partial scores for some sites. To correct this, I consulted with John Fay and created a looping iterator tool in ArcGIS that would select each site individually, draw a buffer around that particular site and calculate the statistics for it without the interference of nearby sites (Appendix Figure 8). This produced accurate mean values for each 30-mile buffer around (and including) the protected core sites.

[53] Hinton et al., "Space Use and Habitat Selection by Resident and Transient Red Wolves (Canis Rufus)"; Hinton and Chamberlain, "Space and Habitat Use by a Red Wolf Pack and Their Pups During Pup-Rearing"; Dellinger et al., "Habitat Selection of a Large Carnivore, the Red Wolf, in a Human-Altered Landscape."

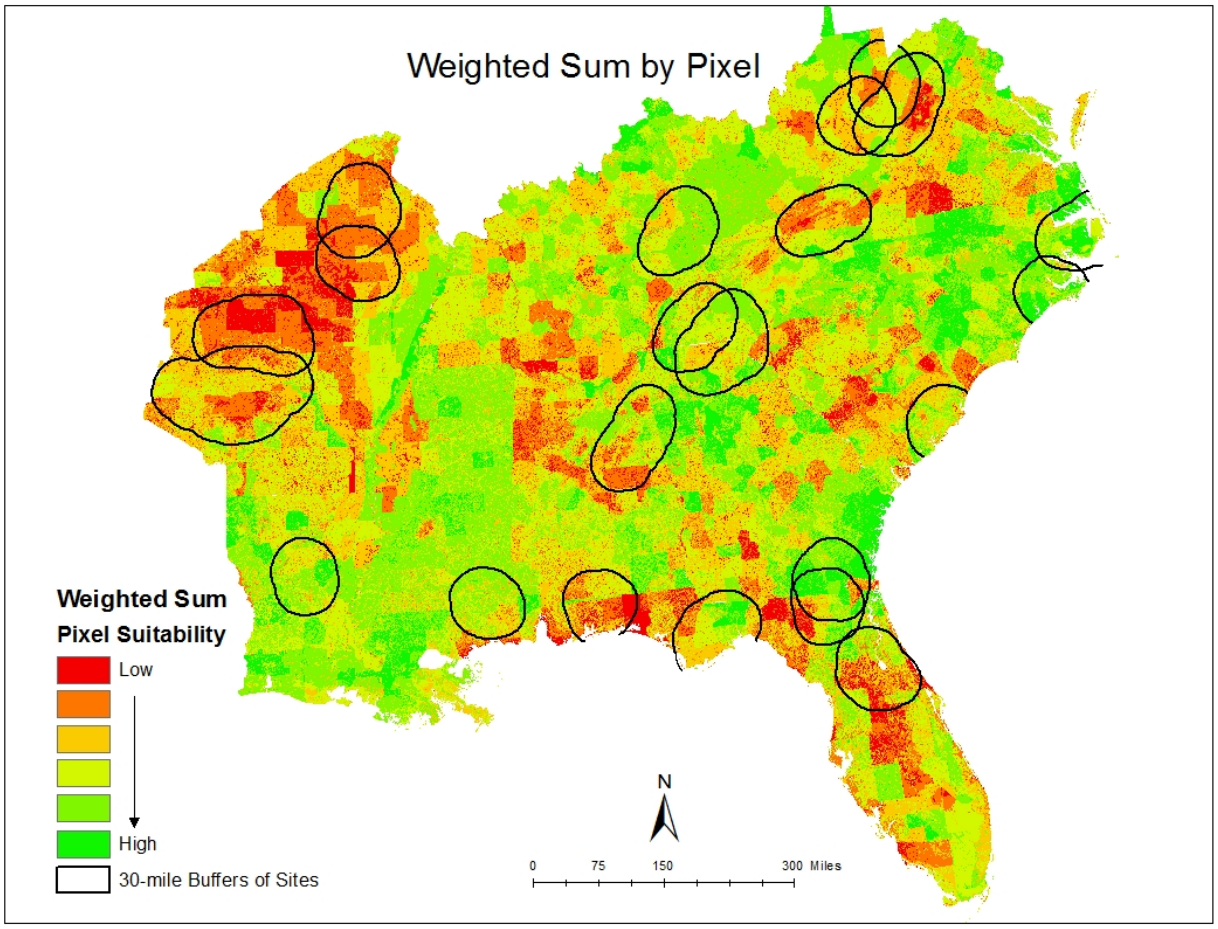


Figure 3. After weighting and reclassifying each variable, this represents a "suitability surface" for red wolves. The areas with the highest weighted sum values are represented in green, and the lowest are in red. The scores were calculated for each 30 meter-by-30 meter pixel that was covered by all five variables, and statistics were calculated on this surface within each 30-mile buffer zone.

VIII. Statistical Analysis

I repeated this looping tool for all five variables individually to get scores for each variable for each zone. The goal of this was to see which variable has the biggest impact on each location. In order to properly measure the value of the land cover dataset, I had to use a "Mask" based on the Deer raster so that it would not count open ocean as potential habitat for the coastal sites in the dataset. As the dataset with the smallest extent, the Deer image set the boundaries for what went into the final equation, and so using it as a Mask ensures that these results match the inputs that would have gone into the Weighted Sum, where only pixels with values for all five images were included.

After calculating scores for all five variables in all 22 zones (the 21 new sites plus the current range), I compiled them into a table and imported them into the R software package. I then calculated a Euclidian Distance matrix, comparing all 22 sites against each other across all five variables, thereby

producing a 22x22 matrix containing measures of ecological "distance" between each site based on the mean values of each contributing variable. The distance measurements are akin to measuring the dissimilarity between sites, with those pairs that have higher values being the most dissimilar.

Results

I. Survey Statistics

Response to the survey was excellent, as I received a much higher rate of completion than anticipated. After distributing the survey in early December 2017, and sending a reminder in early January 2018, I recorded complete responses from 10 out of 14 experts for a response rate of 71.4%. Many researchers also had constructive feedback on the project and offered to serve as resources.

The responses to the survey provided weights for the variables, which are provided in Table 2. Responses were highly varied, but I chose to use mean value for the weights in the final overlay. Additionally, experts chose a distance around each site within which I should analyze the key variables. Based on the responses (Table 3), the mean distance to consider outside the core area was 29 miles, and the median was 30 miles, so I chose to use 30 miles as my zone to analyze around the protected areas.

Table 2. Weights to the variables from expert survey.

Variable	Mean Weight	Median Weight	Range	Std. Deviation
Age of residents	44.8	50.5	2 – 90	30.39
Presence of Cattle (livestock ownership)	39.4	45	1 – 80	23.93
Amount of Deer for prey	67.6	75	5 – 100	28.7
Type of Habitat/Land Cover	62	64	40 – 81	13.36
Amount of Hunting	78.9	71.5	50 - 100	18.26

Table 3. Expert survey results for how far away from core site to analyze. (* = One respondent selected 5 miles on the survey but emailed me afterwards to state that he misunderstood the question and wished to change his response to 40 miles.)

Distance from Core Site to Analyze	Number of Responses
1 mile	0
5 miles	0*
10 miles	1
20 miles	4
40 miles	5*

II. Ranking Sites

The weighted sum was calculated for each 30-meter by 30-meter pixel in the study area, based on the weight-adjusted values of all five variables. This produced the equation in Figure 4, used by the Weighted Sum tool to assign a score to every pixel that the five Raster images had in common:

Pixel Score = 0.789*(Hunting reclassification) + 0.676(Deer reclassification) + 0.62*(Land Cover reclassification) + 0.448*(Age reclassification) + 0.394*(Cattle reclassification)

Figure 4. Equation used to assign suitability scores to each pixel within the historic range of the red wolf.

The 30-mile buffer zones that were used to define each site's relevant surroundings were analyzed using the Zonal Statistics tool, producing a mean weighted sum value for the entire area around each site. These mean weighted sums are reported in Table 4 and sorted from the most to least suitable sites, based on my analysis. The sites were also grouped into tiers based on these results, with sites being considered roughly equivalent within tiers. These are displayed visually in Figure 5 and were created by appending the mean weighted sums to their respective sites in ArcMap and then classifying them into 5 classes based on Arc's Natural Breaks/Jenks classification method.

Table 4. Mean suitability scores from the Weighted Sum tool for each potential reintroduction area. (Abbreviations: NF = National Forest, FWS = U.S. Fish & Wildlife Service, USFS = U.S. Forest Service, FFS = Florida Forest Service.)

Site Name	**Agency**	**State(s)**	**Weighted Sum Mean Score**	**Tier**
Okefenokee National Wildlife Refuge	FWS	GA	2015	1
Croatan National Forest	USFS	NC	2009	1
Alligator River & Pocosin Lakes National Wildlife Refuges (*current range*)	FWS	NC	1994	-
Kisatchie National Forest	USFS	LA	1876	2
Osceola National Forest	USFS	FL	1874	2
Daniel Boone National Forest	USFS	KY	1855	2
De Soto National Forest	USFS	MS	1846	2
Nantahala National Forest/Chattahoochee-Oconee National Forest	USFS	NC/GA	1807	2
Cherokee National Forest	USFS	TN	1793	2
Apalachicola National Forest/Tate's Hell State Forest	USFS/FFS	FL	1789	2
Francis Marion and Sumter National Forests	USFS	SC	1787	2
Talladega National Forest	USFS	AL	1697	3
Monongahela National Forest (Unit 2)	USFS	WV	1678	3
George Washington and Jefferson National Forest	USFS	VA	1659	3
Mount Rogers National Recreation Area	USFS	VA	1657	3
Monongahela National Forest (Unit 1)	USFS	WV	1645	3

Ocala National Forest	USFS	FL	1600	4
Ouachita National Forest	USFS	AR/OK	1583	4
Blackwater River State Forest	FFS	FL	1510	4
Mark Twain National Forest (Unit 2)	USFS	MO	1472	5
Mark Twain National Forest (Unit 1)	USFS	MO	1406	5
Ozark-St. Francis National Forest	USFS	AR	1391	5

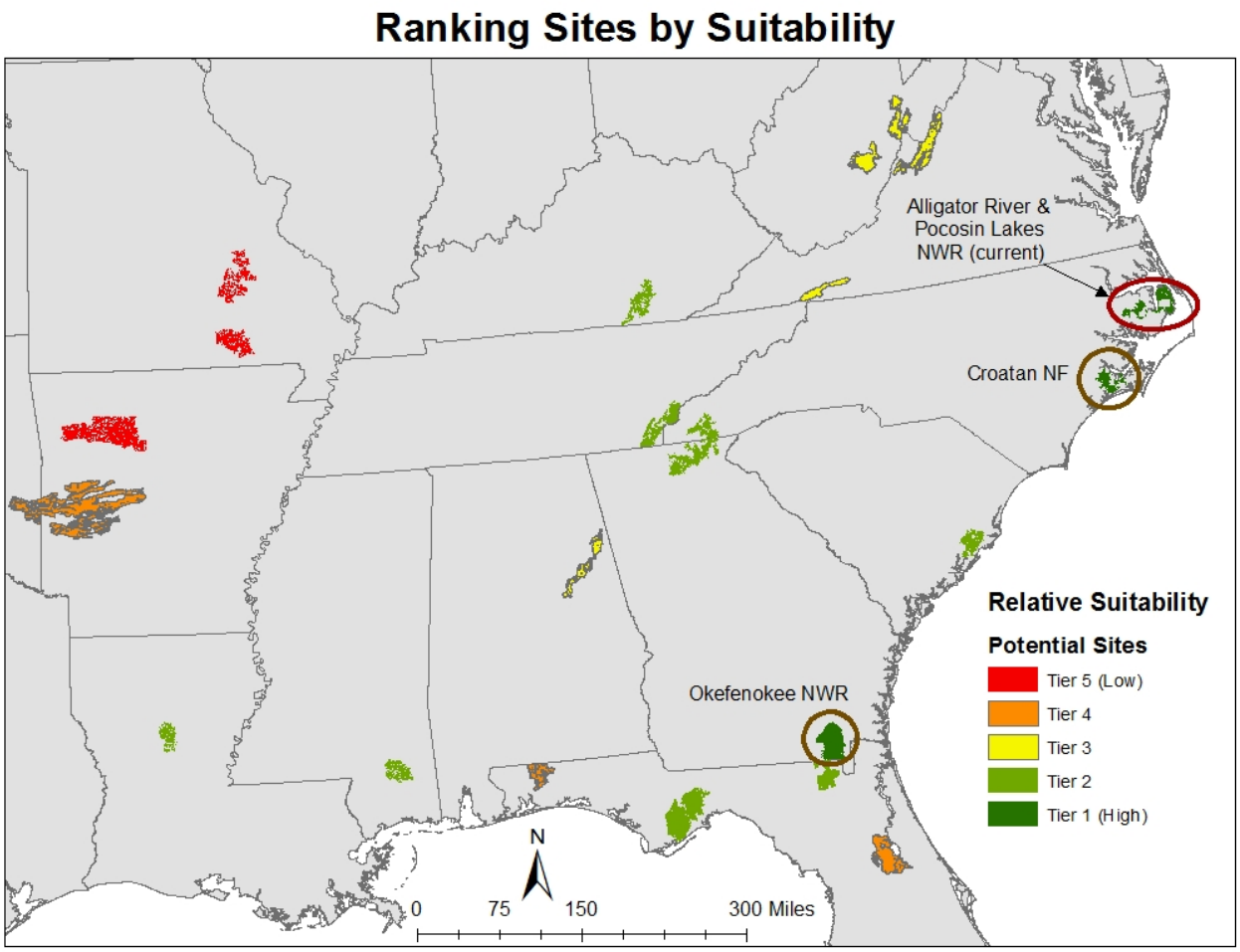


Figure 5. Each of the potential sites ranked by their relative suitability, with the highest scoring sites shown in dark green and the lowest in red. The two top sites are indicated and labeled in the map. The current territory of Alligator River & Pocosin Lakes NWR was also scored, and had the third-highest overall, which would have placed it in Tier 1.

III. Descriptive Statistics

Calculating the Euclidian Distance matrix in R produced a 22x22 matrix comparing each site to all of the other potential reintroduction sites, along with the current site of Alligator River & Pocosin Lakes NWR. The matrix's values (Appendix: Figure 9, Table 12) represent the amount of dissimilarity

between any pair of sites. This can be used to look for sites that are roughly comparable across all five of the variables that I analyzed, not just ecologically, and could be a good way to propose similar alternative locations for reintroduction if one area proves to be infeasible.

As an example of this, I set a dissimilarity threshold of 2 and pulled out all of the pairs of sites that fell below this level. These sites can be described as "similar" across all of the measured variables (Table 5).

Table 5. Similar sites based on the Euclidian Distance matrix measuring the distance between sites based on the values of the variables within their buffer zone areas. Sites across rows are considered "similar."

Site	Similar Sites	Similar Sites	Similar Sites
Alligator River & Pocosin Lakes National Wildlife Refuges (NC)	Croatan NF (NC)		
Apalachicola National Forest (FL)/Tate's Hell State Forest (FL)	Osceola NF (FL)	Nantahala NF /Chattahoochee NF (NC/GA)	
Blackwater River State Forest (FL)	Mark Twain NF (1) (MO)	Mark Twain NF (2) (MO)	
Cherokee National Forest (TN)	Nantahala NF /Chattahoochee NF (NC/GA)		
Croatan National Forest (NC)	Alligator River & Pocosin Lakes NWR (NC)		
Daniel Boone National Forest (KY)	Nantahala NF /Chattahoochee NF (NC/GA)		
De Soto National Forest (MS)	Kisatchie NF (LA)		
Francis Marion and Sumter National Forests (SC)	De Soto NF (MS)		
George Washington and Jefferson National Forest (VA)	Monongahela NF (1) (WV)	Monongahela NF (2) (WV)	Mt Rogers NRA (VA)

Kisatchie National Forest (LA)	De Soto NF (MS)		
Mark Twain National Forest (1) (MO)	Blackwater River SF (FL)		
Mark Twain National Forest (2) (MO)	Ouachita NF (AR/OK)	Blackwater River SF (FL)	
Monongahela National Forest (1) (WV)	Monongahela NF (2) (WV)	Mt Rogers NRA (VA)	George Washington and Jefferson NF (VA)
Monongahela National Forest (2) (WV)	Monongahela NF (1) (WV)	George Washington and Jefferson NF (VA)	
Mount Rogers National Recreation Area (VA)	Monongahela NF (1) (WV)	George Washington and Jefferson NF (VA)	
Nantahala National Forest /Chatahoochee-Oconee National Forest (NC/GA)	Cherokee NF (TN)	Daniel Boone NF (KY)	Apalachicola NF (FL) /Tate's Hell SF (FL)
Ocala National Forest (FL)			
Okefenokee National Wildlife Refuge (GA)	Osceola NF (FL)		
Osceola National Forest (FL)	Okefenokee NWR (GA)		
Ouachita National Forest (AR/OK)	Ozark-St Francis NF (AR)		
Ozark-St. Francis National Forest (AR)	Ouachita NF (AR/OK)		
Talladega National Forest (AL)			

Discussion

The collection of results presented here represents the first major recent attempt to comprehensively analyze the entire historic range of the red wolf in order to identify which parcels of federally owned and protected land would be best for the reintroduction of a new population. Previous reintroduction efforts in North Carolina have shown that the wolves can thrive in the wild when given the chance, and as the Fish & Wildlife Service considers the next location where they will attempt to reintroduce wolves this project should serve as a helpful road map.

I. Findings

Okefenokee National Wildlife Refuge and Croatan National Forest stand out as the best choices for red wolf reintroduction, based on the collection of sites analyzed. Their scores in Table 4 are nearly identical and far higher than the rest of the potential new sites, landing them a place in the first tier. These scores represent the mean pixel value in the 30-mile zone surrounding and containing the site in question, after the variables were weighted and summed across the entire study area.

Okefenokee NWR and Croatan NF both scored very highly in the 'Hunting' and 'Livestock' metrics, but their scores for the 'Habitat' metric were in the lowest third of the locations. For the 'Deer' variable, Croatan NF was in the top third and Okefenokee NWR was in the middle third, while the reverse was true for the 'Age' variable. This similarity in results led to them having comparable final suitability scores, taking the top two spots overall. The component scores for all variables and all sites can be seen in Table 13.

This breakdown of the component variables for the sites, which can be seen visually in Figures 10-14, paints an interesting picture of where red wolf introduction is likely to occur. Croatan NF was found to be similar to the current range of the wolves in Alligator River & Pocosin Lakes NWR, and the closeness of these two sites to Okefenokee NWR based on final suitability scores indicates that they must all possess similar characteristics that makes them a "good" place for red wolves to live.

This seems counterintuitive based on their low scores in the 'Habitat' variable, presumably due to their preponderance of swampy, wetlands-dominated land. However, all three of these protected areas compensate for this by being areas with a low likelihood of human conflict. While the landscape conditions may not be ideal for wolves, they are not ideal for agriculture or ranching either, or even for serious development of human settlement and cities. While other areas that contain the grasslands and pine forests that wolves prefer may seem like a better choice, much of this land across the East has been cleared for farms, towns, and cities, leaving few pristine stretches that wolves could thrive in. These trade-offs are fully evident both in the previous choices of FWS to introduce wolves to Alligator River

NWR and in the model's selections for best future sites. If the goal is to avoid human conflict, sites like Croatan, Okefenokee and Alligator River may be the best option.

The tiers that are assigned to the sites in Figure 5 are meant to represent a rough hierarchy of where reintroductions should occur. The sites in the highest tier, as discussed above, would be the best places based on this analysis. However, if circumstances should prevent either of these from being an option, sites in tier 2 such as Kisatchie National Forest in Louisiana would be the next best options, and so on down the line (Table 4). If one site has the characteristics deemed most desirable by the Service but some circumstances should render it no longer viable, the grouping of similar sites in Table 5 provides a guide for possible alternatives that have similar characteristics to those desired in the original site.

II. Scope and Context

The way that the project was structured allows for future efforts to draw from the same data and methodology while adding their own personal beliefs or interests to the models. The expert weights that were used to calculate the final suitability scores contained a wide range and lots of variation, and so these results only represent the suitability for wolves based on an average of these expert views. I believe that by using 10 different experts from academia, non-profits and governmental agencies I was able to capture a wide range of opinions, making the weights representative of the average view of someone who works with red wolves and therefore useful for this project. A different individual though could reconstruct this project and input their own beliefs on the relative importance of these variables, and of the different levels within each one.

Similarly, the results presented here do not represent a guaranteed likelihood of success or failure based on the relative rank of the sites. By virtue of being large, protected federal or state lands within the past range of the red wolf, these potential sites were chosen because they all could theoretically support wolves under the right conditions. The top sites in Table 4 are not certain successes, just as the lowest sites in the table are not doomed to failure.

Local and national conditions that are not captured in this model can have a strong influence on the potential success of a reintroduction, such as a beloved local politician being strongly in favor of the project, or a local industry leader being vocally opposed. These situations are hard to predict or model, although my variables of 'Age', 'Livestock Ownership', and 'Hunting' are an attempt to measure these social conditions through proxies. Future efforts that are focused on any one specific locality could benefit from a close look at the politics or key stakeholders in the region. Ensuring that there will be significant community buy-in is a major key to ensuring a successful reintroduction effort.

One example of local conditions potentially complicating a release that could arise from these results is the potential selection of Croatan NF. Given that the current red wolf reintroduction project is

already underway just a short distance to the north along the coast of North Carolina, residents in the area around Croatan NF may already be biased in one direction or another by the heated rhetoric that has occasionally emerged in the state surrounding this topic. Getting a better understanding of potential existing biases may be important and could cause the other top choice of Okefenokee NWR to seem like a safer choice. These sorts of considerations should be taken into account for each site as much as is feasible.

The project also fits in with a growing international movement to "rewild" areas that have been developed or settled for centuries, typically by returning extinct or extirpated animals to their historic ranges.[54] A recent paper on the topic even looked at reintroducing the red wolf, but their analysis was extremely broad and did not have the amount of species-level detail that is included here.[55] Public awareness and support of endangered species issues more broadly could be increased by successful rewilding projects, and this study aims to provide data to increase the likelihood of success for future red wolf reintroductions in particular.

III. Limitations

This study has some inherent limitations that should be accounted for when considering the potential broader applications of the results. The analysis was not conducted with perfect information, as several of the variables required some adjustment of the data or other assumptions.

The deer abundance and range data are from a study that was published in 2008, with data that was gathered by QDMA from state agencies over the years 2001-2005.[56] Therefore the data was not gathered very recently, but given my need for data that covered the entire eastern United States, it was the best available. In addition, the dataset does not include data for the state of Oklahoma, but since the Ouachita National Forest extends from Arkansas into the eastern portion of Oklahoma, I needed to make an estimate for that area. I selected the deer density value that was most common along the western border of Arkansas and applied it to the range around Ouachita NF in Oklahoma, lacking better data.

The greatest challenge with regards to data availability and quality came from locating reliable hunting data. As described in the Methods, there were many inconsistencies between the states and their various reporting systems for white-tailed deer harvest. The lack of county-level data in Mississippi was a

[54] For example: Rewilding Europe, "Rewilding Europe – Making Europe a Wilder Place," accessed April 15, 2018, https://www.rewildingeurope.com/; "Yellowstone to Yukon Conservation Initiative," Cover, accessed April 15, 2018, https://y2y.net.
[55] Christopher Wolf and William J. Ripple, "Rewilding the World's Large Carnivores," *Open Science* 5, no. 3 (March 14, 2018): 172235, https://doi.org/10.1098/rsos.172235.
[56] Adams, Hamilton, and Ross, "QDMA's Whitetail Report."

major issue, as the one candidate site in the state did not have data at the proper scale to truly rate the suitability of its surroundings. Using the average number of deer hunted was a serviceable approximation.

Other issues arose when states do not differentiate between “reported” and “actual” harvest of deer. The adjustments made to data in Georgia, Alabama, and Louisiana brought their reported harvest levels more in line with the expected totals, based on communications with state wildlife officials and those with personal experience hunting in the area.

Finally, it would have been useful to have data on all types of possible red wolf prey, including raccoon, nutria, rabbits and more, but there is little data available on these species. What little information is out there typically does not contain numeric abundancies but is rather just simple presence/absence data. Having a more complete way to estimate prey for red wolves would be beneficial to future studies.

Conclusions

The information contained in this report should serve as guidance for the U.S. Fish and Wildlife Service as they prepare to publish their final decision and rulemaking on the status of the current non-essential experimental wild population of red wolves. This work could allow them to prioritize the potential sites where their reintroduction efforts will have the best chance of succeeding, which benefits everyone involved, from the wolves themselves to the FWS Administrator. The two top scoring sites based on suitability for red wolves were Okefenokee National Wildlife Refuge in Georgia and Croatan National Forest in North Carolina, and therefore these federally protected sites should be the two locations that Wildlands Network advocates for with the Service as the best places to initiate the newest reintroduction effort for the critically endangered red wolf.

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Appendix

```
#using PyPDF2, tabula, and pandas to turn a massive PDF into an Excel sheet
#State of Florida

#importing modules, after installing with pip
import PyPDF2, os, glob, tabula
import pandas as pd

#Create object with PyPDF2, read PDF
PDFReader = PyPDF2.PdfFileReader(open("V:/FINAL_so106/Data/FLDeerReport2015.pdf", 'rb'))
pages = PDFReader.numPages

#list of states that have files in Data folder
statename = "FL"
counter = 15
os.mkdir("V:/FINAL_so106/Scratch/" + statename + "/")

#add pages from imported PDF to Writer, name files, write to Docs folder
for i in range(PDFReader.pages.lengthFunction()):
    PDFWriter = PyPDF2.PdfFileWriter()
    PDFWriter.addPage(PDFReader.getPage(counter))
    counter = i + 17
    filename = "V:/FINAL_so106/Scratch/" + statename + "/" + statename + "Deer_" + str(counter) + ".pdf"
    with open(filename, "wb") as pdffile:
            PDFWriter.write(pdffile)
    if counter == 18:
        break

#just pick FL PDFs to convert
path = "V:/FINAL_so106/Scratch/" + statename + "/"
tabula.convert_into_by_batch(path, output_format="csv")
```

Figure 6. Sample Python script that was used to extract data on white-tailed deer harvest from a state agency's website. The relevant data for this state (Florida) was on two pages of a very long document, requiring a tool to snip out only the desired tables from the rest of the material.

Table 6. List of sources that supplied data on white-tailed deer hunting numbers for each state. Direct hyperlinks available upon request.

State	Responsible State Agency	Year of Data Used	Estimated % Reported (if applicable)
Alabama	AL Department of Conservation and Natural Resources	2017-2018 (through 2/10/18)	35%
Arkansas	AR Game and Fish Commission	2016-2017	
Florida	FL Fish and Wildlife Conservation Commission	2014-2015	
Georgia	GA Department of Natural Resources	2016-2017	58%
Kentucky	KY Department of Fish and Wildlife Resources	2016-2017	
Louisiana	LA Department of Wildlife and Fisheries	2016-2017	50%
Mississippi	MS Department of Wildlife, Fisheries and Parks	2015-2016	
Missouri	MO Department of Conservation	2015-2016	
North Carolin	NC Wildlife Resources Commission	2015-2016	
Oklahoma	OK Department of Wildlife Conservation	2016-2017	
South Carolin	SC Department of Natural Resources	2016-2017	
Tennessee	TN Wildlife Resources Agency	2015-2016	
Virginia	VA Department of Game & Inland Fisheries	2016-2017	
West Virginia	WV Division of Natural Resources	2016-2017	

Red Wolf Reintroduction Variables - Master's Project

Start of Block: Default Question Block

Intro Thank you for helping my Master's Project by agreeing to provide your expertise on red wolves. The variables listed on the next page will all be used to analyze potential reintroduction sites for the wolves within their historic range. Potential sites were identified as being protected lands that met certain criteria and could serve as the source population for reintroduced red wolves. The model will determine which sites are the most likely to succeed, as the goal of reintroduction is to establish a population that will have the best chance of becoming established and eventually leading to the delisting of the species.

All variables that are listed were identified after a thorough search of the literature, and have been found to have some predictive power over the success or social acceptance of wolves.

All input will *not* be associated with your name, and will be presented in the aggregate in any future publications. Thank you again!

-Shane O'Neal

#1 Your Name (for my records only)

_____

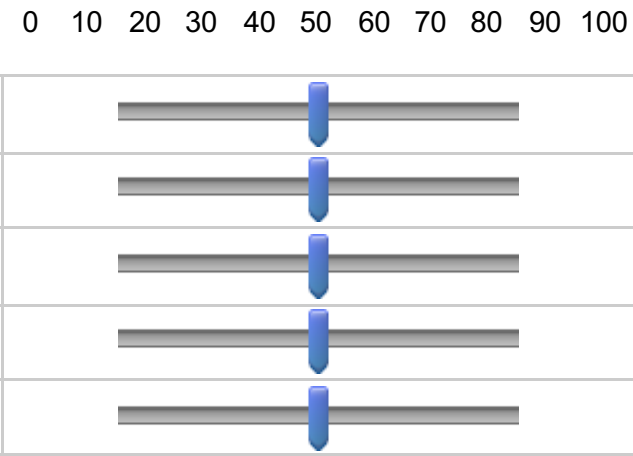
End of Block: Default Question Block

Start of Block: Block 1

Instructions Please rate each of the following variables from 0-100, where a score of 0 indicates that the variable will have no impact on the survival of introduced wolves and a score of 100 means that this variable has an enormous influence on the chances of success based on current conditions. The variable scores are not cumulative, and each should be rated

independently. These seek to understand which factors are the most important in determining the success of reintroduced wolves.

#2 Variables to Rate:



#3 How far away from the protected core area should these variables be analyzed? I have selected a set of 25 protected areas within the historic range that will serve as core areas for the reintroduction, and the distances below are measuring how far away the variables in question will still be relevant to the success of the introduction and establishment of a sustainable population.

- 1 mile (1)
- 5 miles (2)
- 10 miles (3)
- 20 miles (4)
- 40 miles (5)

End of Block: Block 1

Start of Block: Block 2

Thanks Thank you very much for your participation in my survey. If you would like to be sent a copy of the final product, please indicate so below, along with a method of contact or any other comments you may have.

Q6 Would you like to be sent a copy of the final project?

- ○ Yes (1)
- ○ No (2)

Q7 Best method of contact and any further comments.

_____

_____

_____

_____

_____

End of Block: Block 2

Figure 7. Copy of the expert survey used to elicit weights of variables.

Table 7. Reclassification values for the habitat layer, converting National Land Cover/Land Use Database classifications into suitability scores (1-10).

NLCD Classes:	Suitability:
11- Open Water	1
21- Developed, Open Space	3
22- Developed, Low Intensity	2
23- Developed, Medium Intensity	1
24- Developed, High Intensity	1
31- Barren Land	3
41- Deciduous Forest	8
42- Evergreen Forest	10
43- Mixed Forest	9
52- Shrub/Scrub	5
71- Grassland/Herbaceous	10
81- Pasture/Hay	8
82- Cultivated Crops	7
90- Woody Wetlands	7
95- Emergent Herbaceous Wetlands	5

Table 8. Reclassification values for converting from the abundance levels provided in the QDMA report data into suitability scores (1-10).

Deer Concentration:	Suitability:
Rare/Absent	1
<15/sq mile	2
15-30/sq mile	5
30-45/sq mile	8
>45/sq mile	10

Table 9. Reclassification values for converting the median age in a county into suitability scores (1-10). Class ranges were created using ArcMap Classification method Jenks/Natural Breaks with six classes.

Median Age/County:	**Suitability**:
22.4-31	10
31-36	8
36-39.1	6
39.1-42	4
42-46	2
46-62.7	1

Table 10. Reclassification values for converting the levels of cattle concentration in the FAO Gridded Livestock of the World dataset into suitability scores (1-10). Because most of the study area contained very low levels, the distribution was not even.

Cattle/km^2:	**Suitability**:
0	10
0-25	8
25-50	6
50-75	4
75-100	2
100-6230	1

Table 11. Reclassification values for converting hunting data into suitability (1-10). The number of deer hunted in a season per county was divided into 10 quantiles to form 10 classes.

Deer Hunted/County:	**Suitability:**
0 - 506	10
506 - 965	9
965 - 1315	8
1315 - 1716	7
1716 - 2073	6
2073 - 2471	5
2471 - 2984	4
2984 - 3165	3
3165 - 4020	2
4020 - 9761	1

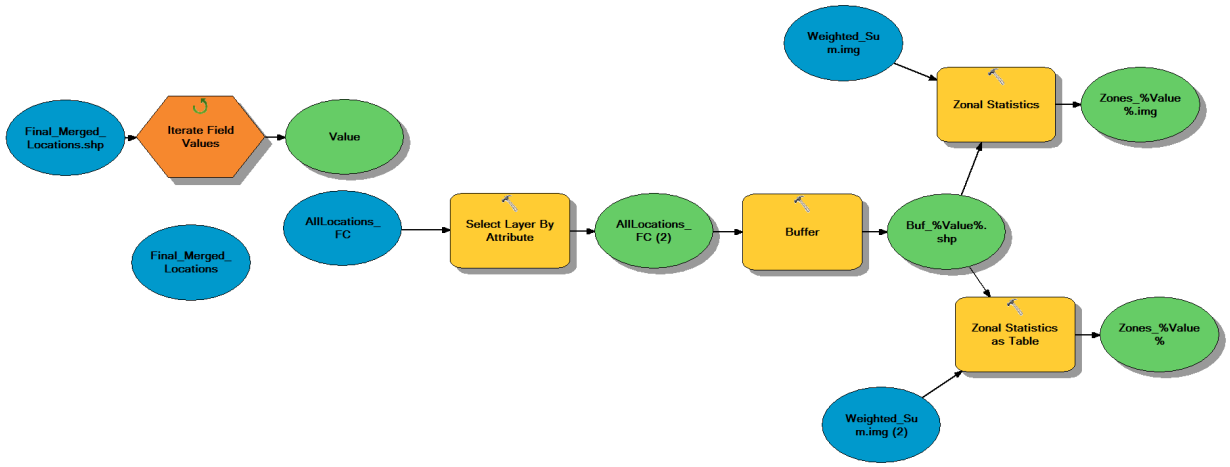


Figure 8. Tool made in ModelBuilder using a Looping Iterator to Iterate through all 21 of the potential reintroduction sites and calculate statistics for each one. This eliminated the issue caused by overlapping zones and considered each buffer zone independently.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	0	3.42390128	4.5382706	2.0731136	2.35112739	6.73173826	4.2940191	7.31849028	4.64028016	3.87708654	3.89362299	4.58904129	3.45199942	2.48889534	1.03865297	5.97552508	1.68656456	3.76546146	2.06855022	2.71040587	4.0254565	4.64705283
2	3.42390128	0	1.64401946	4.83972107	5.35061679	3.96550123	2.83737555	4.30562423	2.6805783	2.2041098	2.74714397	2.60595472	2.95445426	3.06174787	3.76625809	3.21172851	4.46781826	3.70178335	4.15689788	2.3712444	3.50653675	4.97969879
3	4.5382706	1.64401946	0	5.90417649	6.51019969	4.08905857	3.37109774	4.62506216	1.70689777	1.54431214	3.17023658	3.02473139	3.72150507	3.70068913	5.05120778	3.6991891	5.52230025	5.1260121	5.62410882	2.68663358	3.05447213	6.19682177
4	2.0731136	4.83972107	5.90417649	0	1.3903237	8.36557828	4.47854887	8.69674077	5.51733631	4.96956739	4.19670109	5.06004941	3.39159255	2.86136331	2.46329048	7.60480769	0.66128662	4.56794264	3.21015576	4.14300615	5.24027671	4.67584217
5	2.35112739	5.35061679	6.51019969	1.3903237	0	8.78782681	5.45164195	9.0633934	6.2924558	5.64450175	5.27347134	6.03041458	4.30765598	3.94583325	2.18920077	7.82039002	1.75342522	5.11369729	2.91683047	4.3879722	5.49418784	5.540731
6	6.73173826	3.96550123	4.08905857	8.36557828	8.78782681	0	5.92353779	2.07402989	5.70437551	5.53937722	5.93122247	5.23782398	6.51680904	6.39577204	6.82585526	1.85639435	7.96733331	5.11409816	6.61239745	5.92347871	6.65140587	6.57676212
7	4.2940191	2.83737555	3.37109774	4.47854887	5.45164195	5.92353779	0	5.76960137	2.94648944	3.10618737	0.98402236	0.92773919	1.26739891	2.66315602	4.8703388	5.46088821	4.25108222	4.16349613	5.31735837	4.0021869	4.89923463	4.29060602
8	7.31849028	4.30562423	4.62506216	8.69674077	9.0633934	2.07402989	5.76960137	0	6.07660267	6.03240416	6.07853601	5.15740245	6.44217355	6.96203275	7.30314316	1.88271081	8.36860801	5.45780176	7.05298518	6.42454668	7.25470882	6.83752879
9	4.64028016	2.6805783	1.70689777	5.51733631	6.2924558	5.70437551	2.94648944	6.07660267	0	0.92757749	2.65109411	2.90735275	3.18293889	3.30656922	5.3524387	5.32055448	5.19258125	5.84245668	6.17192839	2.7865929	2.75635629	6.48936823
10	3.87708654	2.2041098	1.54431214	4.96956739	5.64450175	5.53937722	3.10618737	6.03240416	0.92757749	0	2.7092988	3.09885463	3.10198324	2.96027026	4.56832573	5.02476865	4.60733111	5.41910509	5.42205681	1.92028644	2.12393503	6.23627293
11	3.89362299	2.74714397	3.17023658	4.19670109	5.27347134	5.93122247	0.98402236	6.07853601	2.65109411	2.7092988	0	1.14341593	1.55441307	2.12863806	4.62104966	5.60687079	3.86367701	4.07325423	5.13320563	3.70002703	4.57101739	4.16787716
12	4.58904129	2.60595472	3.02473139	5.06004941	6.03041458	5.23782398	0.92773919	5.15740245	2.90735275	3.09885463	1.14341593	0	2.08997608	2.99190575	5.16796865	4.96304342	4.74562957	3.9791959	5.5010908	4.18301327	5.07549012	4.21293247
13	3.45199942	2.95445426	3.72150507	3.39159255	4.30765598	6.51680904	1.26739891	6.44217355	3.18293889	3.10198324	1.55441307	2.08997608	0	2.09148273	4.00328615	5.84251658	3.26588426	4.15783598	4.61126881	3.46865968	4.45228031	4.35433118
14	2.48889534	3.06174787	3.70068913	2.86136331	3.94583325	6.39577204	2.66315602	6.96203275	3.30656922	2.96027026	2.12863806	2.99190575	2.09148273	0	3.35735015	6.06248299	2.57645105	3.84212181	4.05387469	3.15263382	4.05779497	4.05582297
15	1.03865297	3.76625809	5.05120778	2.46329048	2.18920077	6.82585526	4.8703388	7.30314316	5.3524387	4.56832573	4.62104966	5.16796865	4.00328615	3.35735015	0	5.89330977	2.2491554	3.78569677	1.29448832	3.14774522	4.52796864	4.89549793
16	5.97552508	3.21172851	3.6991891	7.60480769	7.82039002	1.85639435	5.46088821	1.88271081	5.32055448	5.02476865	5.60687079	4.96304342	5.84251658	6.06248299	5.89330977	0	7.2570104	4.85145339	5.72646488	5.00397842	5.87409568	6.54808369
17	1.68656456	4.46781826	5.52230025	0.66128662	1.75342522	7.96733331	4.25108222	8.36860801	5.19258125	4.60733111	3.86367701	4.74562957	3.26588426	2.57645105	2.2491554	7.2570104	0	4.25469153	3.00413049	3.8260162	4.97869461	4.4412836
18	3.76546146	3.70178335	5.1260121	4.56794264	5.11369729	5.11409816	4.16349613	5.45780176	5.84245668	5.41910509	4.07325423	3.9791959	4.15783598	3.84212181	3.78569677	4.85145339	4.25469153	0	3.12592386	5.18474686	6.6240471	1.97823153
19	2.06855022	4.15689788	5.62410882	3.21015576	2.91683047	6.61239745	5.31735837	7.05298518	6.17192839	5.42205681	5.13320563	5.5010908	4.61126881	4.05387469	1.29448832	5.72646488	3.00413049	3.12592386	0	4.14687834	5.6092602	4.40973922
20	2.71040587	2.3712444	2.68663358	4.14300615	4.3879722	5.92347871	4.0021869	6.42454668	2.7865929	1.92028644	3.70002703	4.18301327	3.46865968	3.15263382	3.14774522	5.00397842	3.8260162	5.18474686	4.14687834	0	1.58164471	6.32181936
21	4.0254565	3.50653675	3.05447213	5.24027671	5.49418784	6.65140587	4.89923463	7.25470882	2.75635629	2.12393503	4.57101739	5.07549012	4.45228031	4.05779497	4.52796864	5.87409568	4.97869461	6.6240471	5.6092602	1.58164471	0	7.65802847
22	4.64705283	4.97969879	6.19682177	4.67584217	5.540731	6.57676212	4.29060602	6.83752879	6.48936823	6.23627293	4.16787716	4.21293247	4.35433118	4.05582297	4.89549793	6.54808369	4.4412836	1.97823153	4.40973922	6.32181936	7.65802847	0

Figure 9. Euclidian Distance Matrix comparing all 21 potential sites, along with the current site of Alligator River & Pocosin Lakes (22). The values in the matrix represent the dissimilarity between the two sites, with higher numbers representing sites that are “farther apart” in terms of the five variables that were analyzed.

Table 12. Key to the numbered sites in the Euclidian Distance Matrix in Figure __.

Name	Number
Apalachicola NF in FL/Tate's Hell State Forest	1
Talladega National Forest	2
Blackwater River State Forest	3
Cherokee National Forest	4
Daniel Boone National Forest	5
Francis Marion and Sumter National Forests	6
George Washington and Jefferson National Forest	7
Kisatchie National Forest	8
Mark Twain National Forest (1)	9
Mark Twain National Forest (2)	10
Monongahela National Forest (1)	11
Monongahela National Forest (2)	12
Mount Rogers National Recreation Area	13
Ocala National Forest	14
Osceola National Forest	15
De Soto National Forests	16
Nantahala National Forest-NC / Chattahoochee-Oconee National Forest- GA	17
Croatan National Forest	18
Okefenokee National Wildlife Refuge	19
Ouachita National Forest	20
Ozark-St. Francis National Forest	21
Alligator River & Pocosin Lakes National Wildlife Refuges	22

Table 13. Each site's unweighted mean scores for each variable, calculated within the 30-mile buffer zone including and surrounding the site. Scores are scaled from 0-10, with 10 being an ideal situation.

Site	Habitat Scores	Deer Scores	Hunting Scores	Age Scores	Cattle Scores
Alligator River & Pocosin Lakes NWR (*current range*)	6.47	7.16	8.06	2.76	9.77
Apalachicola National Forest (FL)/Tate's Hell State Forest (FL)	7.37	3.36	7.07	4.71	8.52
Blackwater River State Forest (FL)	7.6	4.8	2.85	4.02	8.09
Cherokee National Forest (TN)	7.42	3.08	8.45	3.36	7.82
Croatan National Forest (NC)	6.81	6.95	7.2	4.47	9.47
Daniel Boone National Forest (KY)	7.65	2.74	8.96	4.48	7.32
De Soto National Forest (MS)	7.67	7.42	3.14	6.61	8.24
Francis Marion and Sumter National Forests (SC)	6.69	7.91	2.44	6.07	9.45
George Washington and Jefferson National Forest (VA)	7.81	5.74	5.2	1.92	7.38
Kisatchie National Forest (LA)	7.69	9.05	2.64	5.83	8.07
Mark Twain National Forest (1) (MO)	7.77	3.89	3.05	2.68	7.62
Mark Twain National Forest (2) (MO)	7.86	3.62	3.53	3.37	7.89
Monongahela National Forest (1) (WV)	7.78	5.17	5.16	1.89	8.18
Monongahela National Forest (2) (WV)	7.82	6.18	4.69	2.07	8
Mount Rogers National Recreation Area (VA)	7.67	4.93	5.96	2.33	6.95
Nantahala National Forest /Chatahoochee-Oconee National Forest (NC/GA)	7.63	3.18	8.09	3.42	8.32
Ocala National Forest (FL)	6.51	3.96	6.02	2.72	8.34
Okefenokee National Wildlife Refuge (GA)	7.38	4.59	8.06	6.04	8.65
Osceola National Forest (FL)	7.48	3.63	7.52	5.54	8.2
Ouachita National Forest (AR/OK)	8.01	3.05	4.62	4.81	7.61
Ozark-St. Francis National Forest (AR)	7.82	2	3.52	4.6	7.28
Talladega National Forest (AL)	7.7	5.32	4.33	4.5	8.05

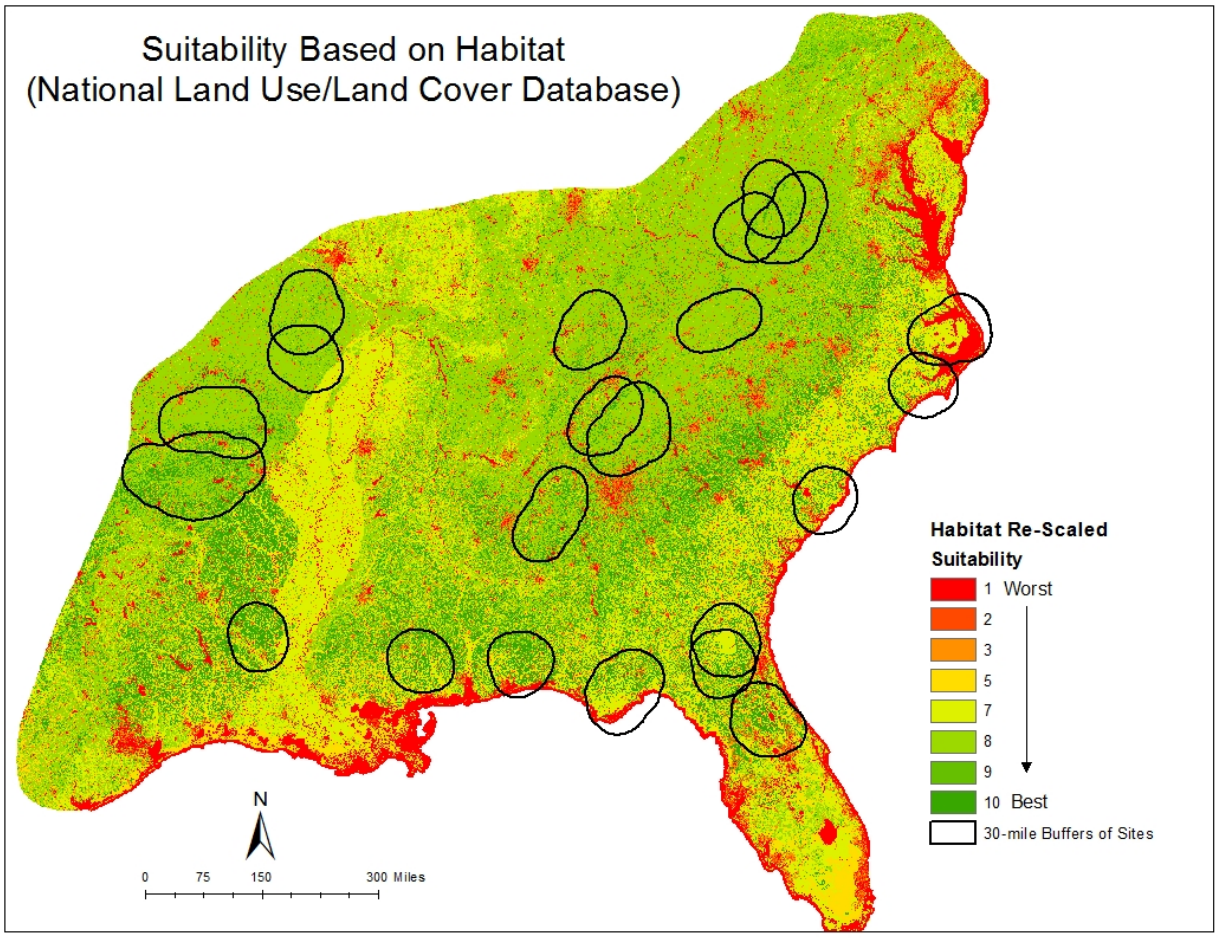


Figure 10. Map of suitability for red wolves based on habitat type per 30-meter by 30-meter pixel, with 1 as the least suitable habitat and 10 as the most suitable.

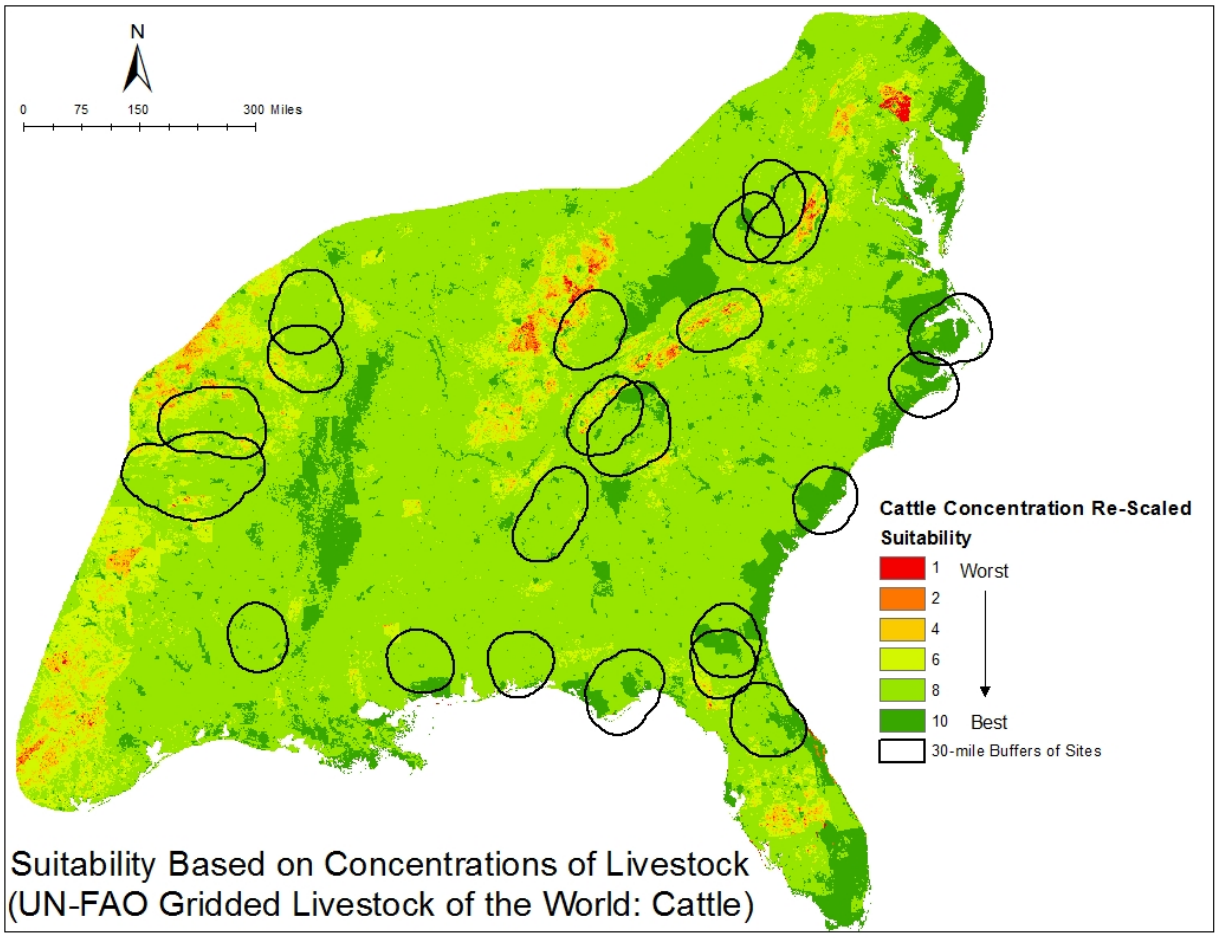


Figure 11. Map of suitability for red wolves based on concentration of cattle per 30-meter by 30-meter pixel, with 1 as the highest concentration of cattle (and therefore the least suitable) and 10 as the lowest concentrations. This represents pressure from livestock owners overall.

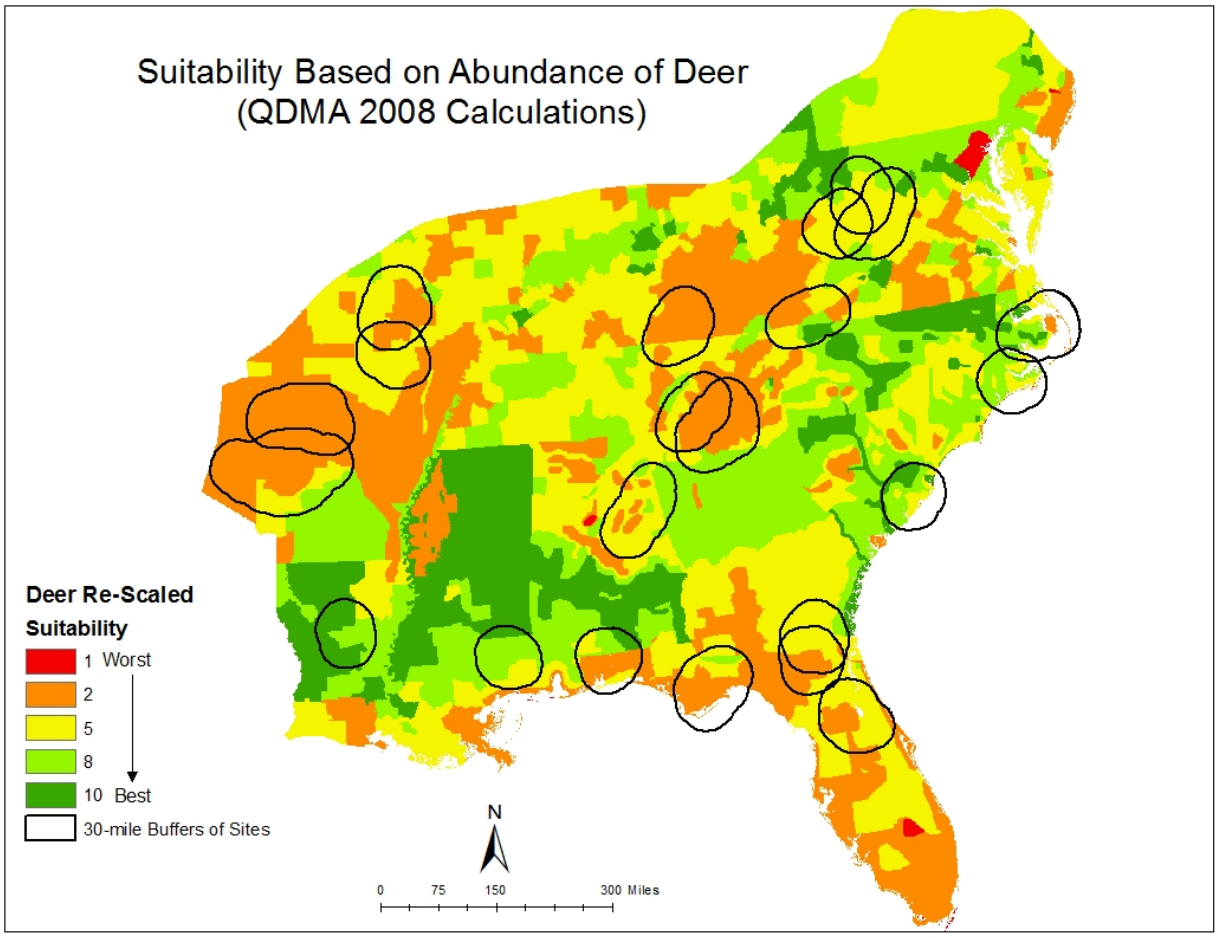


Figure 12. Map of suitability for red wolves based on the abundance of deer, with 1 as the lowest amount of deer and 10 as the highest amount. This represents the availability of prey for the wolves.

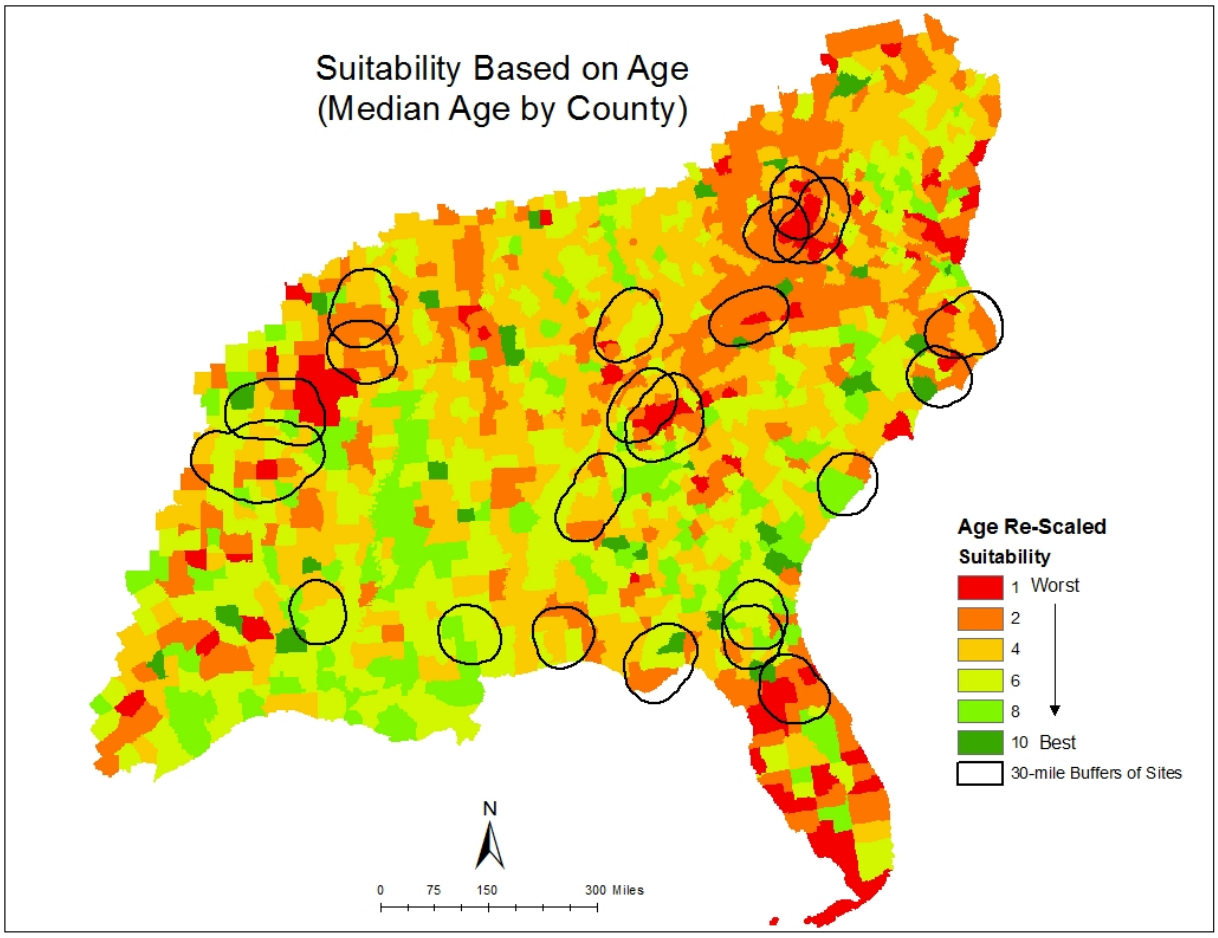


Figure 13. Map of suitability for red wolves based on the median age of residents per county, with 1 as the oldest median ages and 10 as the youngest. The older counties are predicted to express more opposition to the reintroduction of wolves.

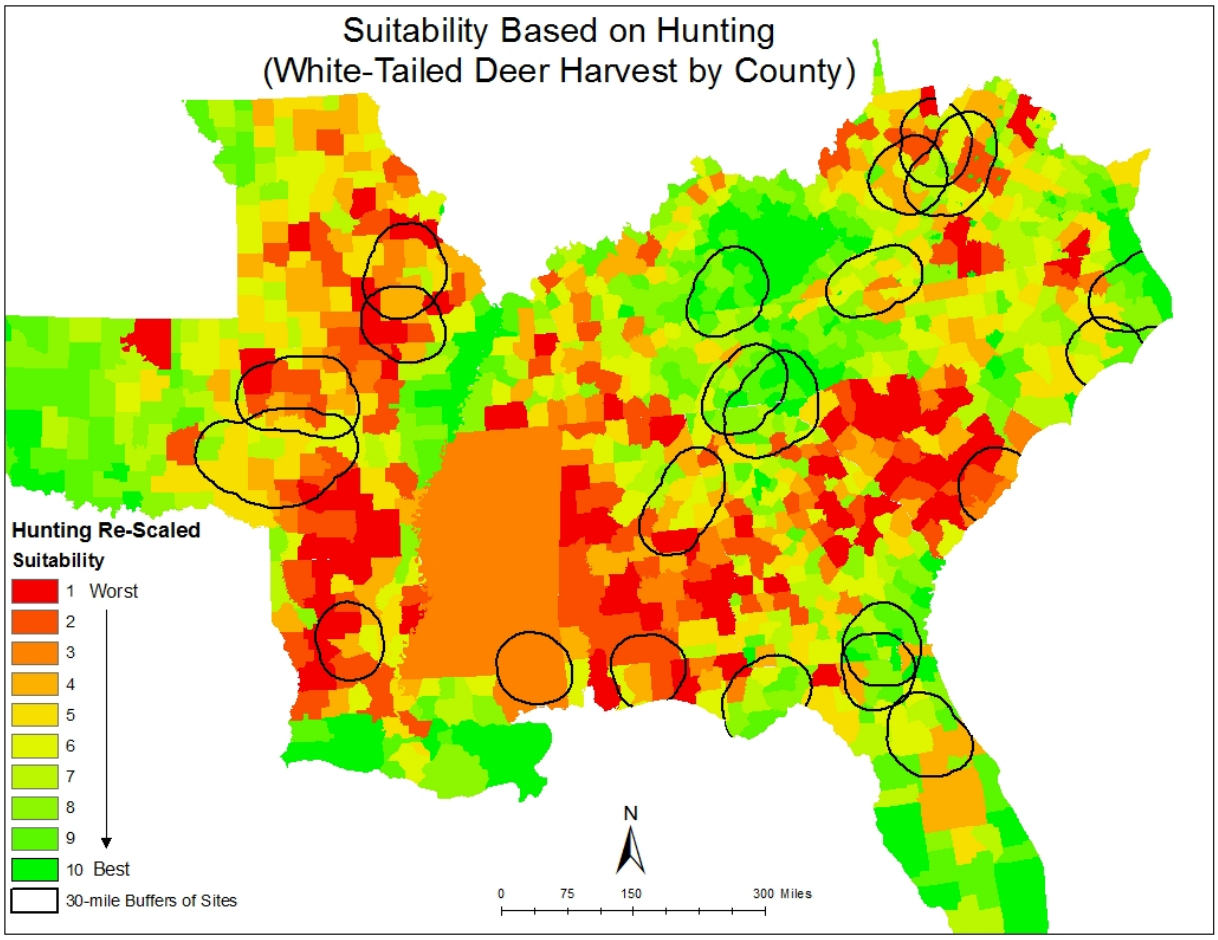


Figure 14. Map of suitability for red wolves based on the amount of hunting of white-tailed deer per county, with 1 as the highest amount of hunting (and therefore the least suitable) and 10 as the lowest levels of hunting. This represents pressure from recreational hunters.

Interactions of Human-Caused Mortality, Genetic Introgression, and Management among Wild Red Wolves: Developing Scientific Consensus

Final Report

August 2016

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United States Fish and Wildlife Service

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DRAFT

Introduction

After being nearly driven to extinction by the combination of human persecution, human-caused habitat change, and subsequent hybridization with coyotes, red wolves (*Canis rufus*) were rescued from extinction by the establishment of a captive breeding program in 1973. In 1987, red wolves were first released into a coyote-free (*Canis latrans*) area in northeastern North Carolina. But by the early 1990's coyotes began colonizing the area, and pairings between red wolves and coyotes were first detected in 1993. In 2000, a program to contain hybridization and introgression by sterilizing coyotes and removing hybrids began. Genetic assignment tests were used to determine which canids were red wolves, hybrids, and coyotes. But despite these management efforts, the number of red wolves in the reintroduced population has remained around 100. Given these additional sources of uncertainty surrounding hybridization and the potential increase in introgression along with the existing challenges for survival of red wolves as individuals and a species, the success of the recovery program remains unclear. We convened an expert workshop to investigate, address, and seek scientific consensus for two primary interrelated questions at the source of the uncertainty: (a) how does human-caused mortality affect reproductive barriers among red wolves and coyotes; and (b) at what biological point should genetic introgression prompt the delisting of red wolves? These two objectives are critical steps in the management process required to guide strategic planning and conservation for the species.

Recently, the USFWS contracted the Wildlife Management Institute (WMI) to conduct an independent review and evaluation of the red wolf recovery program. The WMI focused on three critical areas: (1) Supporting Science, (2) Program Management, and (3) Human Dimensions and identified gaps in each of these critical areas. WMI also suggested potential avenues for improvement, but was quick to point out that the independent report was "not intended, nor should it be construed, to be a decision document with recommendations relative to the fate of the current red wolf recovery program". In light of the findings of the WMI and the ongoing and unresolved surrounding controversy, it is paramount that decisions associated with the future existence and planning of the red wolf recovery program be addressed. In order to do so, the primary question revolves around whether or not the red wolf is a unique species worth conserving.

We convened a workshop on May 24-26 in Atlanta, GA involving world-class, leading experts in endangered species policy/law, as well as in conservation genetics, taxonomy, and population biology, with special focus on canids and red wolves in particular (Table 1). The workshop will employed structured decision making (SDM) as a framework to formally structure and evaluate the problem with a focus on the aforementioned questions. Although SDM will be the foundational approach, we relied on expert elicitation (Burgman 2005) to gather scientific evidence and to identify and characterize major sources of uncertainty. We used best practices for expert elicitation to engage the experts in facilitated discussion (USEPA 2011) and asked experts for their individual, professional knowledge on specific topics and encouraged group discussion and exchange.

Below we provide the historical context including a literature review on the relevant topics related to the problem and an annotated bibliography (Appendix 1). We then provide information on the selection of experts, workshop outcomes, next steps, and the summarized notes and results from the workshop.

Literature Review

Red wolf evolutionary origin and taxonomy

The origin of red wolves (*Canis rufus*) has long been a matter of debate. But since the advent of molecular markers, two primary hypotheses for the evolutionary origin of red wolves have been posited– the hybrid origin hypothesis (also called the "two species hypothesis") and the "three species hypothesis."

Wayne and Jenks (1991) first proposed that red wolves arose from hybridization between gray wolves (*Canis lupus*) and coyotes (*Canis latrans*) or originated as a distinct taxon that hybridized with coyotes and gray wolves over much of its historic range. In this paper the authors examined mtDNA from coyotes and gray wolves throughout North America as well as from red wolves in the captive breeding program, wild canids captured in Louisiana and Texas from 1974 to 1976 to initiate the red wolf captive population, and from six historical specimens collected from 1905 – 1930.

They found that the genotype of the captive red wolf population was identical to that found in two recent coyotes in Louisiana. Maximum parsimony placed this genotype in a monophyletic clade containing only coyote genotypes. This genotype was also common among the wild canids captured from 1974-1976 to found the captive breeding population. Genotypes among these wild canids were classified as 84% coyote, 7% northern gray wolf, and 9% Mexican wolf (*Canis lupus baileyi*).
Morphological and genetic classifications of the wild canids often did not correspond. The high frequency of morphological hybrids, poor correspondences between morphological and genetic classifications, and the presence of only coyote and gray wolf haplotypes suggested hybridization between these species occurred in the source population from which the captive population was founded before 1974.

Subsequently, a series of papers using autosomal microsatellites, mtDNA and increased sample sizes (Reich et al. 1999; Roy et al 1994; 1996) further explored the origin of red wolves. These papers also concluded that red wolves had a hybrid origin, dating from 12,800 years ago to as recent as the 1700's.

Von Holdt (2011) assessed genetic variation among wolf-like canids from around the world, across all 38 autosomes using 46k single nucleotide polymorphisms (SNP) based on the dog genome. They conducted several types of analyses with a particular focus on examining the genetic composition of red wolves and wolves from the Great Lakes region. The authors concluded red wolves are closely related to coyotes, "…but somewhat divergent from them due to a history of limited admixture with gray wolves. Such historic admixture between gray wolves and coyotes was followed by extensive backcrossing to coyotes, as the source population of gray wolves disappeared in the American South and the Southeast. We estimate admixture was initiated 144 generations (287–430 yr) ago."

Wilson et al. (2000) first proposed what has become known as the three species hypothesis for the origins of the eastern wolf (*Canis lycaon)*, best typified by wolves in and around Algonquin Provincial Park(APP) in Ontario and red wolves. Specifically, they examined two

alternative hypotheses: 1) eastern and red wolves are hybrids of coyotes and gray wolves; and 2) eastern and red wolves evolved independently of gray wolves in North America. Like red wolves, the origin and taxonomy of eastern wolves has long been a matter of debate. Both wolves are known to hybridize with coyotes. To test these hypotheses they used eight microsatellite loci from wolves in and around APP from 1960 – 1965 (n= 19) and from 1985 – 1996 (n = 49), and samples from the captive red wolf breeding program (n = 60). Coyotes were sampled from Texas (n = 24) which were the geographically closest population to the red wolf founders, and gray wolves were sampled from the Northwest Territories (n = 67). Prior microsatellite data from coyotes and gray wolves from additional locations were also used in analyses. In addition the authors examined mtDNA control region sequences from the early APP wolves.

They concluded that eastern wolves, red wolves, and coyotes evolved in North America independently from gray wolves, which evolved in Eurasia. Based on mtDNA sequence divergence, they estimated eastern and red wolves shared a common ancestor with coyotes 150,000 – 300,000 years ago. They further estimated that this new world lineage diverged from gray wolves 1 – 2 million years ago. The three "species" are gray wolves, eastern wolves (considered synonymous with red wolves), and coyotes.

Further supporting the claim that eastern wolves are not gray wolves, Wilson et al. (2003) found that mtDNA from two historical wolf specimens collected in the late 1800's in Maine and New York, about 40 years prior to the first documented presence of coyotes in the region, were not of gray wolf origin. The Maine sample had an eastern wolf haplotype, and the New York sample had a haplotype found in modern western coyotes. And two samples from an archaeological site in southwestern Ontario dated to 1530 AD had coyote-like mtDNA sequences, suggesting the canids in this area were not gray wolves (Rutledge et al. 2010b).

Rutledge et al. (2012) used the SNP data from vonHoldt et al. (2011) along with existing mtDNA and microsatellite data, the fossil record, ecological data, and early naturalists' accounts "…to show how a broader frame of reference is important for interpretation of genomic data." In their reanalysis of the SNP data they use the three species model (eastern wolves, gray wolves, and coyotes) for North American wolf-like canids, rather than the two species model (gray wolves and coyotes) used by vonHoldt et al. (2011). They concluded there is substantial support for the three species model of wolf evolution in North America.

Rutledge et al. (2015) used 127,235 SNP loci based on a gray wolf genomic assembly from each of 17 individuals of five different *Canis* types (gray wolves, Great Lakes wolves, eastern wolves from Algonquin Provincial Park, western coyotes, and eastern coyotes) along with genomic simulations to test hypotheses of hybrid origins among eastern North American *Canis*. A principal components analysis was consistent with the eastern wolf being a distinct species. Simulated gray wolf x western coyote hybrid genomes failed to overlap with any other *Canis* type. But simulated eastern wolf x gray wolf genomes overlapped Great Lake wolves, and simulated eastern wolf x western coyote overlapped existing eastern coyotes. These patterns were consistent with previous suggestions that the eastern wolf is a conduit for gene flow between gray wolves and coyotes (Rutledge et al. 2010a), but are in contrast to previous work that concluded (under the assumption of the two-species model) that the eastern wolf from Algonquin Park was a gray wolf x western coyote hybrid.

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History of red wolves

Red wolves occurred historically throughout southeastern North America from eastern Texas into Pennsylvania and perhaps through Maine (Nowak 2002). Prior to European settlement of North America, the geographic range of red wolves had little overlap with that of coyotes, whose eastern limits largely coincided with the westerly plains (Nowak 2002). By the early 1900s the combination of direct persecution, forest clearing, road building, and perhaps the decline of deer herds had eliminated red wolves from most of their historic range (USFWS 1989), and hybridization between red wolves and coyotes had begun in central Texas (Nowak 2002). By the 1960s red wolves were confined to a single small population in Louisiana and Texas, encompassed by coyotes that had expanded their range eastward (USFWS 1989).

Upon learning that few red wolves remained in the wild and that they were interbreeding with coyotes, the U.S. Fish and Wildlife Service (USFWS) listed red wolves as endangered in 1967 under the Endangered Species Preservation Act and initiated a captive breeding program for them in 1973 (Riley & McBride 1975; USFWS 1989). Over the next 7 years, more than 400 wild canids were captured from the area of the remaining red wolf population. Only 43 of these were thought to be red wolves. Initial pairings among some of these animals produced pups that were thought to be hybrids. Consequently the pups and parents were removed from the captive breeding program. Eventually, seventeen of these canids were considered to be "pure" red wolves, underscoring the precarious status of the species in the 1970s. Three of these animals, however, were too old to breed, and ultimately the captive breeding population was founded by 14 wild red wolves.

Efforts to restore a wild population in eastern North Carolina began with the releases of captive-born red wolves into the Alligator River National Wildlife Refuge (ANWR) on the Albemarle Peninsula in 1987. The first litter of pups was born the following year. From October 1987 through December 1994, 63 red wolves were released in the area (Phillips et al. 2003). In 1992, efforts to establish a second wild population of red wolves began in Great Smoky Mountains National Park. This effort, however, was unsuccessful, and the wolves were removed in 1998. Red wolves were also released on at least three coastal islands in the southeastern USA from 1978 to at least 2005. The island releases were used to refine field methods and to provide a halfway house for captive born wolves before being released into eastern North Carolina.

When red wolf releases began in eastern North Carolina, there was no evidence of coyotes in the area, but by 1992 coyotes had colonized the recovery area. And three red wolves (one female and two males) were observed consorting with coyotes. The female was removed. One of the males was shot and was thought to have not sired a litter. The second male did sire a hybrid litter in 1993, but the litter was removed (Phillips et al. 2003).

An adaptive management plan to address hybridization was implemented in the spring of 1999. This plan called for two strategies to minimize hybridization: the use of sterile "placeholders" to reduce the production of hybrids and the use of genetic testing to identify hybrid individuals (Adams et al. 2006, Miller et al. 2003). Placeholders were single or paired coyotes or hybrids that had been sterilized, radiocollared, and released. These placeholders occupied space until they were killed or displaced by red wolves or removed by managers to provide space for red wolves (Gese & Terletsky 2015). Captured hybrids that were not sterilized

were removed. The plan called for initial implementation in the easternmost portion of the Red Wolf Experimental Population Area (RWEPA; Figure 1, Zone 1) and then to sequentially expand management actions westward into the other two zones.

Current status of the captive and wild populations

Captive population

The captive population of red wolves had a total of 202 wolves distributed among 45 institutions, as of July 20, 2015 (Waddell & Long 2015; Figure 2). The reproductively capable population, however, numbered 166 red wolves. Of the 36 red wolves that were not reproductively capable 13 had been sterilized, two had medical conditions, and 21 were considered to be too old to breed (females>10 and males > 12 years old). The pedigree is 100% known, and the target size for the captive population is 200.

Although the captive population was founded by 14 wild-caught red wolves, the current population retains ancestry from only 12 founders. And founder representation in the current captive population is unequal, ranging from about 2 to 16% for each of the 12 founders (Figure 3). Unequal founder contributions results in more rapid loss of genetic variation. The number of founder genome equivalents (FGE) for the captive population is 4.56. If founder representation could be equalized there would be 7.36 FGE. FGE are approximately the number of wild-caught animals that would be needed to obtain the same amount of genetic diversity as is in the current captive population.

The mean kinship of the captive population is 0.1095 (range among individuals 0.0983 - 0.1184) meaning that on average, individuals in the population are a bit less related to one another than half- siblings. The mean of individual inbreeding coefficients (*f*) for the population remains low at 0.0785. For reference, a pair consisting of half siblings would produce pups with $f = 0.125$.

For 2016, the red wolf SSP recommended 39 breeding pairs to achieve a growth rate of 0-2% to meet demographic and genetic goals. Litter size ranges from one to nine with a mean of four pups. The number of breeding pairs recommended is based on an average litter size of four and a 20% chance of a breeding pair will successfully reproduce. The low breeding success of captive pairs may in part be a result of reduced female fertility associated with delayed breeding (Penfold et al. 2014).

Red wolf experimental population

Following implementation of the adaptive management plan in 1999, the numbers of known red wolves and known red wolf social groups increased (Figure 4; Gese et al. 2015). Numbers of known red wolves exceeded 100 from 2006 – 2010, but then began to decline. The numbers of known red wolf social groups peaked at 22 in 2004 and then declined to 13 by 2013. Notably the numbers of red wolves and social groups in Zone 1 both declined during this period. The number of red wolf litters detected ranged from 6 – 12 each year (Figure 5), with the highest numbers of litters occurring from 2004 – 2009 when 10-12 litters were detected each year. By 2013, however, the number of litters detected declined to seven. Mean inbreeding levels among red wolf litters increased linearly from 1988 to 2012 (Figure 6; Brzeski et al. 2014). Inbreeding coefficients were calculated from pedigree developed from genetic parentage and assignment

testing. From 1993 – 2013, zero to five hybrid litters were detected each year (Figure 5; Bohling & Waits 2015). Hybrid litters were removed when possible. Currently, only 45 red wolves are known to occur in the RWEPA (*http://www.fws.gov/redwolf/Images/Mortalitytable.pdf*).

Systematic use of genetic assignment tests to identify hybrids, determined that two F_1 hybrids produced in 1993 went undetected. And at least one of these hybrids backcrossed with a red wolf. In addition, it was discovered that a substantial number of animals considered to be "pure" red wolves actually had some coyote ancestry as a result of hybrids backcrossing with red wolves. Removing all of these animals would have resulted in a substantial demographic cost to the population. In addition, the genetic assignment tests used to identify hybrids could reasonably detect hybrids with as little as 12.5% coyote ancestry. But distinguishing between "pure" red wolves and animals with <12.5% coyote ancestry was more complicated, requiring a tradeoff between type I and type II statistical errors. Consequently, it was decided that animals with <12.5% coyote ancestry would be considered red wolves for management purposes.

Despite the discovery of coyote introgression and the ongoing generation of hybrids in the RWEPA, there has been little introgression of coyote ancestry into the red wolf population. In 2014, it was estimated that among red wolves, 96.5% of the population's ancestry was from red wolves and only 3.5% was coyote ancestry. And all coyote ancestry was from a single male coyote that bred a female red wolf in 1993 (J. Adams personal communication).

Furthermore, Bohling (2011) estimated that only 4% of individuals in the RWEPA and in areas immediately west were hybrids. He also estimated that red wolves comprised 80 and 50% of canids in Zones 1 and 2, respectively. Coyotes were predominant in areas further west. No red wolves and few hybrids were detected west of the RWEPA. Over the entire sampling area, however, coyotes far outnumbered red wolves. An earlier survey of canids in a 22,000 km^2 area ranging from the western boundary of the RWEPA north to the Virginia border also found no evidence of red wolves, and very little red wolf ancestry among the canids detected (Bohling & Waits 2011).

For red wolves to persist in the presence of coyotes with minimal management, reproductive barriers between red wolves and coyotes must operate. Simulations by Fredrickson and Hedrick (2006) suggested that red wolves may persist in the presence of coyotes if there is some degree of positive assortative mating among red wolves and if red wolves displaced coyotes and hybrids at sufficient rates. Bohling and Waits (2015) found some evidence of assortative mating among red wolves. They noted that red wolves that did not pair with other red wolves appeared to preferentially pair with admixed individuals rather than coyotes, even though coyotes vastly outnumbered hybrids. And Gese and Terletzky (2015) found that from 1999 – 2013 there was an average 3.4 displacements of placeholders by red wolves annually. Twenty seven percent of displaced placeholders were killed by red wolves.

Hinton et al. (2015) and Bohling and Waits (2015) evaluated factors associated with hybridization between red wolves and coyotes. They found that most hybridization events followed the disruption of social groups. And most disruptions resulted from the death or disappearance of a breeding adult. Most deaths leading to red wolves pairing with coyotes or hybrids resulted from human-caused mortality, particularly from gunshot shortly before or during the breeding season, which coincides with the deer hunting season. Similarly, wolf culls in APP resulted in increased hybridization among eastern wolves and coyotes (Rutledge et al.

2011). A later ban on wolf hunting and trapping around the park led to a reduction in coyote ancestry among park wolves and a large decrease in packs adopting unrelated wolves Rutledge et al. (2010). Hinton et al. (2015) found that anthropogenic break-ups among red wolf pairs increased from 15% in phase 1 of their study (1991-1998) to 48.2% in phase 3 (2006-2013). Both studies found evidence that female red wolves were more likely than males to pair with a coyote following loss of its mate. These data suggest that gunshot mortality among red wolves during the deer hunting season may be a particularly potent driver of hybridization. In addition to facilitating hybridization, Gese and Terletsky (2015) noted that gunshot mortality may also prevent production of red wolf pups the following year.

Overall, Gese et al. (2015) concluded the success of the red wolf adaptive management program at controlling hybridization and facilitating recovery was mixed. Although the RWEP had low coyote ancestry, and hybrids were limited to 4% of the population, the numbers of coyotes and hybrids detected over time did not decrease, and the ratio of hybrid to red wolf litters did not decline over time indicating hybridization is an ongoing challenge. Ideally red wolves would fully occupy the area and coyotes entering the area would be excluded by resident red wolves. But the authors believe this is unlikely to occur because wolf habitat is discontinuous and anthropogenic changes in habitats will favor coyotes. At 90 – 95 adult red wolves, the population may have reached carrying capacity. Consistent with this, the habitat model developed by Dellinger et al. (2013) suggested that red wolves may be patchily distributed across the RWEPA. Finally, Gese et al. (2015) noted that the high rate of human caused mortality leading to hybridization may also be limiting.

When should hybrids be listed under ESA?

Below are listed a few thoughts from the literature on when conservation and / or listing of hybrids under the Endangered Species Act may be appropriate.

Allendorf, F.W., R.F. Leary, P. Spruell, and J.K. Wenburg. 2001. The problems with hybrids: setting conservation guidelines. Trends in Ecology and Evolution 16:613-622.

One factor is how many PURE POPULATIONS of the taxon remain. The smaller the number of pure populations, the greater the conservation and restoration value of any hybridized populations. In addition, the greater the phenotypic (behavior,morphology, etc.) differentiation between the hybridized population and remaining pure populations, the greater the conservation value of the hybridized population. Another factor to consider is whether the continued existence of hybridized populations poses a threat to remaining pure populations. The greater the perceived threat, the lower the value of the hybridized population.
Note that the authors are speaking of populations, not species or subspecies.

We believe that the pallid sturgeon represents an important evolutionary component of sturgeon in the Mississippi River that is worthy of protection. Nevertheless, the available genetic evidence suggests that pallid and shovelnose sturgeon are not isolated evolutionary lineages. The conservation policy for these taxa should consider these fish as a complex of populations that naturally exchange genes, rather than as two isolated

evolutionary lineages. The current listing of pallid sturgeon as a separate species would not allow protection of pallid sturgeon from the southern Mississippi River, because they are clearly hybrids. However, pallid sturgeon in the Atchafalaya River should be protected because the hybridization between pallid and shovelnose sturgeon appears to be natural. Note that in this case the authors are speaking of two species.

Allendorf FW, Leary RF, Hitt NP, Knudsen KL, Lundquist LL, Spruell P. 2004. Intercrosses and the U.S. Endangered Species Act: Should hybridized populations be included as westslope cutthroat trout? Conservation Biology 18:1203–1213.

"Although any remaining nonhybridized introgressed populations should be given priority in this case, remaining hybrids should be protected in the hope that they will fill the ecological role of the native taxon."

O'Brien, S.J., and E. Mayr. 1991. Bureaucratic mischief: recognizing endangered species and subspecies. Science 251:1187-1188.

Hybridization between species should be discouraged, and listing of such hybrids under ESA would be inappropriate. But species that hybridize within zones that "does not disintegrate the genetic organization of the species in contact" should be listable. Hybridization between subspecies and populations may be acceptable in some cases, but "managed facilitation of subspecies mixing would generally be discouraged although, in certain extreme cases, it may be justified."

Von Holdt B et al. 2011 A genome-wide perspective on the evolutionary history of enigmatic wolf-like canids. Genome Res. 21, 1294–1305. (doi:10.1101/gr.116301.110)

The authors state:

> It has been suggested that hybrids are not clearly protected under the ESA (O'Brien and Mayr 1991), especially hybrids between nonlisted entities (U.S. Fish and Wildlife Service 1973). Since a critical aim of the red wolf recovery project is to maintain the introduced population free from hybridization (Hedrick and Fredrickson 2008), the rationale of the program may need reconsidering as the extant red wolves clearly derive from a process of admixture.

The authors further conclude:

> Using a genome-wide approach, we show that the red and Great Lakes wolves have a distinct but admixed evolutionary history. This result has important implications for conservation policy, because current preservation efforts are focused on populations whose admixed genomes may be due in part to recent habitat changes and predator control efforts (Lehman et al. 1991; Wayne and Jenks 1991). However, these concerns must be weighed against the beneficial top-down ecosystem effects that admixed populations have in environments, which now may be unsuitable for large wolves. Such ecologic, rather than strictly taxonomic considerations are also integral to deciding which species and subspecies should be preserved (e.g., Crandall et al. 2000; Allendorf et al. 2001; Carroll et al. 2010).

Wilson, PJ, LY Rutledge, TJ Wheeldon, BR Patterson, and BN White. 2012. Y-chromosome

evidence supports widespread signatures of three-species Canis hybridization in eastern North America. Ecology and Evolution 2(9): 2325–2332.

The authors note that:

> The contemporary hybrid species-complex represents various forms. Specifically, a spectrum of coyote to eastern wolf to gray wolf phenotypes exists in a range of natural to human-modified landscapes, including regional differences in wolves (Mech and Paul 2008) and eastern coyotes (Kays et al. 2010).

They also state:

> As a result, standard taxonomic nomenclature is difficult to apply to the classification, conservation, and management of wolves and coyotes in eastern North America. We encourage managers and policy makers to consider the evolutionary potential of these hybrid genomes because they may support the adaptability necessary to refill the ecological role once occupied by the purer wolf species that existed prior to European colonization.

Perhaps throwing red (or Algonquin Provincial Park) wolves a bone, they further state:

> However, we also recognize that in situations where sufficient habitat exists for recolonization of historic species, efforts to minimize anthropogenic factors that exacerbate hybridization are an important aspect of conservation.

Identifying and Inviting Experts

The workshop planning team (Pacifici, Mills, Fredrickson, Smith, and Collazo) used best practices for eliciting information from experts to identify and invite scientific experts to participate in the workshop (Burgman 2005). The planning team first identified three main areas of interest relevant to the workshop: Conservation genetics/hybridization, Wolf/Coyote Biology, and ESA Law/Policy. Then, the planning team reviewed the literature to identify experts who had authored studies or participated in research relevant to these three main areas. We used selection criteria based on an expert's professional credentials, position, area of expertise, and experience to develop a list of potential invitees. Part of the process was to ensure that we had representative groups from differing and competing scientific viewpoints. In addition, we were less interested in having all of the wolf/coyote biologists in the room because the focus of the workshop was less about wolf/coyote management and more about genetics and policy therefore we limited the number of wolf/coyote biologists on the list of potential invitees. These criteria helped ensure that the invitations to participate were made only to scientific experts familiar with the topic and that the selections were transparent, unbiased, and captured a broad diversity of expertise and professional judgments related to the topics of interest.

The planning team identified experts based solely on their scientific qualifications, rather than their affiliation with a particular organization or interested party (with the exception of ensuring we had a representative from USFWS and the NC WRC). The planning team then invited experts (Appendix 3) via email and served as the primary points of contact for the experts. If an expert declined an invitation, the facilitators invited a replacement from the planning team's list.

Invited experts represented a diversity of expert judgment on the main areas of interest for the workshop within the scientific community and would effectively contribute to group discussions.

The facilitators limited the meeting size to (~20 experts) in order to maximize open, scientific discussion between all participants. Further, in order to maintain an open, intimate meeting environment, only members of the workshop planning team were invited to observe the workshop.

Preparing the Experts for the Workshop

Before the workshop, the planning team hosted informational webinars attended by most of the experts. The webinars explained the workshop's purpose, agenda, and ground rules. The planning team also provided a bibliography of background references and readings.

Workshop Facilitation

During the workshop, trained facilitators (Pacifici, Smith, and Collazo) used best practices for expert elicitation to engage the experts in facilitated discussion (Drescher 2013). The facilitators used formal elicitation techniques on specific technical questions regarding genetics and evolutionary origins of the Red Wolf. Throughout the workshop, the facilitators asked experts for their individual, professional knowledge on specific topics. The workshop obtained facts and information only, and if needed to address uncertainty, professional judgment from each individual expert.

Red Wolf Agenda

Atlanta Marriott Marquis Room M202

Day 1 - Tuesday

Breakfast on your own

8:30-9:00: Introductions, goals, objectives, logistics

9:00-10:30: Presentations on background and overview of problem.

1. Pete Benjamin – overview of problem, USFWS position
2. Rich Fredrickson – overview of current state of Red Wolf genetic status and management
3. Holly Doremus/Dale Goble – overview of policy issues/precedence
4. Round the table - 3 min reports

10:30-11:00: Break

11:00-12:00: Framing problem and begin general template to problem

12 – 1:30: Lunch on your own

1:30-3:00: Continue discussion

3:00-3:30: Break

3:30-5:00: Continue discussion and wrap up general template to problem

Dinner on your own

7:00: Meet up at Pulse bar in hotel

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Day 2 – Wednesday

Breakfast on your own

8:30 – 9:00 – Recap of Day 1

9:00-10:30 – Red Wolf as case study:

Apply the general template/framework to red wolf (adapt general framework as necessary)

10:30 – 11:00: Break

11:00 – 12:00: Continue Red Wolf Case Study

12-1:30: Lunch on your own

1:30 – 3:00: Continue Red Wolf Case Study

3:00 – 3:30: Break

3:30 - 5:00: Continue to apply the general template/framework to red wolf

Dinner on your own

7:00: Meet up at Pulse bar in hotel

Day 3 - Thursday

Breakfast on your own

8:30-11:30: Tie up loose ends; talk about next steps and products (pubs and reports), TWS conference panel

11:30-12: Wrap-up

Lunch on your own

Checkout and travel to Airport

Workshop Outcomes

The first contribution of the workshop was a review of the historical context for the recovery program and the current status of the program. Several of the invited experts provided an overview of the program as well as their own research relevant to the project. The majority of the time on the first day was spent in open discussion as it served to orient all of the participants on the problem and working with each other. There was lively discussion about some of the factors surrounding the program and strong viewpoints regarding the challenges faced by the project.

As the workshop moved forward it became clear that one of the major sticking points to deciding the fate of the recovery program was the evaluation of the evolutionary origin of the red wolf. This became the central focus for the remaining 1.5 days of the workshop as well as the major contribution put forth by this effort. We explored several of the competing hypotheses about the evolutionary origins of the red wolf at different points in time (Pre-Columbian, 1970's, and

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modern), specifically the 2-species hypothesis and the 3 or 4 species hypothesis. Given the expertise in the room we were able to break down the different hypotheses (Figure 1).

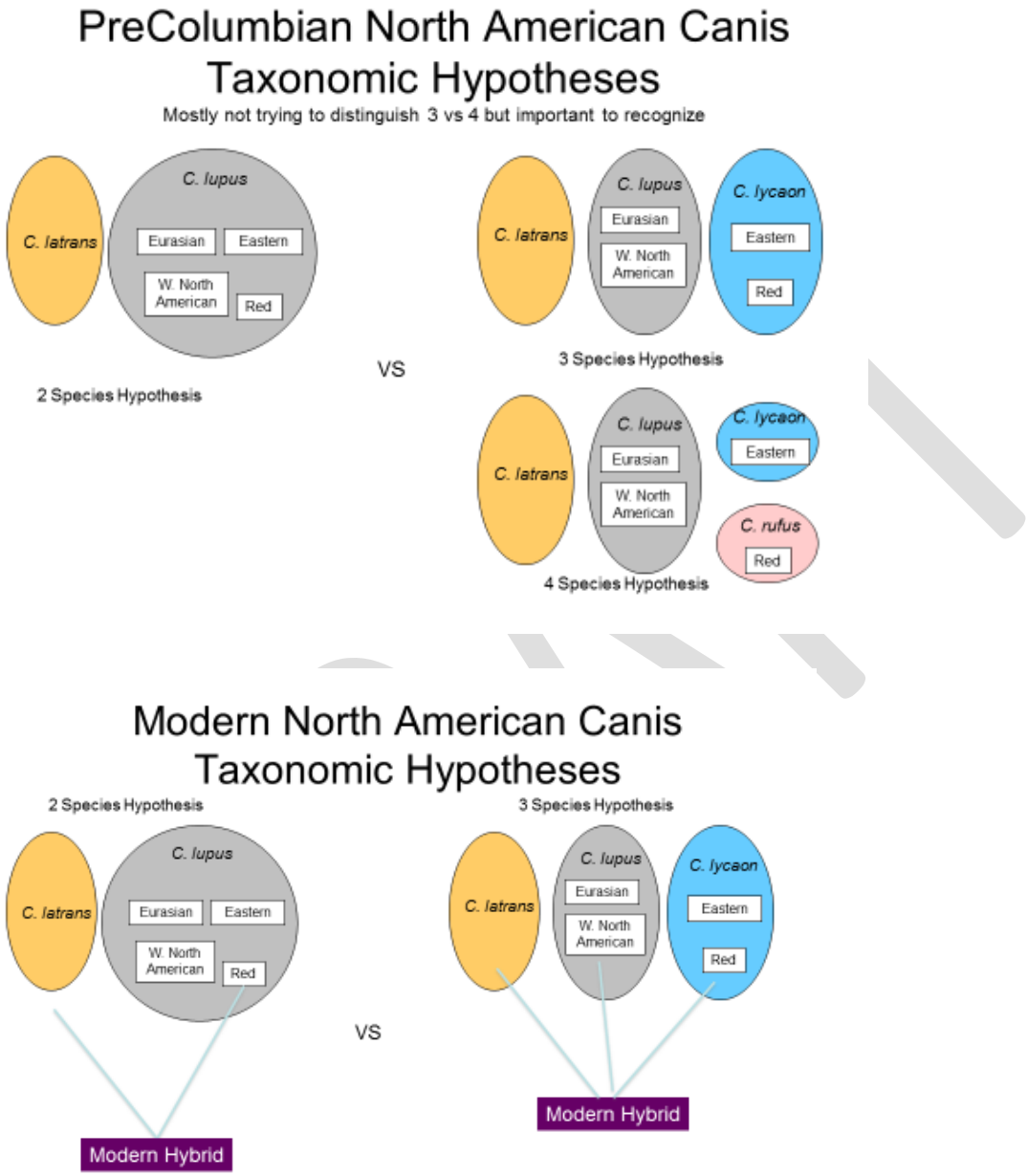


Figure 1. Breakdown of the 2 and 3 or 4 species hypotheses at two time points: PreColumbian and Modern.

The goal was to evaluate the potential for the Red Wolf to be a listable entity under each of the different hypotheses and at each different time point. To do so we first went over the criteria for deciding a listable entity:

1996 DPS policy criteria

Discreteness

1. It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors. Quantitative measures of genetic or morphological discontinuity may provide evidence of this separation.
2. It is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of Section 4(a)(1)(D) of the ESA.

Significance

1. persistence of the discrete segment in an ecological setting unusual or unique for the taxon,
2. evidence that loss of the discrete segment would result in a significant gap in the range of the taxon,
3. evidence that the discrete segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historical range, or
4. evidence that the discrete segment differs markedly from other populations of the species in its genetic characteristics.

We then broke down each scenario and determined if there was a path to a listable entity. In addition we explored a separate 2 species hypothesis (labelled 2 species II) which was posed suggesting that the red wolf might is a hybrid that is more related to C. latrans. It is important to note that although this hypothesis was suggested there is currently no scientific evidence that suggests this is a viable hypothesis, however, we still went through the process of evaluating it. Below is the summary of plausible pathways to determining whether or not the red wolf is a listable entity under several different evolutionary origin hypotheses.

4 Species hypothesis

C. rufus is a species

3 Species hypothesis

- RW is not a species
- RW might be a subspecies of C. lycaon
- If not, RW must be a DPS of C. lycaon
    - Discreteness: meets both criteria
    - Significance: meets #1, #2, maybe #4

2 Species hypothesis I

- RW is not a species
- RW might be a subspecies of C. lupus
- If not, RW likely is a DPS of C. lupus

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- Discreteness: meets #1 based on PCA and Structure results; separated from Eastern lupus by international border
- Significance: arguably meets #1, meets #2

2 Species hypothesis II (historic Pre-columbian)

- RW is not a species
- RW might be a subspecies of C. latrans
- If not, RW likely is a DPS of C. latrans
  - Discreteness: meets #1 based on PCA and Structure results;
  - Significance: arguably meets #1, meets #2

2 Species hypothesis II (current 1970's/now)

- RW is not a species
- RW might be a subspecies of C. latrans
- If not, RW likely is a DPS of C. latrans
  - Discreteness: meets #1 based on PCA and Structure results;
  - Significance: might meet #4

Under all scenarios it was clear there was a logical and valid pathway to make a determination that the red wolf is a listable entity. Under the three hypotheses that have scientific evidence (2 species, 3 species, or 4 species) there was unanimous support by the participants for the red wolf to be a listable entity. This of course does depend on the interpretation of a DPS, but all participants recognized the logical and credible path that would lead to a listable entity.

The participants were not comfortable discussing the degree of support for each of these different hypotheses and suggested that an independent team would be better suited to handle that task as many of the participants had played critical roles in putting forth and supporting either of the 2 species or 3 species hypotheses. Ideally, an unbiased and qualified group could determine this, but that was not the case for this workshop.

The last morning of the workshop was spent drafting a summary of the workshop and discussing publications and next steps. The agreed upon summary is below:

- A majority of the group concluded that the red wolf was listable and that it continues to be listable under all plausible evolutionary hypotheses.
- There was strong agreement that a number of factors including hybridization with coyotes, high human-caused mortality particularly gun shots, low public support, small population size lead to poor prospects for success of the reintroduction project in northeastern NC. The group discussed how to phase out the reintroduction project in northeastern NC.
- Many emphasized the importance of continuing the recovery program and of finding alternative reintroduction locations.
- There are many important scientific understandings derived from the northeastern NC reintroduction project that will assist red wolf and other species reintroductions,

and the group discussed the importance of continued monitoring as the project changes.

Future Directions

The workshop participants agreed to produce at least one publishable product that summarizes the evaluation of the different evolutionary hypotheses and the determination of a listable entity. This is to be led by Robin Waples as he was the driving force behind the framework for evaluation and the most experienced participant with the implementation of the DPS policy.

Ideally, we could have elicited relative support for the different hypotheses to help provide information to USFWS, but this was not an appropriate task given the conflict of interest for many of the participants. This could be something that is pursued in the future if warranted.

Finally, we discussed the participation in The Wildlife Society Panel to be held in October in Raleigh, NC. Several of the participants expressed their willingness to attend and be a part of the panel.

Workshop Notes

Red wolf workshop 24 – 26 May, Atlanta, GA

24 May 2016

- Intros (name and affiliation), ground rules, publication(s) wrkshp product
- General template ➔ RW case study
- Products
    - Report to FWS
    - Publications
    - Panel at TWS in Raleigh in Oct
- Trigger
    - Sue asked about trigger for the workshop.
    - Pete future directions for RW conservation under aggressive timeline.
    - Mike pointed out that conservation projects can be separate from recovery program, i.e., FWS could decide to discontinue the recovery program, but conservation projects could continue.
- Agenda
- (respect and ground rules regarding sensitive information that will be presented during the workshop…)
- Pete:
    - Controversial conservation. Concerns around reintroduction and concerns by private landowners. Reintroduced popn is struggling; peaked and since declined. FWS HQ initiated review of recovery effort, management plan, and human dimension; conducted by WRI. FWS HQ wants to decide on RW direction by end of summer. Recovery team meeting to formulate recommendations to feed into FWS decision making.
    - Looking through ESA. Is RW a listable entity? (species, subspecies, or DPS)

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        - If no, delist.
        - If yes, recover.
        - If maybe, "sustainment focus". Manage to reduce uncertainty.
    - Recovery program: species survival program (SSP) cooperative program/started with 14 founders. Wild populations in eastern NC (popn in Smokeys was terminated)
    - Is wild popn conservation-reliant to be self-sustaining?
        - If no, then move to full recovery. Requires private lands. Human caused mortality increases the chance of hybridization with coyote.
        - If yes, perpetual commitment to maintain populations in the wild and consider recovery differently
            - SSP plus small manageable popns with research focus or
        - If maybe, SSP plus on population managed to test the reliance hypothesis. Manage to reduce uncertainty.
    - What's needed to get support from private landowners for recovery efforts.
    - Questions
        - Mike P: RW project was not always controversial. Simple NEPA process started without an EIS. Had a good relationship with trappers. Didn't become controversial until coyotes showed up. Current recovery plan does not include downlisting and delisting criteria.
        - Fred: emphasize that the questions about listing is separate from conservation reliance. Proposes 2000 as a recovery goal using Ne criteria; if unattainable, always conservation reliant.
        - Mike S: is conservation-reliance part of the ESA framework?
            - Pete: the Act talks about recovery and non-conservation-reliance is consistent with full recovery in the traditional sense.
        - Robin: important to be clear about the language from the ESA vs not in the ESA. Do not know of anything from ESA that need to recover to functioning ecosystems – maybe in FWS policy but not in the Act.
            - Pete: section 2 – purpose of ESA is conserving species and ecosystems
            - Robin: restoring species to functioning ecosystems. Bringing species to the point where no longer needs protection of the act = recovery
- Rich (see briefing paper)
    - Current status of captive population
    - Current status of wild population
        - Criteria for level of admixture consistent with RW (<12.5% coyote) based on considerations of policy and detection limits
        - Whether RW popns can sustain themselves in the presence of coyotes. How many displacements per year are needed for a population to be self-sustaining.
        - Gunshot mortality contributes to hybridization by loss of a breeder. Fall breeding season coincides with loss of cover (ag harvest) and deer hunting. Surviving breeder looks for options increasing chance for hybridization
    - evolutionary hypothesis
        - RW arose from hybrid of GW and coyotes
        - Or RW and EW share common ancestor with coyotes

- Holly (see presentation)
    - Long but inconclusive history re hybridization and ESA. What should be saved, at what cost?
    - Listing
        - Is there a listable entity
        - Which individuals count as a listed entity
    - Consultation
        - Do actions cause or contribute to hybridization
    - Recovery
        - How does hybridization affect recovery potential
    - Distinguish between "must" and "should"
        - Services must comply with statutory and regulatory requirements, but substantial discretion
            - Things that must be done are subject to judicial reversal
        - ESA does not define what is a species
        - Best science and commercially available information required, but that standard does not mean an objective answer exists
        - What should the Services do? Conserve species and prioritize species (allocation of funding)
        - Decisions can be overturned if they are arbitrary capricious or otherwise inconsistent with the law. Start with assumption the action is valid.
        - Courts are especially deferential to decision that are especially scientific or a the frontier of science
        - Statute does not directly address hybrids. Except 'similarity of appearance' clause to a listed species (ESA 4(3))
        - Not a formal hybrid policy, proposed but not adopted – never finalized and not withdrawn. Can use the reasoning behind the policy but because it's not formalized, the policy cannot be used to justify action.
            - Recognized both conservation value and conservation threat
            - Avoid need to protect taxonomic "purity"
            - 'intercross' policy, thus could apply to DPS
        - FWS tends to defer to established taxonomic consensus, if there is one and the consensus remains current
        - Review of listing, consultation and recovery case law and policy
- 3 minute round (notes on slides)
    - Bob Wayne: reviewed recent work on mtDNA D-Loop haplotypes; identified ancestral RW haplotype
    - Rich: referred to a 'in review' paper that applied RSF to identify potential areas where RW could exist
    - Mike P: present for many of the foundational wolf conservation efforts
    - Bridgett: presented recent work (in revision) on canid evolution. RW have a high ancestral proportion derived from coyote (>80%). Suggests RW lineage appeared 55 to 117 kya.
    - Lunch
    - Mike S: broad experience, some re hybridization including wolf, lynx, marten, grouse, WCT

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- Lisette: recent work – bone samples and extracted DNA from RW founders looked at genetic groups and ancestry. RW founders lumped with Algonquin wolf for K=3 and 4, and splits off for K=5. Hybrid zone questions: frequency of hybridization, spatial structure of RW and coyote,… Scat sampling to survey density of coyote, RW and hybrid. Hybridization infrequent and lower than predicted by simulations (Fredrickson and Hedrick 2006). Thus, some evidence of isolating mechanism and management effectiveness. But why no RW outside of recovery area?
    - Mike S hypothesized whether reduced fitness plays a role in absence of backcrosses. (All detected introgression in RW populations traces to 1993 and 2 F1 hybrid males.)
- Luigi: European perspective. Hope focus is global scope. Hybridization is very important in Eurasia. Dog intercross with wolf first noticed in 70's. Some 30 to 40% of canids in Apennines are hybrids (hybrid swarm). National protocol for how and when to remove hybrids based on genetic analysis. If hybrid, must be kept in captivity for life. Italian wolf popn 1500-2000; free ranging dogs up to 1 million. Balkan wolf from Slovenia was tracked to mating with an wolf in Italian Alps; 3 successful litters since – example of natural hybridization, viewed to be beneficial (positive) in contrast to intercross with domestic dogs. Golden jackal (Asian species) moving in Latvia, Estonia, Switzerland. Natural spread although human altered landscape has influenced spread. Distinguish between natural and anthropogenic hybridization. Accept that some subspecies will go extinct. Mismatch between science and policy. Need a science that can be interpreted including rule to navigate uncertainty.
- Fred: proposed guidelines in Allendorf et al. (2001). Natural vs Anthropogenic is initial consideration results in 6 different hybrid types. Reviewed the literature on hybrids (Allendorf et al. 2004). Evaluated optional policies and made recommendation based on reduced fitness in intercrosses with RT.
- Robin: worked to provide scientific products for ESA determinations, including DPS/ESU identification, role of artificial propagation, and SPR. Scientific basis for listing determination and recovery planning for salmon and other marine spp. Reviewed hybrid policy.
    - Chambers et al study (published in FWS journal) concluded that RW was a valid taxon.
- Dale: worked on problem of conservation reliant species.
    - Scott: can conservation reliant species be delisted. Dale: if separate party/agency can step in and ensure conservation and other conservation criteria are met, then there are some that can be delisted.
- Linda: some lessons learned working on conservation of eastern wolves in Algonquin Provincial Park are relevant to RW. 2 vs 3 species models may not be resolvable but does that matter? What else can be considered beside genomic data? What determines conservation status? Stresses ecological role and evolutionary potential.
    - Mike S: has it been considered to transplant Algonquin wolves to RW to increase popn size.
    - David C: there are other considerations besides genetics.
    - Luigi: asked about different ecological roles between RW and coyote. (Lisette and Mike P: diets similar but social structure are different)

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        - Pete: Ongoing PVA modeling is projecting SSP and wild populations including inbreeding effects of which will eventually be apparent.

25 May 2016

- Plan for the day
    - What are the dominant hypotheses on the origin of RW?
    - Given hypotheses, what do hypotheses mean for eligibility for listable entity under the ESA
- Roland: presented on hypotheses on the origin of RW (see presentation slides)
    - 2 species hypothesis RW is subspecies of C. lupus and C. latrans is separate species
    - 3 species hypothesis, RW groups with eastern wolf in C. lycaon, separate from C. lupus, and separate from C. latrans
    - 4 species hypothesis, similar to 3 species hyp but C. rufus splits from C. lycaon
    - Mike P: in 2 species hypothesis, why is RW with C. lupus and not C. latrans given all the similarity with coyote
    - Linda: RW functions like a wolf more so than a wolf
- Robin: evaluated eligibility as a listable entity (see presentation slides)
    - For 3 or 4 species hypotheses, eligible
    - For 2 species hypothesis, eligible as at least a DPS
    - Question remains whether hybridization is still consistent with eligible status. Given hybridization over the past hundreds of years, is the modern hybrid version of RW eligible as a listable entity.
    - Reviewed 1996 DPS policy criteria
        - Discreteness and significance
        - Discreteness met under any hypothesis
        - Significance mets unusual ecological setting, only survival natural occurrence, differs markedly from other populations
    - 4 species: RW is a species
    - 3 species: RW is not a species, may be a subspecies of eastern wolf (C. lycaon), else RW must be a DPS of C. lycaon
    - 2 species: not a species, may be a subspecies of grey wolf (C. lupus), else RW is likely to be a DPS of C. lupus
        - If 2 species and RW a subspecies of C. latrans, then eligible as a subspecies
- Mike P: points out that under intensive conservation, RW can be kept separate from coyote but that falls short of recovery
- Holly: important to separate “does RW qualify for listing” from “what do we do about it, if yes”. Would like to hear more about ‘modern hybridization’ – what does ‘modern’ mean? Do not know of case law, but if spread of coyote cannot be the basis for losing qualification for listing, esp for anthropogenic caused hybridization.
- Rich: modern hybridization occurred at time when RW were removed from the wild to create captive breeding program

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- Lisette: no evidence that any of the founders were F1 hybrids
- Bob: Founders may not have been F1 but may have been drawn from a hybrid swarm. There was somewhat of an admixed history.
- Robin: knows of no example of a listed species be removed due to genetic pollution
- Pete: brings up the question "at what point of introgression would trigger would lose eligibility as a listable entity"
    - General discussion regarding this question
    - Fred: asked what is the proportion of admixture in the RW population
    - Robin: can estimate proportion but at what point the unit no longer is eligible is not wholly a scientific question
- Robin: Continued evaluation of the scientific evaluation of eligibility for listable entity
    - Amount of admixture contingent on time period (Mike S)
        - Pre-columbian: some natural introgression; admixture depends on the assumed model
        - 1970's (ESA; captive rearing started): high introgression; 14 founders (30-50% wolf haplotype (SNPs)) 75% admixture, other canids >85%
        - Current wild: persistent high pressure for introgression due to coyote spread; slightly higher than 75% admixture – similar to founders due to intensive management
    - 2 species hypothesis II (RW is a large coyote), less likely hypothesis than other hypotheses
        - Historic
            - RW is not a species, may be a subspecies of C. latrans, is likely to be a DPS
        - Current
            - RW is not a species, may be a subspecies of C. latrans, is likely to be a DPS (discreteness could be simply due to founder effect; not distinctive habitat and no gap in distribution of C. latrans, but shows marked genetic difference (criteria #4))
- Scott: is there a consensus recommendation for RW as eligible for a listable entity and could the group write a paper on that topic
    - Mike P: expressed concern about consensus
    - Scott: proposed "evaluation of whether RW is a listable entity", in that paper the answer would be yes for pre-columbian and today but concern for recent and increasing admixture
    - Mike P: agrees under lupus but not lycaon
    - Fred: says agree RW is listable for pre-columbian but because of high admixture in 1970 whether RW would be eligible for listing is debatable. However useful to document that evaluation

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    - Holly: would like to know if pre-columbian is different from the 1970s. Categorical mistake to apply the DPS policy to determine how much admixture is too much because DPS policy and intercross policy arise differently.
    - Robin: that makes it important to consider a different question about recent and ongoing introgression with a nonlisted entity
    - Roland: suggests paper on the value of listing hybrids
    - Lisette: plenty of examples of hybrids being listed
    - Robin: returned to framing to answer the following series of questions "Is RW eligible under 1) pre-columbian, 2) current, 3) at what point does introgression cause extinction by hybridization?"
- Discussed "Is red wolf eligible as a listable entity at least as a DPS under the ESA conditioned on species hypotheses? Assume current level of knowledge and policies as they exist today."
- Discussed conservation actions
    - Adaptive management program:
        - Augmentation, placeholders, removal of hybrids
        - phasing in and out of actions
        - shifts in policies re control of RW emigrants and change in coyote hunting increased public opposition
            - shift from will retrieve emigrants from private land to landowners must request retrieval
            - night time hunting for coyote prohibited
    - Future actions
        - Build fences
        - "wipe slate clean"
            - At what point would introgression and other factors trigger the termination of the reintroduction project?
        - Recovery team has developed options
        - Genetic management
            - Sperm and egg banking (ongoing)
            - Selection for large individuals "push in the direction of size" (wolf genetic markers) to reduce introgression
- At what point would introgression trigger the termination of the reintroduction project?
    - Strawdog offered to start discussion: "Based on genetic monitoring, terminate the project when more than half of the litters are coyote."
        - Replace litters with individuals in the population
        - Based on scats
        - Over some time period – needs to be defined
        - Based on rate of introgression rather than threshold, e.g., when the rate is more than 1% per year, and
            - Rate is the change in RW genes in the population

            - Can that rate be mitigated?
            - If not, terminate reintroduction project
            - Influenced by RW population size and coyote population size
        - Applicable for intensive or minimal level of management
        - No scientific answer, value based decision
        - Only genetics, phenotype, or combination
- Discussed option to terminate the reintroduction project in northeastern NC. Strong agreement that a number of factors including introgression, high mortality, small population size, low population growth – overall poor prospects for success of the reintroduction project – lead to a conclusion that the prospects for success of the reintroduction project are poor. Discussed how the project could be terminated, and there was variation in opinion regarding how best to terminate the project.
- Reviewed agenda for Thursday AM

26 May 2016

- Review agenda
- Open for discussion on other issues/questions
    - Pete: asked what would be expect about characteristics of a red wolf population that can be sustained in the wild and could those characteristics be observed on a scale smaller than a full blown reintroduction?
        - Discussed substantial effort needed for a rigorous study even if small scale and confounding due to Allee effect. Considered value of a small scale effort given concerns related to removing animals if reintroduction project is terminated. Could animals be left in northeastern NC to study if some could persist (not get shot or introgressed). Discussed how the public would perceive how the project is terminated especially how that perception might impact public acceptance of future reintroduction. Concern that expectations are clearly communicated and actions meet those expectations.
        - Discussed option of use of Sandy Ridge (island on Alligator River) for holding some of the animals removed from northeastern NC project. Funds would be needed to rehabilitate existing pens.
    - Discussed how to report out
        - Draft summary
            - A majority of the group concluded that the red wolf was listable and that it continues to be listable, under all plausible evolutionary hypotheses.
            - There was strong agreement that a number of factors including hybridization with coyotes, high human-caused mortality particularly gun shots, low public support, small population size lead to poor

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prospects for success of the reintroduction project in northeastern NC. The group discussed how to phase out the reintroduction project in northeastern NC.

- Many emphasized the importance of continuing the recovery program and finding alternative reintroduction locations.
- There are many important scientific understandings derived from the northeastern NC reintroduction project that will assist red wolf and other species reintroductions, and the group discussed the importance of continued monitoring as the project changes.

- Workshop products
  - Report, publications, TWS panel
  - Report due end of June
    - Google doc for review and editing
  - Publications
    - Topic on listable entity
      - Robin as lead author
      - Journal: Bioscience
      - Final draft by summertime
    - Topic on 'what next' for RW in the context of continued pressure for hybridization
      - Implications of hybridization for recovery
      - How does ongoing hybridization effect prospects for recovery
      - RW and WCT as case studies, bring in international case studies
    - Topic: At what point should hybridization trigger reintroduction projects
    - Topic: Hybrid policy
      - What sort of entity should the FWS try to recovery, e.g., a RW that is pushed toward larger size? What principles should be considered to answer this question?
        - Holly will outline the aspects of that question and circulate to the group and invite individuals to express interest or not
      - Need for an international policy guidance on deciding what a hybrid is, how to detect it and what to do
        - Two components
          - Practical question of which individuals get included as a protected entity
          - How to consider the role of hybridization in recovery of a species

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- How can selection and introduction of new genetic material be used and how does it interface with the law
    - Case studies include RW selected for large size, Peregrine falcon
    - Ref evolutionary rescue and climate change
    - Re legal implications when a DPS is diluted

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Table 1: List of participants

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Dr. Luigi Boitani	University of Rome, Rome, Italy
Dr. David Cobb	North Carolina Wildlife Resource Commission
Dr. Jaime Collazo	NC Cooperative Fish and Wildlife Research Unit, USGS, Raleigh, NC
Dr. Holly Doremus	University of California, Berkeley, CA
Dr. Richard Fredrickson	Unaffiliated, Missoula, MT
Mr. Dale Goble	University of Idaho, Moscow, ID
Dr. Sue Haig	USGS Forest and Rangeland Ecosystem Science Center, Corvalis, OR
Dr. Roland Kays	North Carolina Museum of Natural Sciences, Raleigh, NC
Dr. L. Scott Mills	North Carolina State University, Raleigh, NC
Dr. Krishna Pacifici	North Carolina State University, Raleigh, NC
Mr. Mike Phillips	Turner Endangered Species Fund, Bozeman, MT
Dr. Linda Rutledge	Princeton University, Princeton, NJ
Dr. Mike Schwartz	USFS Rocky Mountain Research Station
Dr. David Smith	Leetown Science Center, USGS, Kearneysville, WV
Dr. Lisette Waits	University of Idaho, Moscow, ID
Dr. Robin Waples	National Oceanic and Atmospheric Administration, Seattle, WA
Dr. Robert Wayne	University of California, Los Angeles, CA
Mr. Michael Morse	Senior Biologist, U.S. Fish and Wildlife Service
Mr. Pete Benjamin	U.S. Fish and Wildlife Service, Raleigh, NC
Dr. Bridgett vonHoldt	Princeton University, Princeton, NJ
Ms. Kairsten Fay	North Carolina State University, Raleigh, NC

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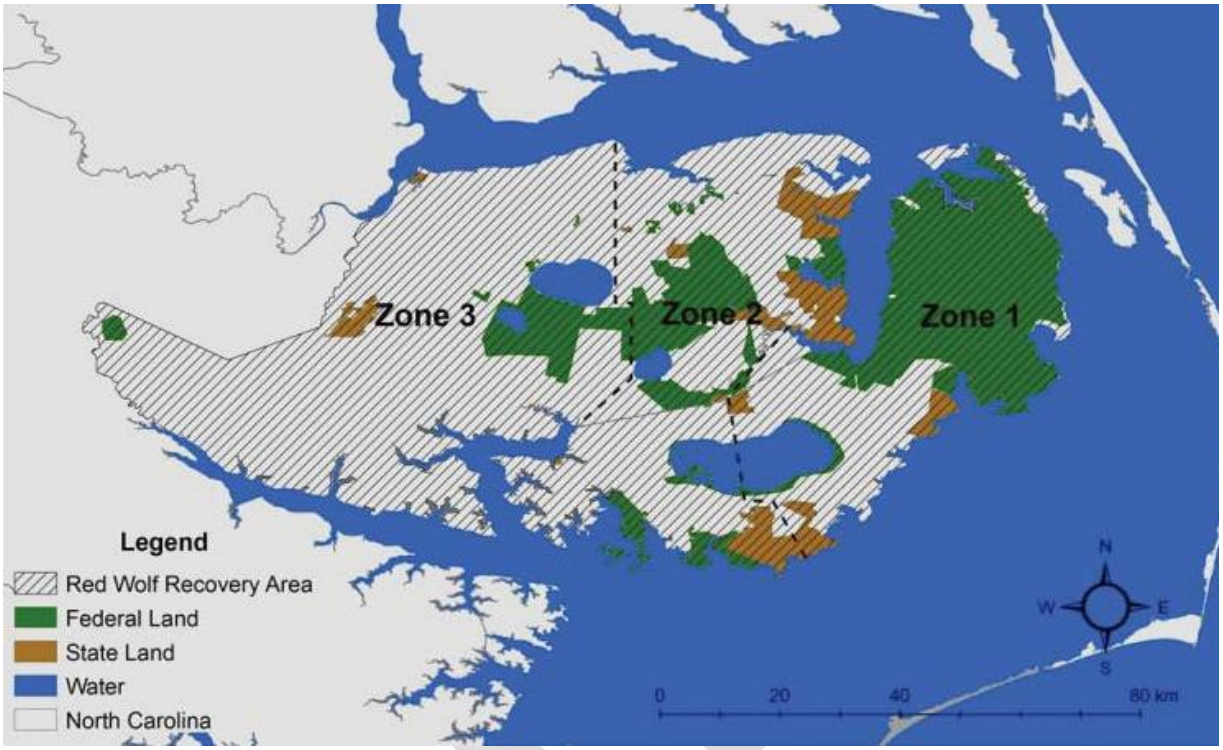


Figure 1. Red wolf experimental population area with the three management zones (From Hinton et al. 2013).

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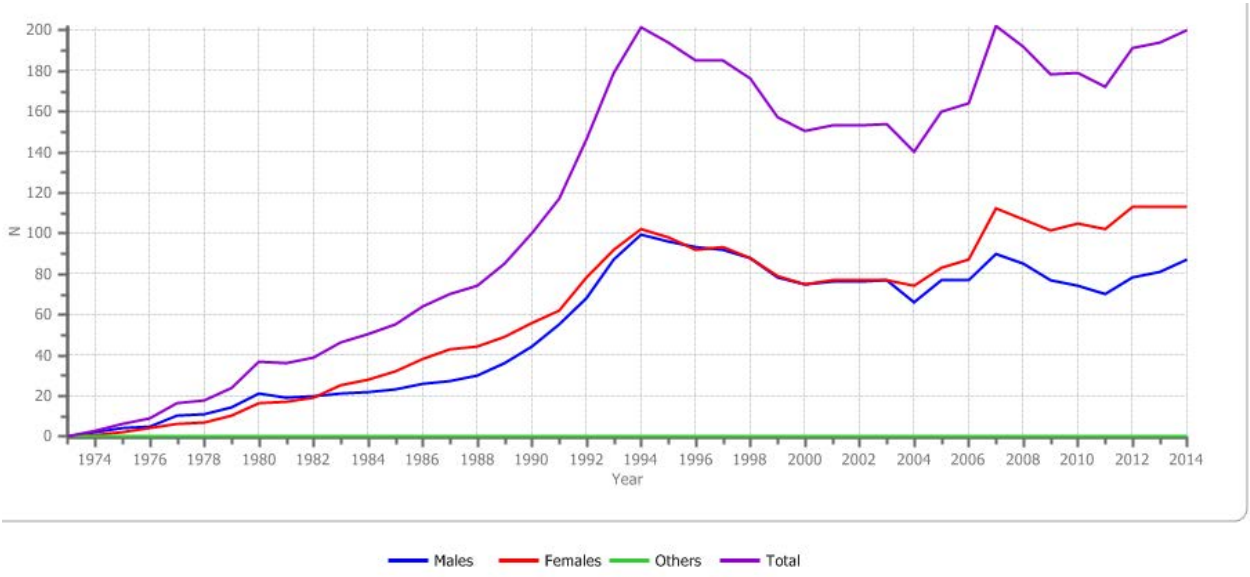


Figure 2. Red Wolf SSP population size based on data through 31 December 2014 (Waddell & Long 2015).

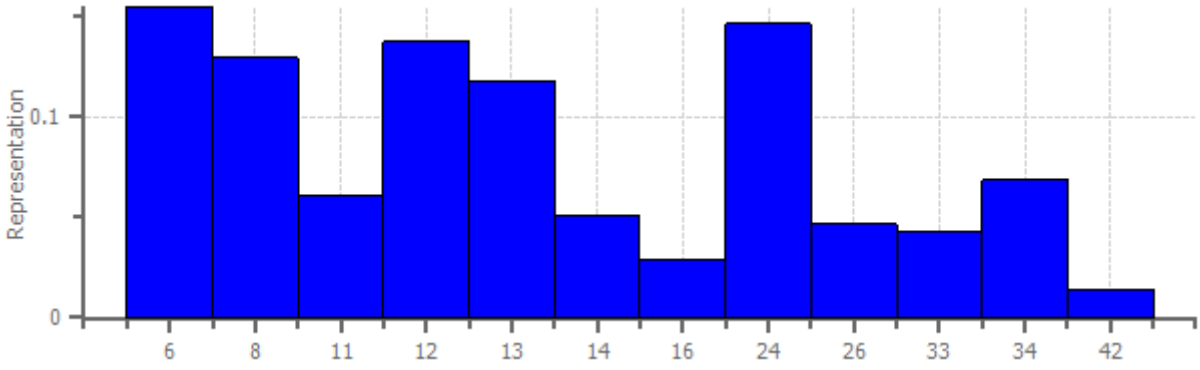


Figure 3. Founder representation illustrating the inequality of the 12 founder lineages that have descendants in the living Red Wolf SSP population as of September 2015 (Waddell & Long 2015).

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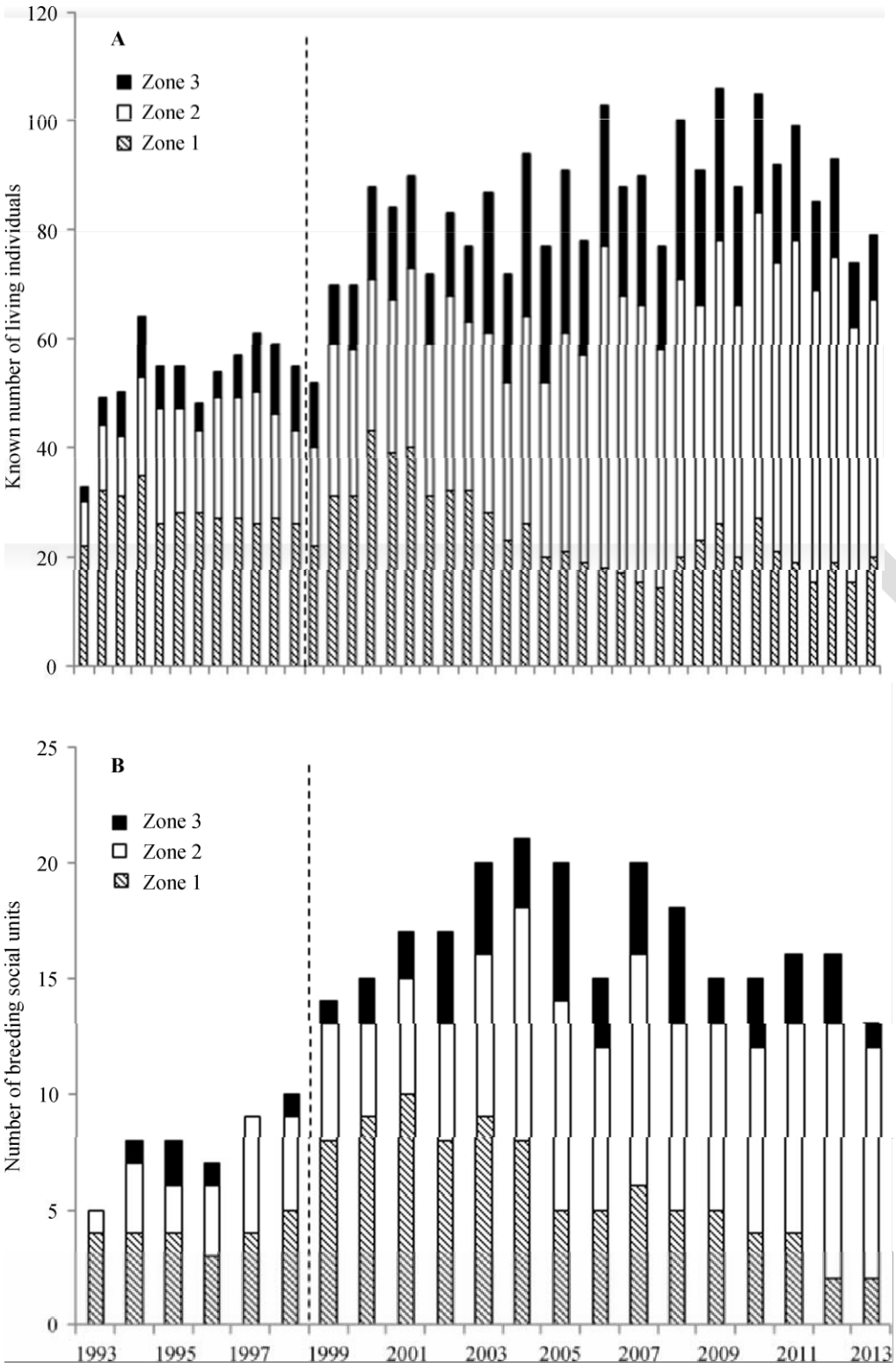


Figure 4. Known numbers and distribution of A) red wolves during spring (March 1st) and Fall (September 1st) inventories, and B) known red wolf social units in spring, among management zones within the red wolf experimental area on the Albemarle Peninsula, North Carolina, 1993-

2013. Vertical lines represent initiation of adaptive management plan (From Gese et al. 2015).

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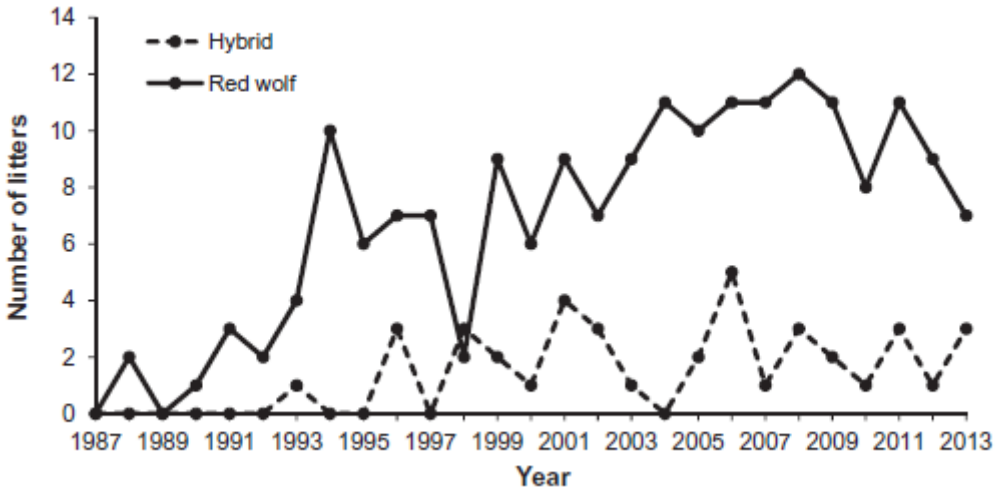


Figure 5. Number of red wolf and hybrid litters since the reintroduction of red wolves in North Carolina. Beginning in 2000 the FWS implemented an adaptive management program to genetically monitor and reduce hybridization (from Bohling and Waits 2015).

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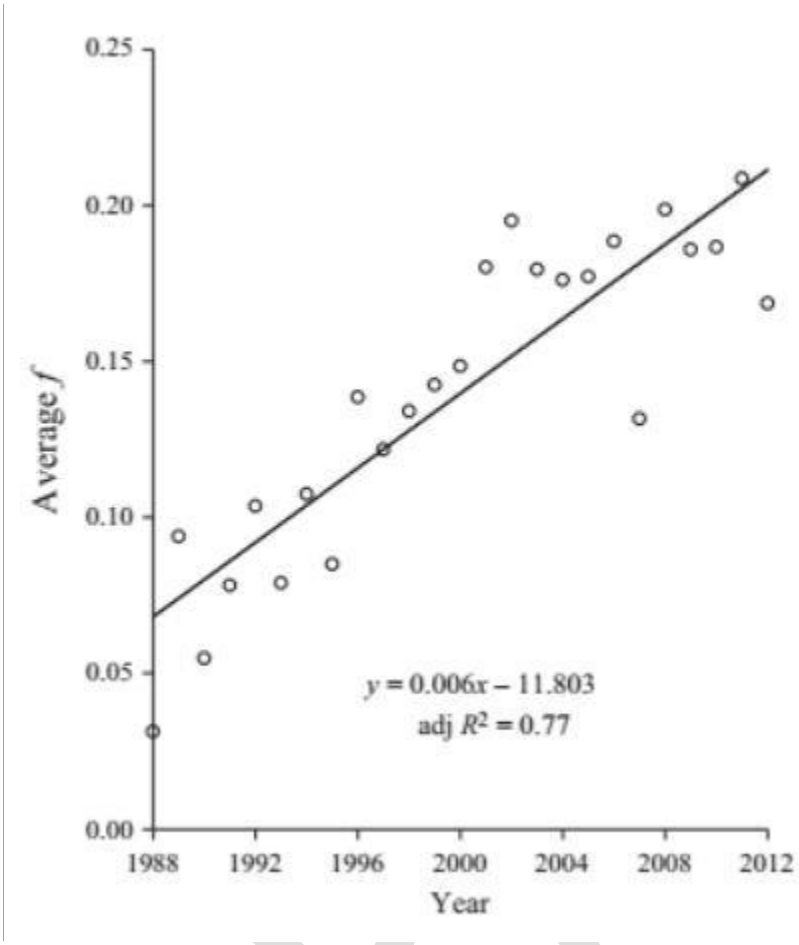


Figure 6. Average yearly inbreeding coefficients (*f*) for wild born red wolf litters (*n* = 182) since 1988 (from Brzeski et al. 2014).

Appendix 1. Annotated Bibliography.

Red Wolf Hybridization

Bohling, J.H. and L.P. Waits. 2015. Factors influencing red wolf–coyote hybridization in eastern North Carolina, USA. Biological Conservation 184:108-116.

Evaluated factors that may promote hybridization between red wolves and coyotes by examining the circumstances under which hybrid litters were produced from 2001 to 2013. Most hybridization events (18 of 23 litters for which both parental histories were known) resulted from the disruption of social groups. And most disruptions (11 of 18) resulted from human-caused mortality, primarily gunshot shortly before or during the breeding season. Two disruptions followed the disappearance of radio- collared wolves, and five of the disruptions were due to natural causes. Both male and female red wolves interbred with coyotes, although a majority (90%) of the observed events involved females.
Wolves that produced hybrid litters tended to be young, first-time breeders with slightly higher levels of coyote ancestry. The available data suggested there was positive assortative mating among red wolves. Although coyotes vastly outnumbered hybrids, red wolves that did not pair with other red wolves appeared to preferentially pair with admixed individuals rather than coyotes. This is an important observation because Fredrickson et al. (2006) concluded that under some circumstances the combination of positive assortative mating and observed aggressive displacements of coyotes and hybrids by red wolves may allow a small population of red wolves to grow and persist with minimal management of hybridization.

Bohling, J.H., Waits, L.P., 2011a. Assessing the prevalence of hybridization between sympatric Canis species surrounding the red wolf (Canis rufus) recovery area in North Carolina. Mol. Ecol. 20, 2142–2156.

Sampled a 22,000 km^2 area north, south, and west of the Red Wolf Experimental Population Area for canids in 2008 using fecal DNA. They genotyped 82 individuals, but none were classified as red wolves. Two individuals had red wolf mtDNA but no significant red wolf nDNA ancestry. One individual possessed significant red wolf nDNA ancestry (approximately 30%) using all criteria, although seven other individuals showed evidence of red wolf ancestry (11–21%) using the relaxed criterion. Overall, seven individuals were classified as hybrids using the conservative criteria and 37 using the relaxed criteria. They found evidence of dog (*C. familiaris*) and gray wolf (*C. lupus*) introgression into the coyote population. These results suggest red wolf colonization and introgression in North Carolina is minimal.

Bohling, J.H., 2011b. Exploring Patterns and Mechanisms of Red Wolf (Canis rufus) Hybridization in North Carolina. Ph.D. Dissertation. University of Idaho, Moscow, ID. CHAPTER 2.

In this chapter, Bohling examines the nature of the hybrid zone between red wolves and coyotes. Scat sampling within the Red Wolf Experimental Population Area (RWEPA) in 2010 combined with samples from 2008 outside the RWEPA (Bohling et al. 2011) resulted in 392 genotyped individual canids. Red wolves comprised more than half of sampled canids in the two eastern-most zones of the RWEPA, but in the western-most zone of the RWEPA red wolves comprised only about 30% of sampled canids. No red wolves were found west of the RWEPA. Coyotes were found throughout the RWEPA and comprised 50% of canids within the area. Hybrids, however, comprised only 4% of canids within the RWEPA. The low frequency of hybrids is probably in large part a result of the aggressive removal and sterilization of coyotes and hybrids by the USFWS. Some information suggests, however that mate choice by red wolves may also have played a role.

Fredrickson RJ, Hedrick PW. 2006. Dynamics of hybridization and introgression in red wolves and coyotes. Conservation Biology, 20, 1272-1283.

Used individual-based simulations to examine the process of hybridization and introgression between red wolves and coyotes in colonizing and established populations. Under the range of circumstances we considered, red wolves in colonizing and established populations were quickly extirpated, persisted near the carrying capacity, or had intermediate outcomes. Sensitivity analyses suggested that the probabilities of quasi extinction and persistence of red wolves near the carrying capacity were most affected by the strength of two reproductive barriers: red wolf challenges and assortative mating between red wolves and coyotes. In addition, the analyses suggested the survival rate of adult red wolves also had a strong effect on population outcomes. Sterilization of coyotes and hybrids could substantially increase red wolf numbers and reduce introgression if there was substantial effort was devoted to this management. In hindsight these simulations have two limitations. First, we did not consider the effects of red wolves displacing other red wolves, which Bohling et al. (2011b) suggests may increase hybridization in the presence of coyotes. Second, we assumed that red wolves could largely exclude coyotes by occupying all available habitat. In some landscapes, however, coyotes may occupy areas that red wolves will not.

Red Wolf Ecology

Dellinger, J. A., Ortman, B. L., Steury, T. D., Bohling, J., Waits, L. P., 2011. Food habits of red wolves during pup-rearing season. Southeastern Naturalist 10, 731-740.

Investigated food habits of six red wolf packs over two years during the pup-rearing season (May – July) in 2009 and 2010. A total of 455 scats were used in the study. The minimum

number of scats per pack per year was 26. Adult and fawn white-tailed deer accounted for 66% of prey biomass consumed during the two seasons. Adult and fawn deer accounted for 37% of prey items based on frequency of occurrence. Diets varied between pack, with one pack relying substantially on wild boar, and another relying heavily on anthropogenic material from garbage and carcass pits.

Dellinger, J.A., Proctor, C., Steury, T.D., Kelly, M.J., Vaughan, M.R., 2013. Habitat selection of a large carnivore, the red wolf, in a human-altered landscape. Biol. Conserv. 157, 324–330.

The authors examined habitat selection of red wolves in the wild population in northeastern North Carolina. They used data from 20 GPS collared wolves over three years to construct resource selection functions (RSF) at the landscape level. They found that wolves selected human-associated land-cover types (agricultural fields, pine plantations, and early successional fields) and areas near secondary roads. Roads were thought to provide easier travel and greater visibility for hunting. Wolves, however, avoided areas with high human density such that avoidance of natural cover types (lowland forests, wetlands, and pocosin – a type of forested wetland) decreased as human density increased. This interaction was strong enough that wolves selected for natural land-cover types over human-associated land-cover types at relatively high human density. The top four models were similar, and all had AICc values <2.
The combined weight (*w*) of these four models was 0.88 "demonstrating a strong ability to predict habitat use in the RWEPA." The best RSF predicted a patchy distribution of red wolves across the RWEPA. The averaged RSF based on the four top models was cross-validated with locations not used in model construction. This RSF was able to predict habitat selection by wolves other than those used to build RSFs (see figure 2).

Hinton, J.H., M. J. Chamberlain, and D. R. Rabon Jr. 2013. Red Wolf (Canis rufus) Recovery: A Review with Suggestions for Future Research. Animals, 3:722-744.

Hinton, J.H., K.E. Brzeski, D.R. Rabon, and M.J. Chamberlain. 2015 Effects of anthropogenic mortality on critically endangered red wolf *Canis rufus* breeding pairs: implications for red wolf recovery.
Oryx doi:10.1017/S0030605315000770

The primary objective of this paper was to identify the causes of disbandment of red wolf breeding pairs and sterile placeholder pairs. The authors also examined whether red wolves were replacing lost breeders. They used information from radio-collared animals and trapping efforts to determine when breeding pairs formed and disbanded. Red wolf and "congeneric" pairs (red wolf with a coyote or hybrid) were considered. Pair breakups were categorized as due to natural, management,
anthropogenic (poison, trapping, suspected or confirmed gunshot, vehicle collision), or unknown

causes. Trapping data was used to estimate relative abundances of red wolves, coyotes and hybrids during three phases (1991-1998, 1999-2005, 2006-2013). Over the twenty two year period, 510 red wolves, 416 coyotes, and 218 hybrids were captured. The ratios of red wolves to coyotes and hybrids declined from phase 1 to phase 3 (7.1 to 0.71 and 11.7 to 2.1, respectively). During the 22 year period 174 *Canis* breeding pairs were identified (109 red wolf and 65 congeneric pairs). The percentage of *Canis* breeding pairs disbanded by anthropogenic mortality increased and the annual preservation rates of pairs declined steadily during this period. During phase 3, replacement rates by red wolves were lowest, and annual rates of disbandment were highest. Ratios of red wolves to coyotes were negatively correlated with anthropogenic disbandment and were lowest during Phase 3, when breeder loss due to anthropogenic mortality was highest.

Mortality, pooled across all causes, was responsible for most disbandment in *Canis* breeding pairs (73.6%). Anthropogenic causes accounted for 40.6% of deaths. Mortalities caused by gunshot caused 71.2% of disbandment due to anthropogenic causes and 21.3% of all disbandment. Relative to red wolf pairs, congeneric pairs were disrupted more often by management actions (40.0 vs 6.4%) and less by natural (27.7 vs 51.4%) and anthropogenic causes (21.5 vs 34.9%). Anthropogenic and unknown causes of *Canis* pair break-ups were highest in Phase 3. Among red wolf pairs, anthropogenic break-ups increased from 15% to 48.2% from phase 1 to 3. Red wolves were more likely to replace *Canis* breeding pairs following disbandment from natural causes and management actions than after disbandment due to anthropogenic mortality. Pairs with sterile placeholders were also disbanded at a high rate due to anthropogenic mortality.
Congeneric pairs contained more female than male red wolves (69.2 vs 30.8%). A more extreme skew (90% of red wolves that paired with coyotes were females) was observed by Bohling and Waits (2015). Bohling and Waits (2015) suggested their results may have been due to their relatively small sample size (23 red wolf pairs for which both individuals were known) and ascertainment bias. Hinton et al., however, believe female red wolves are more likely to pair with coyotes following pair disruption than male red wolves. In this context, Hinton et al. noted that most gunshot mortalities occurred during the fall and winter deer hunting season (October 15 – December 31) which also coincided with the onset of the breeding season. Mean observed duration of red wolf pairs was short in all phases (1.7, 1.8, and 2.0 years for phases 1, 2, and 3, respectively), but it was longer than that among congeneric pairs.

McVey, J.M., D.T. Cobb, R.A. Powell, M.K. Stoskof, J.H. Bohling, L.P. Waits, and C.E. Moorman. 2013.

Diets of sympatric red wolves and coyotes in northeastern North Carolina. Journal of Mammalogy 94:1141-1148.

Investigated food habits of red wolves and coyotes in the RWEPA based on 228 scats collected from January 2009 to February 2010. Fecal DNA was used to determine species and individuals that deposited scats. The scats represented 49 red wolves and 34 coyotes. Overall, the frequency of occurrence of food items were similar between red wolves and coyotes. White-tailed deer and rabbits were the most frequent items for both canids. Small rodents were more often found in scats from coyotes than red wolves.

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Sparkman, A.M., Waits, L.P., Murray, D.L., 2011. Social and demographic effects of anthropogenic mortality: a test of the compensatory mortality hypothesis in the red wolf. PLoS ONE 6, e20868.

Recent studies of large carnivores suggest that anthropogenic mortality can be fully additive to natural mortality thereby constraining annual survival and population growth rate. The authors tested for evidence of additive versus compensatory effects of anthropogenic mortality on annual survival, population growth rate, preservation and reproductive success of red wolf breeding pairs. They found evidence of strong additive effects on annual survival and population growth rate at low and high densities. But they argue the nature of the additive effects at high density may lead to compensatory mortality. When involving death of a breeder, anthropogenic mortality was also additive to natural rates of breeding pair dissolution, and disbanding of a pack following death of a breeder resulted in fewer recruits per litter relative to stable packs. They also found evidence that pup recruitment and the proportion of adults that became reproductive declined steeply with increasing population density.

This study used data from 1988 -2006. Anthropogenic mortality, however, increased after 2006 and has coincided with a substantial reduction in red wolf numbers. Other more recent studies have identified anthropogenic mortality, especially gunshot mortality during the fall hunting season as a driver of red wolf population decline and hybridization. Sparkman et al. used a broader definition of anthropogenic mortality than more recent papers (e.g. including management removals) which may have affected their results. Finally, this paper does not consider hybridization in any context.

Red Wolf Management

Fredrickson, R.J. In press. Focus on Red Wolf Reproductive Barriers, Not Coyote Demography. Conservation Letters.

Comment on Murray et al. 2015.

Gese, E.M., F. Knowlton, J.R. Adams, K.Beck, T.K. Fuller, D.L. Murray, T.D. Steury, M.K. Stoskopf, W.T. Waddell, L.P. Waits. 2015. Managing hybridization of a recovering endangered species: The red wolf Canis rufus as a case study. Current Zoology 61 (1): 191–205.

Reviews the results of the adaptive management efforts for the reintroduced red wolf population from 1993- 2013. Red wolf numbers reached a plateau from 2006-2010 at about 100 wolves, but then declined to about 80 by 2013. The number of social groups increased to about 20 and

was maintained from 2003 – 2008, but then declined with only about 15 maintained 2009-2013. In management zone 1 the number of social groups declined from 10 (all were red wolf pairs) in 2001 to 5 (two were red wolf pairs) in 2013. The numbers of red wolf litters peaked at about 11 per year from 2004 -2011, before declining to 7 in 2013. In contrast there was an average of 2.4 hybrid litters / year from 2004-2013. The authors conclude the success of the red wolf adaptive management program at controlling hybridization and facilitating recovery was mixed. The average red wolf ancestry among reproductively intact wolves and introgressed individuals was 96.5% in 2014. But the numbers of coyotes and hybrids detected over time did not decrease, and the ratio of hybrid to red wolf litters did not decline over time indicating hybridization is an ongoing challenge. Ideally red wolves would fully occupy the area and coyotes entering the area would be excluded by resident red wolves. But the authors believe this is unlikely to occur because wolf habitat is discontinuous and anthropogenic changes in habitats will favor coyotes. Also there is little evidence that red wolves naturally control the coyote population by strife – a core prediction from the competitive exclusion hypothesis. Also at 90 – 95 adult red wolves, the population may have reached carrying capacity. But the high rate human caused mortality leading to hybridization is noted.

Gese, E.M., and P.A. Terletzky. 2015. Using the "placeholder concept to reduce introgression of an endangered carnivore. Biological Conservation 192:11-19.

The authors evaluate the utility of the "placeholder" strategy in limiting hybridization and introgression in the reintroduced population of red wolves in northeastern North Carolina. The placeholder strategy used sterilized coyotes and hybrids to hold territories until they might be displaced by red wolves or removed by managers to allow releases of red wolves. While placeholders were present, they prevented the area from being occupied by reproducing coyotes and hybrids. From 1999 to 2013, useful data was collected on 182 placeholders (125 coyotes and 57 hybrids) along with 410 red wolves. Of the 182 placeholders, 51 were displaced by red wolves (37 spatially displaced and 14 killed by red wolves). In addition, 16 placeholders were removed and a red wolf released into the territory. Thus 37% of placeholders were displaced or removed (67 / 182) leading to occupancy by red wolves. Among the 410 monitored red wolves, there were also 146 displacements of red wolves by other red wolves (35%). All displacements of placeholders were by a red wolf of the same sex, and 98% of red wolf displacements were by a red wolf of the same sex. Figure 3 suggests that hybrids may have experienced a greater rate of displacement than coyotes, although this apparently was not tested statistically. There was some evidence that placeholders with larger home ranges with lower road densities were more likely to be displaced. This and work by Dellinger et al. (2013) appears to be consistent with the suggestion of Murray et al. (2015) that some coyotes on the RWEPA are unlikely to be displaced by red wolves because they occupy small home ranges near human settlements. Adult hybrids had the highest survival rates, and red wolves had the lowest (means: 0.876 hybrids, 0.843 coyotes, and 0.80 red wolves). Cause- specific mortality was largely similar between red wolves, and placeholders, but 19% of the sterile coyote mortalities and 21% of the sterile hybrid mortalities were caused by interspecific aggression from red wolves (red wolves vs. placeholders: $\chi 2 = 50.36$, 1 df, $P = 0.0001$). Red wolves, however, were rarely killed by conspecifics (~6% of mortality) and no placeholders were recorded as killed by conspecifics (red

wolves vs. placeholders: $\chi 2 = 3.95$, 1 df, $P = 0.0469$). And red wolves experienced higher rates of gunshot and health-related mortality. From 2000 – 2013, there was a mean of 2 hybrid litters / year and 9 red wolf litters / year. Although only 37% of placeholders were naturally or artificially displaced, the remaining 63% did protect space in which no hybrid litters could be produced. In 2014, the wild red wolf population was estimated to include <4% red wolf ancestry from recent introgression. But continued intensive management will likely be necessary to limit hybridization and introgression in the future.

The significance of this paper is that it is the first to present data on displacements by red wolves which can act as a reproductive barrier. Over the study period, there were an average of 3.4 displacements of coyotes and hybrids per year. Modeling suggests this will be essential for red wolf populations to persist in the presence of ongoing hybridization with coyotes. Their finding that red wolves may be more likely to displace coyotes and hybrids whose territories are large and / or have low road density suggests that displacement rates for coyotes and hybrids might be landscape-specific.

Murray, DL, G Bastille-Rousseau, JR Adams, LP Waits. 2015. The challenges of red wolf conservation and the fate of an endangered species recovery program. Conservation Letters 8:338-344.

This paper seeks "To help inform the ongoing program review and potential future direction of red wolf recovery" by comparing demography of red wolves, coyotes, and hybrids in the North Carolina recovery area (1999–2007). They posit that red wolves will need higher survival and / or productivity than coyotes and red wolves for the red wolf population to ultimately become viable and self-sustaining. They also compare causes of death between the periods 1999-2007 and 2009-2014 "…to gauge whether gunshot mortality is substantive and increasing, and whether death from natural causes (i.e., strife) is an important mortality factor for coyotes/hybrids, as is predicted by the competitive exclusion hypothesis." They find that all three groups have similar survival and reproductive rates and that death from gunshot has not increased for red wolves or for coyotes/hybrids. They also find that death by natural causes was low for coyotes and hybrids in the early period and dropped to zero in 2007-20014 (but see Gese and Terletsky 2015). They conclude that these results suggest red wolves are unlikely to be successful.

Fredrickson and Hedrick (2006), however, found that red wolf success (or failure) was largely driven by the operation of reproductive barriers. Secondarily, survival of adult red wolves also had a substantial effect on success of red wolf populations. And coyote demography had essentially no effect on outcomes. Thus red wolves do not necessarily need to demographically outperform hybrids and coyotes to succeed. Murray et al. also assumed that "strife" (red wolf aggression towards coyotes and hybrids) must result in the deaths of coyotes and hybrids for it to contribute to the success of the red wolf population by the "competitive exclusion hypothesis." But in the simulations by Fredrickson and Hedrick (2006) "strife" resulted only in displacements of coyotes and hybrids, and not all "challenges" were successful. And red wolf

challenges were the most important of the two reproductive barriers examined in the simulations.

Murray et al. also state that "…the ongoing program review should be considered as an opportunity to chart a new direction in red wolf conservation." Among other things, they note that "…red wolf territories in North Carolina are not contiguous and vacant landscape persists in the interstitial spaces…, speaks to the marginal wolf habitat in the recovery area and the constant opportunity for colonization by coyotes/hybrids" which require less habitat and are more flexible in their needs. They conclude that red wolves may not be able to sufficiently exclude coyotes and hybrids in the current recovery area.
They posit three alternative end points for a re-envisioned red wolf program; one of which is establishment of a new, more suitable recovery area somewhere else. See comment by Fredrickson (In Press).

USFWS, 2007. Red Wolf (Canis rufus) 5-year Review: Summary and Evaluation. US Fish and Wildlife Service, Manteo, NC.

This document provides an in-depth review of the red wolf reintroduction program.

Waddell, W. and S. Long. 2015. Population analysis & breeding transfer plan red wolf (Canis rufus gregoryi). Association of Zoos and Aquariums.

The introductory material provides a demographic and genetic description of the red wolf captive population as of July 2015.

Algonquin Wolves

Rutledge, L.Y., White, B.N., Row, J.R., Patterson, B.R., 2011. Intense harvesting of eastern wolves facilitated hybridization with coyotes. Ecol. Evol. 2, 19–33.

The authors quantify changes in the ancestry of wolves (*C. lycaon*) in Algonquin Provincial Park (APP) from 1964 to 2007 following the removal of about 36% of the wolf population in 1964-1965. They hypothesized that disruption of pack social structures and breeder loss associated with the culls could have facilitated interbreeding with the neighboring coyote population. They used six nuclear microsatellites, mtDNA, and two Y-chromosome microsatellites to quantify changes in ancestry of APP wolves over three periods: 1964-1965, 1987-1999, and 2002-2007. They used samples from a nearby coyote population to the south and a population of gray wolves (*C. lupus*) to the north as reference populations. They found that at the time of the culls there was a substantial proportion of gray wolf-like animals in the APP population and some coyote-like animals. The proportion of coyote-like animals increased substantially from 1964 to

1987-1999 and no gray wolf-like animals were detected. But by the 2000's, coyote ancestry in APP had decreased relative to 1987-1999 and the overall ancestry had become more similar to that in 1964-1965. In the process, one mtDNA haplotype associated with APP wolves that was common in 1964-1965 became rare by 2002-2007. A coalescent simulation also linked the culls with the increase in coyote ancestry in the APP population. They concluded that the culls caused some remaining APP wolves to mate with coyotes from the expanding coyote population to the south. They attribute the change in APP ancestry from the 1990's to the 2000's to a 2001 ban on wolf hunting and trapping in townships around the Park

Rutledge, L.Y., Patterson, B.R., Mills, K.J., Loveless, K.M., Murray, D.L., White, B.N., 2010. Protection from harvesting restores the natural social structure of eastern wolf packs. Biological Conservation 143, 332–339.

This paper examines changes in the social system of wolves in Algonquin Provincial Park, Ontario following a ban on wolf hunting adjacent to the park. Prior to the ban, 67% of total wolf mortality was human-caused. Following implementation of the ban, human-caused mortality among park wolves dropped to 16% of total mortality, but this was largely offset by an increase in natural mortality. The percentage of packs that had adopted unrelated wolves dropped from 80% prior to the hunting ban to 6% (one pack) after the ban. Within five packs known to occupy the same territory both prior to and following the harvest ban, single mitochondrial DNA haplotypes among females within a pack were more common post-ban.

Red Wolf Genetics and Evolutionary Origins

Brzeski, K.E., Rabon, D.R., Chamberlain, M.J., Waits, L.P., Taylor, S.S., 2014. Inbreeding and inbreeding depression in endangered red wolves (Canis rufus). Mol. Ecol. 23, 4241–4255.

The authors examine inbreeding and inbreeding depression in the reintroduced population of red wolves in North Carolina. They used data from monitoring efforts from 1989 – 20012 along with pedigree information to look for effects of inbreeding on seven measures of fitness: lifetime number of litters, average number of litters per reproductive year, litter size, probability of becoming a breeder, adult survival, and juvenile survival. The also looked for evidence of inbreeding depression on body size. During the study period, individual inbreeding coefficients ranged from zero to 0.383, but the mean was
0.154. They found little evidence of inbreeding depression on the seven measures of fitness. Inbreeding depression, however, was evident on wolf body size. Body size did not affect the fitness measures they evaluated, but body size was positively associated with holding a territory. The effect of inbreeding on body size, however, was small. The authors suggest the lack of inbreeding depression may be a result of a founder effect or the lack of outbred wolves with which to contrast inbred wolves (presumably suggesting a high fixed genetic load).

Chambers SM, Fain SR, Fazio B, Amaral M. 2012. An account of the taxonomy of North

American wolves from morphological and genetic analyses. North American Fauna 77:1–67. doi:10.3996/nafa.77.0001

This paper reviews the taxonomy of North American wolf-like canids. They find support for the hypothesis of Wilson et al. (2000) that red wolves, eastern wolves and coyotes derive from a common North American lineage, but based on available evidence they conclude that red wolves and eastern wolves are likely not conspecific.

Dowling T.E., B.D. DeMaraies, and M.E. Douglas. 1992. On the use of genetic characters in conservation biology. Conservation Biology 6:7-8.

This is a comment on Wayne and Jenks (1991).

Kyle, C.J., Johnson, A.R., Patterson, B.R., Wilson, P.J., Shami, K., Grewal, S.K., B.N. White. 2006. Genetic nature of eastern wolves: past, present, and future. Conserv. Genet. 7, 273–287.

This paper evaluates three hypotheses for the taxonomic status of eastern wolves: 1) it is a smaller subspecies of the gray wolf (*Canis lupus lycaon*), potentially resulting from post-Pleistocene/pre- European settlement hybridization between gray wolves (*C. lupus*) and red wolves (*C. rufus*); 2) it is a hybrid, and not a distinct species, resulting from gray wolf (*C. lupus*) and coyote (*C. latrans*) hybridization; 3) it is a distinct species (*C. lycaon*) closely related to red wolves (*C. rufus*). To evaluate these hypotheses, the authors employ an extensive review of relevant genetic and non-genetic studies. Based on their review, they reject the first hypothesis, and conclude that the second hypothesis cannot be rejected by all of the molecular data. But given the lack of gray wolf haplotypes in eastern wolves prior to the mid- to late 1800's expansion of the coyote population, they are "led to reject the second hypothesis." The third hypothesis is currently not rejected by any of the reviewed molecular studies, and they conclude that the review supports the third hypothesis that eastern wolves were likely a distinct species of wolf (*Canis lycaon*) prior to the eastern expansion of coyotes.

Finally, the authors provide some grist for discussion. They note that in the red wolf reintroduction program, managers are actively seeking to minimize hybridization. Rather than attempting to maintain a "pure" genetic stock in the wild, the authors believe that:

> …less emphasis should be given to preserving the eastern wolf's phenotype; the concern should be conserving the evolutionary process (sensu Moritz 1999, 2002). This can be accomplished by protecting the genetic diversity found in *Canis* species, that if lost is not recoverable, whereas adaptive phenotypes can be recovered through recurrent selection.

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And Murray and Waits (2007) offer some discussion on the merits of hybridization presented by Kyle et al. (2006) as it relates to the management of the reintroduced red wolf population. For red wolves, they make the case that it is premature to assume that the red wolf gene pool need not be preserved as distinct. Among other things they point out that allowing widespread hybridization with coyotes would likely lead to the loss of red wolf genetic variation due to strong genetic drift and inefficient natural selection resulting from small population size.

Kyle et al. (2008) in their response to Muray and Waits (2007) state they are not against the current management of red wolves, but they seem to miss that the goal is not to try to "preserve a static interpretation of species." Instead management is aimed at simply establishing a functioning red wolf population that can maintain itself with minimal management.

Murray DL, Waits L (2007) Taxonomic status and conservation of the endangered red wolf: a response to Kyle et al. (2006). Conservation Genetics

This is a comment on Kyle et al. (2006).

Kyle, C.J., A.R. Johnson, B.R. Patterson, P.J. Wilson, K. Shami, B.N. White. 2008. The conspecific nature of eastern and red wolves: conservation and management implications. Conservation Genetics 9:699–701. DOI 10.1007/s10592-007-9380-5

See Kyle et al. (2006).

Nowak, RM. 1992. The red wolf is not a hybrid. Conservation Biology 6:

593–595. This is a comment on Wayne and Jenks (1991).

Nowak, R.M. and N.E. Federoff. 1998. Validity of the red wolf: response to Roy et al. Conservation Biology 12:722-725.

The authors disavow the "ancient origin hypothesis" around which the analysis of Roy et al. (1996) was structured and clarify the position of Nowak (1979) as suggesting "…that the red wolf, and the entire wolf line, is descended from an early coyote-like population… but never hinted that any wolf gave rise to the coyote." They go on to state that more recent work "…revealed a prevailing view that the red wolf is a primitive species or subspecies, representing part of the phylogenetic transition from coyote to gray wolf." They also note that Roy et al. (1996) was not the first to reveal hybridization prior to 1940. Nowak (1979) "…devoted extensive attention to the presence of a red wolf-coyote hybrid population in central Texas in the period 1890-1920 and discussed hybridization in Missouri, Oklahoma, and Arkansas between 1920 and 1940." They further note that other morphological investigators were aware of apparent hybrids long before 1940. They also note Roy et al. (1996) drew their "pre1940"

specimens from west of the Mississippi River which represented only a small part of the historic range and was the area most likely to have been affected by hybridization and introgression from coyotes. Genetic results may have been different if early specimens had been drawn from the much larger and earlier populations to the east, all of which demonstrate the presence of a small wolf with no coyote influence.

They also question why Roy et al. (1996) accepts the validity of eastern wolves even though its current genotype has been extensively influenced by recent hybridization with coyotes, but fail to accept the validity of red wolves as a wolf species. They further note allele frequency data in Roy et al. (1996) suggests an affinity between red wolves and *lycaon* and that both genetic and morphological data show the two taxa occupying a position intermediate to gray wolves and coyotes. Finally they reject both scenarios presented by Roy et al. (1996) for the origin and fate of red wolves.

Nowak, R. 2002. The original status of wolves in eastern North America. Southwestern Naturalist 1(2):95-130.

All available cranial specimens of wild *Canis* dating since the Blancan and prior to AD 1918 in the region east of the Great Plains and south of the Prairie Peninsula, Lakes Erie and Ontario, and the St. Lawrence River were examined. A small wolf appeared near the end of the Rancholabrean. At the same time, coyotes disappeared from the east and did not return until the small wolf was extirpated in the 20the century. Fragmentary remains of the small wolf, dating from around 10,000 and 2,000-200 ybp, show continuity with 14 complete, mostly modern, eastern skulls. Multivariate analysis indicates those 14 represent a well-defined species, C. rufus, distinct from large series of the western gray wolf (C. lupus) and coyote. There is no evidence that the red wolf originated as a hybrid of the latter two species, though early specimens from central Texas suggest it began to interbreed with C. latrans by about 1900. Three long-recognized red wolf subspecies appear valid: C. r. floridanus, Maine to Florida; C. r. gregoryi, south-central United States; and C. r. rufus, central and coastal Texas, southern Louisiana, and probably now represented in the captive/reintroduced populations.

Phillips, M.K. and V.G. Henry. 1992. Comments on red wolf taxonomy. Conservation Biology

6:596-599. This is a comment on Wayne and Jenks (1991).

Roy M, Geffen E, Smith D, Ostrander EA, Wayne RK. 1994. Patterns of differentiation and hybridization in North American wolflike canids, revealed by analysis of microsatellite loci. Mol Biol Evol 11: 553-570.

Ten microsatellite loci were analyzed to quantify genetic differentiation and hybridization in three species of North American wolf-like canids (gray wolves, coyotes, and red wolves). Red wolves shared all their alleles with coyotes, and only 4 of 53 red wolf alleles were not found among gray wolves. The authors conclude that hybridization between coyotes and red wolves in the south central US may have begun around 1700 following the arrival of European settlers. The authors further hypothesize that following the extermination of gray wolves in the southern and northeastern US the hybrids and their descendants (red wolves) became rare and their phenotype was "severely influenced" by backcrossing with coyotes.

Roy, M.S., Geffen, E., Smith, D., Wayne, R.K., 1996. Molecular genetics of pre-1940 red wolves. Conservation Biology 10, 1413–1424.

This paper examines two predictions from the "ancient origin – recent introgression hypothesis" where red wolves are postulated to have arisen in the early Pleistocene and are ancestral to modern coyotes and gray wolves. It is believed that after 1940, interbreeding between coyotes and the last remaining populations of red wolves caused red wolves to acquire some morphological traits of coyotes. Two predictions of this scenario are that: 1) present and pre-1940's red wolves should have unique diagnosable characteristics that distinguish them from gray wolves and coyotes; and 2) diagnosable characteristics should be more apparent in the pre-1940 red wolves compared to red wolves in the captive breeding program. To address these predictions mtDNA sequence variation in the cytochrome b gene were examined in 11 new pre-1940 red wolf specimens along with ten microsatellite loci in 16 pre- 1940 specimens.

All red wolf haplotypes grouped with either the gray wolf or coyote clades in all four most parsimonious trees. To make red wolf haplotypes within the coyote clade define a mono-phyletic grouping of red wolf haplotypes would require just one additional step. Within the gray wolf clade, a monophyletic grouping of red wolf haplotypes was present in one of the four most parsimonious trees. Sequence divergence

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between red wolf haplotypes was similar in magnitude to the divergence of genotypes found within coyotes and gray wolves. But sequence divergence between coyotes and gray wolves was four times greater. Consequently, the mtDNA sequence data does not support the hypothesis that the red wolf had an ancient origin and was ancestral to gray wolves and coyotes. The fact that 8 of 11 pre-1940 red wolf samples grouped with genotypes of coyotes suggested hybridization between red wolves and coyotes was extensive prior to 1940.

Multidimensional scaling indicated pre-1940's and captive red wolves had allele frequencies intermediate between gray wolves and coyotes and were closest to hybridizing gray wolves. Nei's genetic distance between pre-1940 red wolves and coyotes was less than half that between coyotes and gray wolves. Nei's genetic distance between captive red wolves and coyotes was larger than that of pre- 1940 red wolves and coyotes (0.341+- 0.051 versus 0.216 +- 0.061) contradicting the predictions of the ancient origin – recent introgression hypothesis.

Pre-1940 red wolves also had few unique alleles – only three unique alleles in comparison to the entire sample of coyotes, but all were found in gray wolves. Similarly, the three unique alleles found in comparison of pre-1940 red wolves to the entire sample of gray wolves were also found in coyotes. On average when 16 individuals were drawn from the entire sample of coyotes and compared with gray wolves, coyotes had 5.7 +-1.5 unique alleles. There were 6.8 +- 1.2 unique alleles when 16 gay wolves were chosen and compared with those found in coyotes. The frequency of obtaining three or fewer unique alleles when 16 gray wolves or coyotes were randomly selected was 6.8 and 1.8%, respectively. The total number of alleles in pre-1940 red wolves (56) was similar to that expected from populations of 16 gray wolves (59.9 +- 4.7) or 16 coyotes (61.5 +- 3.8). The authors concluded that the pre-1940 red wolves had fewer than expected unique alleles if it is was a species having an ancient origin before gray wolves and coyotes. Moreover it has no unique alleles when compared with both species pooled, consistent with an origin by hybridization between the two species. Similar results were obtained for captive red wolves (Roy et al. 1994). It should be noted, however, that these comparisons were made using wolves from eight populations in Mexico, Alaska, throughout Canada, and Minnesota including two hybridizing populations. Similarly, four coyote populations from throughout the US and one in Canada were used in the comparisons. Two of the coyote populations were hybridizing populations. The authors conclude that their results are consistent with extensive hybridization between gray wolves and coyotes giving rise to red wolves during European colonization or earlier. See comments of Nowak and Federoff (1998) and Wayne et al. (1998) for a response.

Rutledge L, Garroway CJ, Loveless KM, Patterson BR. 2010a. Genetic differentiation of eastern wolves in Algonquin Park despite bridging gene flow between coyotes and grey wolves. Heredity DOI: 10.1038/hdy.2010.6.

This paper examines hybridization and differentiation of canids among three populations in Ontario, Canada: Algonquin Provincial Park (*Canis lycaon*, APP), southwestern Ontario (eastern coyotes), and northeastern Ontario (*Canis lupus*). APP is thought to have the purest population of eastern wolves remaining. Mitochondrial and Y chromosome DNA along with

twelve autosomal microstatellites were used to genotype 217 canids. All three populations had private alleles, and analyses using Structure and Geneland identified three groups corresponding to the three populations. Similarly, principal components analyses separated the three populations. But despite the differentiation, there was evidence of admixture and migration between the populations. There was also a cline in allele frequencies from south to north suggesting that APP wolves act as a conduit for gene flow from coyotes in the south to gray wolves in the north. Patterns of mtDNA and Y chromosome haplotypes were consistent with the hypothesis that females of the smaller species historically mating with males from larger species. Gray wolf DNA was common in the northernmost population with some in APP, but it was absent in the southern most population. No coyote-specific Y introns were found, but APP and the southern population had Y introns and Y microsatellite haplotypes identified as ancestral haplotypes that evolved in North America. This Y haplotype was absent in the northern population. Eastern wolf mtDNA and Y chromosome DNA were present in all three populations, but only one eastern wolf Y chromosome haplotype was found in the northern population.

Breeding wolves in APP tended to have high assignment to the Algonquin cluster, and paired breeders were generally conspecific, based on nuclear markers. But over half of the female breeders had coyote mtDNA. Among APP breeding pairs, 73% had high assignment to APP. Of the 18 breeding males two had gray wolf Y chromosome DNA and the others had eastern wolf DNA. Of all the APP male breeders, only the two wolves with gray wolf haplotypes were identified as admixed. The proportion of APP male breeders with eastern wolf Y chromosome haplotypes was significantly greater than that expected under random mating across the complete Y chromosome microsatellite data set and that within the APP. Overall, the three populations were genetically distinct, despite contemporary gene flow, perhaps as a result of positive assortative mating among APP wolves.

Rutledge L, Bos K, Pearce R, White BN. 2010b. Genetic and morphometric analysis of sixteenth century *Canis* skull fragments: implications for historic eastern and gray wolf distribution in North America. Conservation Genetics 11: 1273-1281.

Control region mtDNA from four canid samples (3 teeth and a partial mandible with two teeth) recovered from archeological site (an Iroquois indian village) in southwestern Ontario, Canada were examined. Carbonized corn dated the site to the year 1530 AD. Two of the samples had ancient dog haplotypes of old world origin. A third tooth had a haplotype identical to a sequence found in existing western coyotes. The fourth sample had a haplotype that differed from a known coyote haplotype by one based pair. Morphometric analysis of the mandible associated with the fourth sample suggested the sample was from a wolf rather than a coyote. The DNA data from the latter two samples reject the hypothesis that the samples were from "pure" gray wolves, and the morphometric analysis rejects the hypothesis that the remains were from coyotes. These results suggest that the wolves present in the area ca. 500 years ago were eastern wolves (*Canis lycaon*), but the results do not exclude the possibility that eastern x gray wolf hybrids occupied the arrea. The results also suggest that eastern wolves and coyotes had come into contact prior to the recent range expansion of the coyote range through

the Great Lakes area.

Rutledge LY, Wilson PJ, Klutsch CFC, Patterson BR, White BN. 2012 Conservation genomics in perspective: a holistic approach to understanding *Canis* evolution in North America. Biological Conservation 155, 186–192. (doi:10.1016/j.biocon.2012.05.017)

The authors use the SNP data from vonHoldt et al. (2011) along with existing mtDNA and microsatellite data, the fossil record, ecological data, and early naturalists' accounts "…to show how a broader frame of reference is important for interpretation of genomic data." In their reanalysis of the SNP data they use a three species model (eastern wolves, gray wolves, and coyotes) for North American wolf-like canids, rather than the two species model (gray wolves and coyotes) used by vonHoldt et al. (2011). In principal components analyses, the two eastern wolves from Algonquin Provincial Park are intermediate between Great Lakes wolves and eastern coyotes, both of which have hybridized with eastern wolves. In phylogenetic trees of coding and non-coding mtDNA data using much larger samples of eastern wolves, eastern wolves form a monophyletic group with high bootstrap support (>=94%). Principal components analysis using 12 microsatellite loci separate old and new world canids on the first principal component, and separate eastern and red wolves from coyotes (Texas and Sasketchewan) on the second principal component. Eastern coyotes appear intermediate between eastern wolves and non-eastern coyotes.
The potential for bias using small sample sizes of individuals and the dog SNP array to classify wild canids is discussed. Finally, the authors note ecological data also does not support the two species hypothesis for the evolution of North American wolf-like canids. The authors conclude there is substantial support for the three species model of wolf evolution in North America.

Rutledge, L.R., S. Devillard, J.Q. Boone, P.A. Hohenlohe, and B.N. White. 2015. RAD sequencing and genomic simulations resolve hybrid origins within North American *Canis*. Biology Letters 11: 20150303.

The authors explore two evolutionary models for North American *Canis*: 1) a two-species model that identifies gray wolves (*C. lupus*) and western coyotes (*Canis latrans*) as distinct species that gave rise to various hybrids, including the Great Lakes wolf, the eastern coyote, the red wolf and the eastern wolf; and 2) a three-species model that identifies the gray wolf, western coyote and eastern wolf (*C. lycaon*) as distinct species, where Great Lakes wolves are the product of gray wolf x eastern wolf hybridization, eastern coyotes are the result of eastern wolf x western coyote hybridization, and red wolves are considered historically the same species as the eastern wolf. They used 127,235 SNP loci based on a gray wolf genomic assembly from each of 17 individuals of five different *Canis* types (gray wolves, Great Lakes wolves, eastern wolves from Algonquin Provincial Park, western coyotes, and eastern coyotes)

along with genomic simulations to test hypotheses of hybrid origins among eastern North American *Canis*. A principal components analysis was consistent with the eastern wolf being a distinct species.
Simulated grey wolf x western coyote hybrid genomes failed to overlap with any other *Canis* type. But simulated eastern wolves x gray wolves overlapped Great Lake wolves, and simulated east wolf x western coyote overlapped existing eastern coyotes. These patterns were consistent with previous suggestions that the eastern wolf is a conduit of gene flow between gray wolves and coyotes, but are in contrast to previous work that concluded (under the assumption of the two-species model) that the eastern wolf from Algonquin Park was a gray wolf x western coyote hybrid.

See the comments of Sefc and Koblmuller (2016) suggesting this work does not rule out the possibility that eastern wolves had an ancient hybrid origin, and the reply by Rutledge et al. (2016). Notably both parties agree that the eastern wolf merits full protection under existing conservation policies. Given that the findings of Rutledge et al. (2015) also suggest red wolves do not have a recent hybrid origin, by extension, red wolves should also be fully protected under the Endangered Species Act.

Rutledge, L.R., S. Devillard, and P.A. Hohenlohe. 2016. Considering all the evidence: a reply to Sefc and Koblmuller (2016). Biology Letters 12: 20151009.

Sefc KM, Koblmuller S. 2016 Ancient hybrid origin of the eastern wolf not yet off the table: a comment on Rutledge et al. (2015). Biology Letters 12: 20150834. (doi:10.1098/rsbl.2015.0834)

vonHoldt B et al. 2011 A genome-wide perspective on the evolutionary history of enigmatic wolf-like canids. Genome Res. 21, 1294–1305. (doi:10.1101/gr.116301.110)

This paper assesses genetic variation among wolf-like canids from around the world, across all 38 autosomes using 46k single nucleotide polymorphisms (SNP) based on the dog genome. All red wolves in the analysis were from the captive breeding population. Principal components (PCA) and *structure* analyses suggested red wolves and Great lakes wolves are genetically differentiated. The red wolf cluster was adjacent to that of coyotes, and Great Lakes wolves were closest to other North American gray wolves. Of the 19 Great Lakes wolves in their sample, only two were from Algonquin Provincial Park and these two wolves were somewhat disjunct from Great Lakes and other North American wolves in the PCA. In a *structure* analysis, red and Great Lakes wolves showed distinct genetic signatures at K= 9 and K= 10, respectively. Using the program SABER, 76% of the red wolf genome was assigned to coyotes, with the remainder assigned to gray wolves. Among Great Lakes wolves, an average of 15% of their genome was assigned to coyotes. Among the two wolves from the phenotypically distinct Algonquin Provincial Park, 58% of their genome derived from gray wolves, with the remainder being from coyotes. It should be noted that ancestry blocks could only be classified as deriving from gray wolves, coyotes, or domestic dogs. F_{ST} values for red wolves were 0.08 and 0.11 in comparisons with Midwestern / southern coyotes and Great Lakes wolves,

respectively. F_{ST} values for Great Lakes wolves were 0.11, 0.08, and 0.05 in comparisons with red wolves, Midwestern / southern coyotes, and western wolves, respectively. The authors conclude red wolves are closely related to coyotes, "…but somewhat divergent from them due to a history of limited admixture with gray wolves. Such historic admixture between gray wolves and coyotes was followed by extensive backcrossing to coyotes, as the source population of gray wolves disappeared in the American South and the Southeast. We estimate admixture was initiated 144 generations (287–430 yr) ago." The authors further state:

> It has been suggested that hybrids are not clearly protected under the ESA (O'Brien and Mayr 1991), especially hybrids between nonlisted entities (U.S. Fish and Wildlife Service 1973). Since a critical aim of the red wolf recovery project is to maintain the introduced population free from hybridization (Hedrick and Fredrickson 2008), the rationale of the program may need reconsidering as the extant red wolves clearly derive from a process of admixture.

The authors further conclude:

> Using a genome-wide approach, we show that the red and Great Lakes wolves have a distinct but admixed evolutionary history. This result has important implications for conservation policy, because current preservation efforts are focused on populations whose admixed genomes may be due in part to recent habitat changes and predator control efforts (Lehman et al. 1991; Wayne and Jenks 1991). However, these concerns must be weighed against the beneficial top-down ecosystem effects that admixed populations have in environments, which now may be unsuitable for large wolves. Such ecologic, rather than strictly taxonomic considerations are also integral to deciding which species and subspecies should be preserved (e.g., Crandall et al. 2000; Allendorf et al. 2001; Carroll et al. 2010).

Wayne, R.K., and Jenks, S. 1991. Mitochondrial DNA analysis implying extensive hybridization of the endangered red wolf, *Canis rufus*. Nature 351: 565–568.

The authors propose that red wolves are either derived entirely from hybridization between coyotes and gray wolves or originated as a distinct taxon that hybridized with coyotes and gray wolves over much of its historic range. To investigate the origin of red wolves, mitochondrial DNA sequences from the cytochrome b gene and restriction enzyme sites were examined among coyotes and gray wolves from throughout North America as well as from red wolves in the captive breeding program, wild canids captured in Louisiana and Texas from 1974 to 1976 to initiate the captive population, and from six historical specimens collected from 1905 – 1930, potentially before substantial hybridization between red wolves and coyotes began.

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The genotype of the captive red wolf population was identical to that found in two recent coyotes in Louisiana. Maximum parsimony placed this genotype in a monophyletic clade containing only coyote genotypes. This genotype was also common among the wild canids captured from 1974-1976.
Genotypes among the wild canids captured from 1974-1978 were classified as 84% coyote, 7% northern gray wolf, and 9% Mexican wolf. Morphological and genetic classifications of the wild canids often did not correspond. The high frequency of morphological hybrids, poor correspondences between morphological and genetic classifications, and the presence of only coyote and gray wolf haplotypes suggested hybridization between these species occurred in the source population from which the captive population was founded before 1974. All cytochrome b haplotypes from the historical specimens grouped either within the coyote or gray wolf clades.

On a policy note, the authors state that even if red wolves are entirely hybrids they should be protected under the Endangered Species Act because they "…filled the role of a top predator throughout its former geographic range and was thus an important part of the ecosystem."

It should be noted that in this analysis eastern wolves were considered a subspecies of gray wolves (*Canis lupus lycaon*), and that hybridization between "gray wolves" and coyotes occurred only in the Great Lakes region, some of which is considered to have been the historic range of eastern wolves.

See comments by Dowling et al. (1992), Nowak (1992), Phillips & Henry (1992) as well as the responses by Wayne (1992) and Wayne et al. (1998).

Wayne, R.K. 1992. On the use of Morphologic and molecular genetic characters to investigate species status. Conservation Biology 590-592.

Wayne, R.K., M.S. Roy, and J.L. Gittleman. 1998. Origin of the red wolf: response to Nowak and Federoff and Gardener. Conservation Biology 12:726-729.

Wilson, P.J., Grewal, S., Lawford, I.D., Heal, J.N.M., Granacki, A.G., Pennock, D., Theberge, J.B., Theberge, M.T., Voigt, D.R., Waddell, W., Chambers, R.E., Paquet, P.C., Goulet, G., Cluff, D., White, B.N., 2000. DNA profiles of the eastern Canadian wolf and the red wolf provide evidence for a common evolutionary history independent of the gray wolf. Can. J. Zool. 78, 2156–2166.

This paper tests two alternative hypotheses: 1) eastern and red wolves are hybrids of coyotes and gray wolves; and 2) eastern and red wolves evolved independently of gray wolves in North America. To test these hypotheses they used eight microsatellite loci from wolves in and around Algonquin Provincial Park (APP) in Ontario, Canada from 1960 – 1965 (n = 19) and from 1985 – 1996 (n = 49), and samples from the captive red wolf breeding program (n = 60). Coyotes were sampled from Texas (n = 24) which were the geographically closest

population to the red wolf founders, and gray wolves were sampled from the Northwest Territories (n = 67). Prior microsatellite data from coyotes and gray wolves from additional locations were also used in analyses. In addition the authors also examined mtDNA control region sequences from the early APP wolves.

Neighbor-joining analyses of the microsatellite data "showed an unexpectedly close relationship" among APP wolves, red wolves, Minnesota wolves and southern Quebec wolves. To evaluate whether this close relationship was due to similar amounts of coyote ancestry among Minnesota, southern Quebec, and red wolves, they ran a second neighboring-joining analysis using red and APP wolves, Texas coyotes, and gray wolves from other populations. The same relationship between red and APP wolves was observed, and the Texas coyotes formed a more distant branch suggesting that the genetic similarity between red and APP wolves was "not heavily influenced" by the introgression of coyote genetic material. In two assignment tests red and APP wolves clustered together separately from gray wolves but closer to the Texas coyotes. This suggested there was little or no gray wolf genetic material among red and APP wolves. No gray wolf control region sequences were found among red and APP wolves from the 1960's. One control region sequence in the APP wolves was not present among coyotes and was divergent from coyotes. This haplotype was present in 7 of 13 APP wolves. A second haplotype was found in 9 of 12 red wolves, but not in coyotes. The APP and red wolf haplotypes grouped together and away from coyotes in a neighbor-joining tree. The remaining APP and red wolf samples contained coyote haplotypes confirming some hybridization. It is noted that the APP wolf population would have had about 30 years of contact with coyotes by the mid-1960's.

Sequence divergence between the red and APP wolf haplotypes was 2.1%. Sequence divergences between coyotes and red wolves and coyotes and APP wolves were 2.3 and 3.2%, respectively.
Sequence divergence between gray wolves and APP and red wolves was 8.0%, and divergence between gray wolves and coyotes was 10%. This is consistent with a separation of 150,000 – 300,000 years between APP wolves and coyotes and 1-2 million years between gray wolves and coyotes. It was concluded that the mtDNA of the APP and eastern wolves is not of gray wolf origin, but is similar to coyotes due to a relatively recent common ancestor.

Wilson PJ, Grewal S, T. McFadden, R.C. Chambers, and B.N. White. 2003. Mitochondrial DNA extracted from eastern North American wolves killed in the 1800s is not of gray wolf origin. Canadian Journal of Zoology 81: 936–940.

About 230 base pairs of control region mitochondrial DNA were sequenced from two historical wolf specimens. One specimen from Maine was collected in the 1880's, and the other specimen was collected in New York in the 1890's. The specimen from New York was described as the last wolf killed in New York and predates the first observation of a coyote-like animal by about 40 years. The Maine specimen predates the first arrival of coyotes in

Maine by about 50 years. Based on the absence of coyotes when these specimens were collected, the authors make two predictions. The first is that if the eastern timber wolf is truly a subspecies of the gray wolf, the mtDNA from these specimens should be of *Canis lupus* origin. The second prediction is that if the eastern timber wolf is a North American-evolved wolf more closely related to the coyote, the mtDNA sequences would be closely related to those of coyotes as a result of evolutionary history and not recent hybridization. Both specimens contained a mtDNA haplotype that was not of gray wolf (*C. lupus*) origin. The Maine sample contained a mtDNA haplotype that clustered with previously identified eastern wolf and red wolf-specific mtDNA. The New York sample clustered with sequences found in modern western coyotes.

Early coyote hybridization, about 40 years prior to recorded sightings of coyotes in New York, cannot be excluded given the similarity of the New York haplotype to those among coyotes. However, the similarity of the Maine sequence to mtDNA found in eastern timber wolves from Algonquin Provincial Park in the 1960s and at present, as well as that obtained from the red wolf captive-breeding program supports the presence of a wolf that is not of gray wolf origin. The authors interpret these findings as supporting the presence of an eastern wolf with an evolutionary history independent of that of the gray wolf.

Wilson, PJ, LY Rutledge, TJ Wheeldon, BR Patterson, and BN White. 2012. Y-chromosome evidence supports widespread signatures of three-species *Canis* hybridization in eastern North America. Ecology and Evolution 2(9): 2325–2332.

Within the historic range of the eastern wolf (*Canis lycaon*), the authors identify Y chromosome and mtDNA haplotypes that are divergent from and monophyletic to those of western coyotes and gray wolves. And these haplotypes are not found in western coyotes or gray wolves outside of the Great Lakes area. The authors conclude this provides additional support for the three species hypothesis for the origins of wolf-like canids in North America. Figures 1 and 2 portray a wide and complex range of hybridization among canid populations in eastern North America. The authors note that:

> The contemporary hybrid species-complex represents various forms. Specifically, a spectrum of coyote to eastern wolf to gray wolf phenotypes exists in a range of natural to human-modified landscapes, including regional differences in wolves (Mech and Paul 2008) and eastern coyotes (Kays et al. 2010).

They also state:

> As a result, standard taxonomic nomenclature is difficult to apply to the classification, conservation, and management of wolves and coyotes in eastern

> North America. We encourage managers and policy makers to consider the evolutionary potential of these hybrid genomes because they may support the adaptability necessary to refill the ecological role once occupied by the purer wolf species that existed prior to European colonization.

Perhaps throwing red (or Algonquin Provincial Park) wolves a bone, they further state:

> However, we also recognize that in situations where sufficient habitat exists for recolonization of historic species, efforts to minimize anthropogenic factors that exacerbate hybridization are an important aspect of conservation.

Hybridization and Policy

Allendorf, F.W., R.F. Leary, P. Spruell, and J.K. Wenburg. 2001. The problems with hybrids: setting conservation guidelines. Trends in Ecology and Evolution 16:613-622.

Allendorf et al. (2001) identify six types of hybridization ranging from natural hybridization that leads to a new taxon to anthropogenic hybridization with backcrossing that has progressed to a hybrid swarm with no pure parental species individuals remaining. Examples of each of the six types are presented.
They also address three management related questions: 1) is there an acceptable proportion of admixture; 2) can individuals of parental species be 'rescued' from hybrid populations, and 3) when might intentional hybridization be desirable.

Allendorf FW, Leary RF, Hitt NP, Knudsen KL, Lundquist LL, Spruell P. 2004. Intercrosses and the U.S. Endangered Species Act: Should hybridized populations be included as westslope cutthroat trout? Conservation Biology 18:1203–1213.

This paper considers the scientific basis for determining whether or not introgressed populations of westslope cutthroat trout (WCT) and populations of unknown hybridization status should be included as part of the units considered for listing under the Endangered Species Act. Both rainbow trout and Yellowstone cutthroat trout (YCT) may hydridize with WCT. Although WCT, YCT, and rainbow trout could be differentiated based on a meristic index, it was not useful for identifying hybrid populations.
Hybridized populations that were at least 50% YCT admixture had meristic indices within the range of YCT. Hybridized populations that were at least 80% WCT had a meristic index within the range of WCT. Lab studies suggested that first generation hybrids between WCT and rainbow trout had reduced fitness. Nevertheless hybridization in the wild between rainbow trout and WCT was ubiquitous and this hybridization could lead to the loss of local adaptation in native populations of WCT and reduce the probability of long-term persistence. Three alternatives for including populations for listing under the ESA were considered: 1) include only nonhybridized WCT; 2) include WCT populations with <10% admixture; and 3) include

all populations that retain the morphological attributes of WCT. Alternative 1 is the only alternative that would protect the historical evolutionary legacy of WCT. This alternative would also protect local adaptations that may be lost through hybridization. Hybridized populations that threaten WCT populations could be managed to reduce hybridization. The primary disadvantage of this alternative is that many nonhybridized WCT populations are small and isolated and thus susceptible to the extinction vortex. For alternative 2, accepting 10% admixture is arbitrary. This alternative would greatly increase the number of populations protected and increase connectivity between populations and would reduce problems associate with small population size. But this alternative would protect hybridized populations that could act as a source for continued introgression into non-hybridized populations and result in the loss of local adaptations. Alternative 3 has all the disadvantages of Alternative 2. Populations may look like WCT, but may not function in the ecosystem as WCT. Local adaptations will likely be lost. The authors believe that only non-hybridized populations of WCT should be considered for listing under the ESA. WCT are a monophlytic lineage isolated from other lineages 1-2 million years. Only non-hybridized populations of WCT are likely to have the local adaptations important for long-term persistence.

Allendorf, F.W., R.F. Leary, N.P. Hitt, K.L. Knudsen, M.C. Boyer, and P. Spruell. 2005.Cutthroat trout hybridization and the U.S. Endangered Species Act: one species, two policies. Conservation Biology 19:1326-1328.

In response to a comment on (Allendorf et al. 2004) the authors note here that in 2002 a USFWS finding for a different subspecies of cutthroat trout (Rio Grande cutthroat trout) agreed with the recommendation of Allendorf et al. (2001) that genetically pure populations should be maintained. They note that this is in contrast to the finding for westslope cutthroat trout (WCT, Federal Register 2003) which would allow populations with up to 20% admixture from other taxa to be treated as WCT under ESA.

Ellstrand, N.C, D. Biggs, A. Kaus, P. Lubinsky, L.A. McDade, K. Preston, L.M. Prince , H.M. Regan, V. Rorive, O. A. Ryder, and K. A. Schierenbeck. 2010. Got hybridization? A multidisciplinary approach for informing science policy. BioScience 60:384-388.

Authors illustrate the wide range of potential biological outcomes when species / subspecies / populations hybridize. They note that policy to address conservation concerns associated with hybridization would need to be flexible, and therefore it may be difficult to develop. Authors also note that South Africa is the only nation which has endangered species legislation that mentions hybrids. The authors suggest that development of policy to address hybridization "lies at the interface between life and social-sciences" and therefore should arise from collaboration with economists, legal experts, biologists, etc. The first author, Ellstrand, is an evolutionary biologist that works with plants, and the examples used to illustrate this collaboration are not very relevant to that of red wolves and similar wildlife examples. On the upside, this paper points out that development of hybrid policy would be a ground-breaking exercise for biologists, legal experts, economists, social scientists, etc.

Federal Register Vol. 68, No. 152, August 7, 2003, pages 46989-47009.

In this document, the USFWS: 1) declines to list westslope cutthroat trout (WCT) under the Endangered Species Act (ESA); 2) explains its position on the inclusion of hybrids in listing decisions; 3) explains their scientific rationale for its decision to not list WCT; and 4) presents a new status review of WCT.

Here I will focus on the USFWS' explanation of its policy evolution in terms of how it considers hybrids in regards to the ESA and their consideration of hybrids of WCT in regards to the ESA. This document is a response to an appeal of an earlier decision to not list WCT under the ESA. In this document it is noted that "… the Court directed the Service to present a scientifically-based conclusion about the extent to which it is appropriate to include hybrid WCT stocks and populations of unknown genetic characteristics in the WCT subspecies considered for listing."

USFWS explains that the two previous proposed "hybrid policies" were withdrawn, and that in cases of hybridization they will determine the extent to which hybrids may contribute to the conservation and recovery of a listed entity on a case-by-case basis:

> Previous Service positions regarding hybridization, based upon interpretations in a series of opinions by the U.S. Department of the Interior, Office of the Solicitor, generally precluded conservation efforts under the authorities of the Act for progeny, or their descendants, produced by matings between taxonomic species or subspecies (O'Brien and Mayr 1991). However, advances in biological understanding of natural hybridization (e.g., Arnold 1997) prompted withdrawal of those opinions. The reasons for that action were summarized in two sentences in the withdrawal memorandum (Memorandum from Assistant Solicitor for Fish and Wildlife, U.S. Department of the Interior, to Director, U.S. Fish and Wildlife Service, dated December 14, 1990): **''New scientific information concerning genetic introgression has convinced us that the rigid standards set out in those previous opinions should be revisited. In our view, the issue of ''hybrids'' is more properly a biological issue than a legal one''** (emphasis added).
>
> Our increasing understanding of the wide range of possible outcomes resulting from exchanges of genetic material between taxonomically distinct species, and between entities within taxonomic species that also can be listed under the Act (i.e., subspecies, DPSs), requires the Service to address these situations on a case-by-case basis. In some cases, introgressive hybridization may be considered a natural evolutionary process reflecting active speciation or simple

> gene exchange between naturally sympatric species. In other cases, hybridization may be threatening the continued existence of a taxon due to anthropogenic factors or natural environmental events. In many cases, introgressed populations may contain unique or appreciable portions of the genetic resources of an imperiled or listed species. For example, populations with genes from another taxon at very low frequencies may still express important behavioral, life history, or ecological adaptations of the indigenous population or species within a particular geographic area. Consequently, **the Service plans to carefully evaluate the long-term conservation implications for each taxon separately on a case-by-case basis where introgressive hybridization may have occurred** (emphasis added).

In the case of WCT, USFWS deemed that populations that met the morphological criteria for WCT would be considered WCT under the ESA. Information available at the time suggested that this would include introgressed populations with up to 20% admixture from rainbow trout or Yellowstone cutthroat trout.

Jackiw RN et al. 2015. A framework to guide the conservation of species hybrids based on ethical and ecological considerations. Conservation Biology 29: 1040–1051. (doi:10.1111/cobi.12526)

The goal of this study was to identify gaps in existing hybrid management policies to inform the creation of hybrid conservation guidelines, particularly when hybrids might be eligible for conservation under existing policies. The authors reviewed 81 conservation policies including laws, amendments, regulations, management protocols, and guiding principles primarily from the USA and Canada to determine if and how they address hybrids and whether they consider hybrids eligible for conservation. They also reviewed the conservation literature (48 peer-reviewed articles) to identify ecological and ethical considerations relevant for determining the conservation value of hybrids. Finally, they developed a framework to guide decision making to determine when hybrids should be protected under conservation policies.

Of the 81 policies reviewed, 30 mentioned hybrids, but only 13 contained hybrid management guidelines relevant to conservation. Of these 13 policies, 10 used only the broad term "hybrid" and did not distinguish between different types of hybrids. A single policy identified hybrid types and noted that conservation decisions should be based on consequences of hybridization, not the level of hybridization. Of the 13 policies containing hybrid management guidelines, six did not allow for hybrid conservation.
The remaining seven provided the potential for hybrids to be conserved. One of these policies was the Intercross policy of 1996 that was never implemented. Overall, "…the bias toward conservation of genetically pure species … is clear, even in policies that provide opportunities for hybrid conservation."

From the conservation literature, the authors identified three key ecological considerations

(genetics and evolution, functional ecosystem role, and species fitness) and two key ethical considerations (social and economic). Economic considerations include the moral implications of spending limited conservation funds on hybrid conservation when there are pure species that need protection. All considerations were context dependent – hybrid conservation could be ecologically beneficial or not beneficial or ethical or unethical depending on circumstances. Ethical considerations were mentioned in only seven of the 48 articles reviewed. The authors concluded that many policies do not adequately account for the conditions under which hybrids may have conservation value, which may result in the loss of biodiversity and the inefficient use of conservation resources.

The framework is based on four assumptions: 1) pure species are highly valued and are generally of greater conservation value than hybrids; 2) natural hybrids have more natural value than anthropogenic hybrids and generally hold higher conservation value than their human-mediated counterparts; 3) anthropogenic hybridization that occurs unintentionally is a more natural process than the intentional hybridization of species by humans; and 4) when there is uncertainty in a management scenario, decisions should be based on cost–benefit analyses that include ecological, social, and economic variables.

The framework is clearly organized, but some species, e.g. red wolves, may still fall into gray areas – are coyotes native? Given the low number of red wolf founders, could hybridization be beneficial? If so, what would be the best source of new genetic material?

In addition, although the paper discusses ethical issues associated with decisions on how populations / species threatened by hybridization should be managed, e.g. how best to spend conservation funds, these are not incorporated into the decision framework. For red wolves, this may be a substantial consideration in determining the future of the recovery program.

Haig SM, Allendorf FW. 2006. Hybrid policies under the U.S. Endangered Species Act. Pages 150–163 in Scott JM, Goble DD, Davis F, eds. The Endangered Species Act at Thirty, vol. 2: Conserving Biodiversity in Human-dominated Landscapes. Island Press.

The authors present the history of hybrid policies under the Endangered Species Act. Developing a policy to address hybridization and hybrids has proven difficult in part because as this chapter states: “The word ‘hybrid’ does not occur in the definition of ‘species’ in the ESA (sec. 3) nor are hybrids considered anywhere in the act.” They also consider the treatment of hybrids in the Migratory Bird Treaty Act, the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES).

O’Brien, S.J., and E. Mayr. 1991. Bureaucratic mischief: recognizing endangered species and subspecies. Science 251:1187-1188.

This letter points out some of the shortcomings of the “hybrid policy” that resulted from the

1977 statements by a Department of Interior solicitor (see Haig & Allendorf 1996). The authors note that a number of species listed under the Endangered Species Act (Florida panther, gray wolves in the midwest, red wolves, and dusky seaside sparrow) may not be listable under this policy. In the case of the dusky seaside sparrow, this policy prevented the release of captive bred "hybrid" sparrows, and the species soon became extinct. In addressing the hybrid policy, they state: "the Hybrid Policy that discourages production of hybrids between species seems appropriate and should be affirmed." But the policy should not prevent listing of species that hybridize within zones so long as the hybridization "does not disintegrate the genetic organization of the species in contact." For subspecies and populations the Hybrid Policy should be dropped. But "managed facilitation of subspecies mixing would generally be discouraged although, in certain extreme cases, it may be justified."

Their thoughts and comments are based on their embrace of the biological species concept for organizing the biological world. This concept maintains that "species" are strongly isolated from one another by reproductive barriers such that gene flow between species does not occur if they come into contact, although bounded hybrid zones may develop. It reflects "…the irreversible process of speciation." Many species, however, can hybridize with other recognized species resulting in introgression which may lead to range of outcomes, including speciation.

Trouwborst, A. 2014. Exploring the Legal Status of Wolf-Dog Hybrids and Other Dubious Animals: International and EU Law and the Wildlife Conservation Problem of Hybridization with Domestic and Alien Species. Reciel 23:111-124

This paper seeks to clarify the obligations of the (European) countries that signed onto the 1979 Bern Convention as it relates to native species of wildlife that hybridize with exotic or domestic animals. He focuses on hybridization between wolves (*Canis lupus*) and domestic dogs. Neither the Bern Convention nor the European Union (EU)'s 1992 Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (Habitats Directive) – which serves the implementation of the Bern Convention within the EU (all EU member states and the EU itself are contracting parties) – and associated case law of the EU Court of Justice (ECJ) does not directly address anthropogenic hybridization. He also examines the Convention on Biological Diversity (CBD) and the Convention on Trade in Endangered Species (CITES).

Tying the Bern Convention and Habitats Directive to CITES, he concludes that: 1) wolves and wolf-dog hybrids should be protected from harvest; and 2) removal of hybrids is essentially required based on policy as an active measure to conserve wolves. He also concludes "…it would probably be most appropriate, in line with evolving scientific insights, to adopt an ad hoc definition of hybrids incorporating genetics and morphology, whereby any wolf-like animal that can be proven (genetically) to have certain dog genes and/or (morphologically) to have certain physical dog characteristics, is considered a 'wolf-dog hybrid'" similar to that which has been recently proposed for discerning mostly pure Scottish wildcats from domestic cats and hybrids between the two.

DRAFT

Appendix 2

Draft of invitation letter sent to participants.

DRAFT

North Carolina State University is a land-grant university and a constituent institution of The University of North Carolina

College of Agriculture and Life Sciences
Department of Applied Ecology

NC STATE UNIVERSITY

127 David Clark Labs
Campus Box 7617
Raleigh, NC 27695-7617

October 5, 2015

Dear XXXX:

Recently, the USFWS halted the recovery program of the Red Wolf partly in response to the uncertainties identified in an independent review and evaluation of the program. One of the key questions centers on the effect of hybridization on a species' conservation status. To address this quintessential question we are convening an expert workshop to investigate, address, and evaluate the level of scientific consensus for two primary interrelated questions at the source of the uncertainty: (a) how does human-caused mortality affect reproductive barriers among red wolves and coyotes; and (b) at what point (if ever) should ongoing genetic introgression prompt the removal of a species from an Endangered Species Act listing? The workshop will involve approximately 15 world-class, leading experts in endangered species policy/law, conservation genetics, taxonomy, and population biology, with a special focus on canids and red wolves in particular.

Based on your expertise and standing within the scientific community and legal/policy community, we would like to formally invite you to participate as a core member of our workshop, and in follow-up publication(s) to emerge from the workshop. We will cover all expenses (travel, room/board, and food) and provide an honorarium in the amount of $2000 for each core participant.

The workshop will take place at the Charlie Elliott Wildlife Center, a 6,400-acre nature preserve located in central Georgia in a beautiful wooded setting easily accessible from the Atlanta International Airport. In addition to 27 hotel-style guest rooms and expansive banquet hall, the Center hosts a diverse array of outdoor activities including fishing, hunting, hiking, bird watching, and a shooting range. We have the week of May 23-27, 2016 reserved at the center and anticipate the workshop taking 2.5 days not including travel time.

We would appreciate a reply and confirmation by November 1 so that we can plan accordingly.

Sincerely,

L. Scott Mills, Department of Forestry and Environmental Resources, NCSU
Richard Frederickson, Missoula, MT
David R. Smith, USGS - Leetown Science Center
Jaime Collazo, Department of Applied Ecology, NCSU
Krishna Pacifici, Department of Applied Ecology, NCSU

DRAFT

Wolf Reintroduction Feasibility in the Adirondack Park

Prepared for the Adirondack Citizens Advisory Committee on the Feasibility of Wolf Reintroduction

by
Paul C. Paquet, Ph.D.,
James R. Strittholt, Ph.D.,
and Nancy L. Staus, M.S.

Conservation Biology Institute
Corvallis, OR 97330
October, 1999



INTRODUCTION

It has been commonly reported that gray wolves (*Canis lupus*) as well as other predators like panthers (*Felis concolor*) and lynx (*Lynx canadensis*) once lived throughout the northeastern U.S. including what is today the Adirondack Park. Extirpation of these summit predators closely followed European settlement (see Schneider 1997). As a result of an active bounty system, the last wolf was believed to have been killed in Upstate New York during the mid 1890s.

In recent years, gray wolf recovery (both natural and human-directed) has been successful in a number of locations throughout North America -- most successfully in the Upper Great Lakes region of the U.S. (see Fuller 1995). A second population of gray wolves in the eastern U.S. outside the Minnesota population has been expressed as a goal for gray wolf recovery in the U.S. by federal agencies (see U.S. Fish and Wildlife Service 1992), and the Northeast has been identified as a potential region to support a viable population of wolves. In addition to northern sections of Maine, New Hampshire, and Vermont, the AP has been identified as potentially supportive of gray wolves (see Mladenoff and Sickley 1998).

This study was by the Adirondack Park Citizens Action Committee organized by Defenders of Wildlife to examine the issue of gray wolf recovery in the Adirondack Park (from now on referred to as simply AP). By combining what has been learned about wolf biology from numerous field studies with geographic information systems (GIS), we addressed the issue of gray wolf reintroduction feasibility in the AP. In addition to developing wolf habitat suitability and connectivity models, we examined the important genetics questions pertinent to wolves in the AP.

GRAY WOLF NATURAL HISTORY

Historically, the primary limiting factor for gray wolves has not been habitat degradation, but direct persecution through hunting, trapping, and predator control programs. As public antipredator sentiment and the economic importance of the livestock industry diminishes, wolves are well equipped biologically to recolonize what remains of their former range. Map-based regional conservation planning can help facilitate human-wolf coexistence by identifying areas where human development and high quality wolf habitat do not come in contact (Mladenoff et al. 1995, Boitani et al. 1997, Mladenoff et al. 1997). To predict what influence wolves would have on the biology of the Adirondacks requires a general understanding of wolf population dynamics, and the ecological relationships between wolves and their prey (primarily ungulates), scavengers, and other predators. The biology, of course, is strongly modified and often constrained by the historic and ongoing activities of humans on the landscape.

Wolf Population Dynamics

Wolf population dynamics are believed to be largely dictated by the per capita amount of prey, vulnerability of prey, and the degree of human exploitation (Keith 1983, Fuller 1989). The effect of food on wolf demography is mediated by social factors, including pack formation, territorial behavior, exclusive breeding, deferred reproduction, intraspecific aggression, dispersal, and by primary prey shifts (Packard and Mech 1980, Keith 1983, Paquet et al. 1996).

The wolf shows high levels of ecological resilience compared with other large carnivores due to the species' exceptional adaptability and favorable life history traits (Weaver et al. 1996). Wolves demonstrate the ability to alter their own social structure by altering pack structure (Chepko-Sade and Shields 1987), fertility levels, dispersal, and tolerance of other wolves in response to shifts in their own population densities. These social changes are usually precipitated by different levels of mortality within packs and regional prey abundances (Fritts and Mech 1981, Fuller 1989, Boyd et al. 1995, Weaver et al. 1996).

Unlike other large carnivores, wolves have a high capacity to replace their numbers because they reach sexual maturity at an early age and have large litters. This is one reason why wolves, in comparison with other large carnivores, have been able to withstand high levels of mortality. Because of this high reproductive capacity, one would expect wolves to outnumber other predators in a region, but population densities of wolves are usually far lower than population densities of other large carnivores (e.g., bears) occupying the same areas. There are several reasons for this: (1) wolves are easily displaced by human activities; (2) social animals are more susceptible to removal than solitary animals; (3) unlike bears, wolves are active throughout the year; (4) wolves occupy large home ranges, which increases exposure to humans; and (5) wolves often travel long distances, which increases exposure to humans. Wolves do not become casualties of management due to direct contact with humans as frequently as bears (wolves tend to avoid humans), but wolves are often sought out and killed because of predation on domesticated animals, predation on a preferred game species, or for sport.

Biologists usually define the home range of a wolf as an area within which it can meet all of its annual biological requirements. Seasonal feeding, security needs, unobstructed travel routes, denning sites, and the bearing and raising of young are all essential life history requirements. The manner in which habitats for these requirements are used and distributed influences home range size and local and regional population densities and distributions. Generally, wolves locate their home ranges in areas where adequate prey is available and human interference is minimized (Mladenoff et al. 1995). Wolves also use their home ranges in ways that maximize encounters with prey (Huggard 1993a,b). Home range selection by wolves is influenced by a number of important factors. Among them is topographic position, which has been shown to influence selection of home ranges as well as intra- and interregional travel routes (Paquet et al. 1996). In mountainous areas, wolf use of valley bottoms and lower slopes during the winter months usually correspond to the presence of ungulate prey (Paquet et al. 1996, Boyd 1997). Notably, humans are

attracted to these same areas for recreation and facility development such as highways and railroads.

In expanding populations, many wolves become dispersers. Wolves can disperse over hundreds of kilometers. Mean dispersal distances reported in published works varied from 65 to 154 km (40-95 miles) for males and from 65 to 123 km (40-76 miles) for females (Fritts and Mech 1981, Peterson et al. 1984, Fuller 1989, Gese and Mech 1991, Wydeven et al. 1995, Ballard et al. 1987, Boyd 1997). The longest dispersal distance recorded for a wolf is 840 km (520 miles) (Boyd et al. 1995). Colonizing wolves have been known to move in areas greater than 100,000 km² (Paquet unpublished data).

Dispersal is a critical element of colonization (Gese and Mech 1991, Boyd et al. 1995). It also may be an important process in gene flow (Forbes and Boyd 1996), social organization, and metapopulation persistence. Because of their capacity for long range dispersal, the typical genetic threats associated with small population sizes are of less concern for wolves than for other animals (Fritts and Carbyn 1995, Boyd et al. 1996, Forbes and Boyd 1997). Both sexes disperse, resulting in higher effective population size (N_e) (Chepko-Sade et al. 1987, Forbes and Boyd 1997). Dispersal dynamics are important at within-population and metapopulation scales (Haight et al. 1998).

Wolf-Prey Interactions

As stated earlier, wolf numbers are closely linked to population levels of their ungulate prey (Keith 1983, Messier 1985, Fuller 1989). Because wolves rely primarily on ungulates for food, survival of wolves in the Adirondacks will depend on protection of habitat for deer and to a lesser degree moose and beaver. Viable, well-distributed wolf populations are always linked to abundant, stable, and available prey populations.

In environments where factors such as weather and hunting reduce prey populations substantially, predation by wolves can inhibit the recovery of prey populations for long periods (Gasaway et al. 1983). In a multiprey system, the stability (or equilibrium) of ungulate prey and wolf populations seems to depend on a variety of factors, including the wolf predation rate, the number of ungulates killed by hunters, the ratio of ungulates to wolves, and the population growth rate of different ungulate species (Carbyn 1982, Paquet 1993, Paquet et al. 1996, Weaver 1994).

Many studies have emphasized the direct effects (e.g., prey mortality) wolves have on the population dynamics of their ungulate prey (Carbyn 1974, Carbyn 1983, Gasaway et al. 1983, Messier 1994, Messier and Crete 1985, Peterson et al. 1984, Ballard et al. 1987, Boutin 1992, and others). However, predation also can profoundly affect the behavior of prey, including use of habitat, time of activity, foraging mode, diet, mating systems, and life histories. Accordingly, several studies describe the influence wolves have on movements, distribution, and habitat selection of caribou, moose, and white-tailed deer (Mech 1977a, Ballard et al. 1987, Nelson and Mech 1981, Messier and Barrette 1985, Messier 1994).

Without human disturbance, wolf densities generally reflect the dependency on ungulate prey species (Keith 1983). Wolves can increase the rate at which they acquire resources by seeking out areas with dense concentrations of prey (Huggard 1991, Weaver 1994). Prey, in turn, can lower their expected mortality rate by preferentially residing in areas with few or no wolves.

Several studies have suggested that ungulate prey seek out predator-free refugia to avoid predation by wolves (Mech 1977, Paquet 1993). Wolf predation in the Superior National Forest (SNF) of northern Minnesota was found to affect deer distributions within wolf territories (Mech 1977). Densities were greater along edges of territories where predation was thought to be less. However, recent studies in Banff National Park, Alberta support an alternative explanation that ungulate productivity is higher in areas without wolves, which results in higher prey numbers in predator-free zones (Paquet et al. 1996). This phenomenon may be pertinent to the Adirondack Park region.

Wolf packs may react to changing conditions in varying ways, depending on the location of their territories in relation to other packs and prey distribution. If packs have lower prey densities within their territories, they may exploit territories more intensely. Territory size is more closely correlated with pack size than with prey density (Messier 1985a, Peterson et al. 1984), and in areas of higher prey density, pack sizes increase (Messier 1985b). Messier's (1985b) data indicate that between 0.2 and 0.4 moose/km², territory area per wolf is independent of moose abundance. This may be achieved by: (1) persevering in each prey attack, (2) using carcasses thoroughly, (3) feeding on alternative and possibly second-choice food resources such as beaver (Messier and Crete 1985), and (4) patrolling their territory more intensely (Messier 1985b). Messier, in his study area in southeastern Quebec, found daily distances of Low Prey packs were on average either greater than (in summer) or equal to (in winter) daily distances of High Prey packs. The territory size, however, was approximately 35% smaller in the Low Prey area, suggesting that wolves were searching each unit area with greater intensity in both seasons.

Miller (1976) reported that wolf-killed caribou were not randomly distributed, and therefore certain sites must give wolves an advantage over their prey. Peterson and Woolington (1984) found most wolf-killed moose on the Kenai Peninsula in old burns, often associated with small stands of timber remaining in the burn. Stephens and Page (1987) concluded that moose seek conifer cover and its associated structure to reduce attack rates by wolves. In theory, changes in habitat composition and distribution can have a profound effect on ungulate densities and distributions, and therefore wolf spatial distribution.

Antipredator behaviors of ungulates may substantially influence habitat selection by wolves and prey. The natural dispersion of ungulate prey over many patches, and spatial variation in population growth, may lead to a "source-sink" population structure for wolves and their prey (Huggard 1991, Paquet et al. 1996). Human activities also may alter these spatial dynamics in unanticipated and adverse ways. For example, deer and

moose are highly vulnerable to wolf predation in fragmented habitats created by clearcuts (ADFG). Fragmented landscapes create greater edge area and potentially less and/or inaccessible escape cover. In some instances, wolves may be deprived access (spatial isolation) to ungulate prey because of human created impediments to movement (e.g., town sites, highways), which results in artificial predator-free zones (Paquet 1993, Paquet et al. 1996). Conversely, activities such as cross-country skiing or keeping roads snow-free may provide wolves access to refugia traditionally used by ungulates to avoid predators (Paquet 1993, Paquet et al. 1996). These changes can lead to different intrinsic rates of growth for ungulates using different habitat patches. Over time, the distribution, density, and long-term demographic patterns of ungulates may depart from the "undisturbed norm."

The human induced change in predator-prey relationships may also affect species other than wolves and their prey. Disruption of top predators can affect interspecific associations by disrupting relationships within food webs. This, in turn, may cause unanticipated ripple effects in populations of other species (Paine 1966, 1969, 1980; Terborgh and Winter 1980, Frankel and Soulé 1981, Wilcox and Murphy 1985, Wilcove et al. 1986), which markedly alter the diversity and composition of a community (Paine 1966). Multispecies effects often occur when changes in a third species mediate the effect of one species on a second species (or analogous higher-order interactions). For example, a wolf can affect a grizzly bear by reducing the availability of a limiting resource (possibly an ungulate). Also a secondary carnivore such as a coyote (*C. latrans*) can affect the degree to which a herbivore's lifestyle is influenced by a primary carnivore such as a wolf. Ecologists have only begun to develop theory that attempts to explain the coexistence of prey in terms of predator-influenced niches ("enemy-free space").

As noted above, many indirect effects of predation on community structure and diversity have been proposed. Research has documented differences within systems from which large predators have been removed or are missing (Soulé et al. 1988, Terborgh 1988). A recent study on Isle Royale, Michigan found strong evidence of top-down control of a food chain by wolves. Growth rates of balsam fir (*Abies balsamea*) were regulated by moose density, which in turn was controlled by wolf predation (McLaren and Peterson 1994). When the wolf population declined for any reason, moose reached high densities and suppressed fir growth. This top-down "trophic cascade" regulation is apparently replaced by bottom-up influences only when stand-replacing disturbances such as fire or large windstorms occur at times when moose density is already low (McLaren and Peterson 1994).

Tolerance to Human Disturbance

If we are to judge the effects of human influence, then we must know the uninfluenced norms and ranges. Information on wolf responses to natural causes of population fluctuations is lacking, and influence by humans is therefore imperfectly understood. The specific conditions in which wolves are "disturbed" (i.e., distribution, movements, survival, or fertility are impaired) are believed to be highly variable. The

extent and intensity of disturbance appear to vary with the environmental and social context and the individual animal. Though many large carnivores are sensitive to human predation and harassment (Thiel 1985, Mattson et al. 1987, McLellan and Shackleton 1988, Knight et al. 1988, Mattson and Knight 1991 a,b, Thurber et al. 1994), we have limited empirical information on tolerance to indirect human disturbance. However, many researchers believe that the response of species to a particular disturbance depends largely on disturbance-history. Disturbance-history is a critical concept in understanding the behavior of long-lived animals that learn through social transmission (Curatolo and Murphy 1986, S. Minta pers. commun.). New disturbances, with established background disturbance, may surpass the level of habituation or innate behavioral plasticity that allows the animal to cope with disruption.

To complicate an already complex situation further, it is unlikely that all carnivore species or individuals within species react equally to human induced change. Species adapted to mature forests or large tracts of undisturbed land, such as grizzly bears or wolves, may be especially vulnerable to loss of habitat and human disturbance.

We can group human impacts into influences on wolf habitat and populations. Habitat disturbance can be short or long term and can include direct loss of habitat (i.e., vegetation removal and change) or indirect loss because of incompatible activities. Direct habitat loss does not include the loss of habitat due to temporal or spatial alienation (sensory disturbance) or from fragmentation of habitat. Indirect losses will occur due to habitat alienation, where animals abandon habitat because of nearby disturbances or are spatially isolated from using them because of impediments to movements. Changes in population can occur directly through alterations in habitat and indirectly because of disturbing activities.

The major effects of human induced changes are, in order of decreasing importance, physical loss of habitat, fragmentation of habitat, isolation of habitat, alienation of habitat, alteration of habitat, changes in original ratios of habitat, and changes in juxtaposition of habitats. These effects combine to have local and population level influences by altering the composition of biological communities upon which wolves are dependent, restricting movements, reducing foraging opportunities, and limiting access to prey. Obstructing movements also increases the vulnerability of wolves to other disturbances as they attempt to learn new travel routes.

The degree to which human activities disrupt wolves reflects the type and extent of disturbance, which interacts with the natural environment to affect environmental quality. In mountainous landscapes such as the Adirondacks, wildlife often responds markedly to disturbances that occur at small spatial scales. This is because the topography amplifies the effects of disturbances by concentrating activities of humans and wildlife into valley bottoms. The forced convergence of activities limits spatially the range of options wildlife has for coping with disruption, reducing resilience to human disturbance (Weaver et al. 1996).

Habitat selection by wolves is a complex interaction of physiography, prey availability, security from harassment, population density, and disturbance history, and each facet is subject to reliable modeling provided the data needed to examine them are available. Seasonality is also an important consideration in examining wolf habitat effectiveness. In summer, wolves need to den and raise their young, whereas in winter, wolves must remain active and survive harsh conditions.

THE LATEST GENETICS STORY

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Genetic Characterization and Taxonomic Description of New York Canids

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HISTORIC NEW YORK WOLVES

Wolves existed within what is now New York State before and during early European settlement. However, the distribution of canids has changed dramatically within the last two hundred years. De Kay (1842) described the common American gray wolf (*Lupus occidentalis*) inhabiting New York State:

Characteristics: Color various from white to black, usually greyish. Space between ears greater than their height. Feet broad. Neck and tail with bushy hair.

DeKay further described two varieties of the American wolf:

Var. a. *Grey Wolf*. White or greyish in winter, in summer it has short reddish hairs. This is the most common kind.

Var. b. *Black Wolf*. Entirely black, more bulky and powerful than the preceding. Very rare.

The predominant prey of the most common wolf (Var. a.) was described as white-tailed deer (*Odocoileus virginianus*). In the mid-1800s, the distribution of wolves in New York State was reduced to mountainous and wooded parts and the counties along the St. Lawrence. The reduction of wolf numbers in the 1800s resulted in the near or complete extirpation of wolves in the State. This was heavily influenced by bounties of $10-$20 per wolf.

Characteristics described by De Kay (1842) are consistent with two overlapping

wolves: the eastern Canadian wolf (*C. lycaon*) as Var. a. and the gray wolf (*C. lupus*). The above taxonomic classifications are based on recent genetic research conducted at Trent and McMaster Universities. The new evidence suggests the need for a revision of canid taxonomy in eastern North America. Mitochondrial DNA (mtDNA) and microsatellite DNA analysis of the eastern Canadian wolf and the red wolf (*C. rufus*) indicated a close genetic relationship between these two wolves. Furthermore, the evolution of these two species appears independent of the gray wolf (Wilson et al. 1999 - see appended manuscript). Under this proposed evolutionary model, the progenitor of the gray wolf migrated to Eurasia 1-2 million years ago and subsequently returned to North America during the Pleistocene approximately 300,000 years ago. In addition to the genetic data, morphology and the fossil record support the close relationship of the eastern Canadian wolf and the red wolf. Perhaps the most important similarity between the proposed North American evolved wolves is their ability to hybridize with coyotes. Hybridization between wolves and coyotes appears limited to eastern North America, i.e. east of Minnesota and Manitoba, and under the proposed evolutionary history, represents the interbreeding of closely related sister taxa and not the hybridization of gray wolves and coyotes that diverged 1-2 million years ago. The recommended species name for the eastern Canadian wolf/red wolf is *C. lycaon*.

We tested this model by analyzing the genetic markers of wolves present in southeastern Canada and the northeastern U.S. before the arrival of coyotes into the area. The last reported wolf in New York was killed and mounted in 1893 (Adirondack Museum; Catalogue Number 79.10.1). This animal was described as follows:
Descriptors: Nat Hist 10
Provenance: Trapped by Reuben Cary, donor's grandfather
Description: WOLF- last gray wolf killed in Adks. Stuffed and mounted. Two tags on mount: "Gray Wolf/canis occidentalis Pick/ The last wolf killed in the Adirondacks. Shot near Brandeth Lake, Hamilton County November 10, 1893 by Reuben Cary. Loaned by General E. A. McAlpin." "This wolf was caught in a trap in the Clearing by Reuben Cary in November 1893." The above inscription was placed on the wolf when he was exhibited at the St. Louis World's Fair by the Forest Fish & Game Commission in 1903.
Dimensions: 27" at shoulder,
Condition: 52" nose to tail.

We analyzed a sample of hide from the 1893 wolf and identified a coyote-related mtDNA. Given the absence of coyotes in New York State in 1893, the coyote-related genetic marker is consistent with the evolution of a New World wolf more closely related to the coyote (*C. latrans*) than the gray wolf. Other genetic models of eastern canid history describe the hybridization of gray wolves (*C. lupus*) and coyotes (Lehman et al. 1991, Wayne and Lehman 1992, Roy et al. 1994, Roy et al. 1996). Under this model, eastern wolves, before the arrival of coyotes, should contain only a gray wolf (*C. lupus*) mtDNA. Coyote mtDNA would not have been introgressed into wolf populations until the expansion of coyotes into this region. Therefore, the genetic analysis of the 1893 historic wolf sample supports the existence of *C. lycaon*.

EASTERN COYOTES

The coyote (*Canis latrans*) has expanded its range extensively over the past 100 years, from southwestern U.S. (Great Plains) into northeastern U.S., southeastern Canada, the Great Lakes region, northern Quebec, Yukon, and Alaska. The cause of this expansion has been accredited to alterations in habitat previously occupied by wolves (*C. lupus*) (Nowak 1978). Following an almost 30-year period during which no wolves were known to occur in New York, a coyote-like animal was reported in the St. Lawrence Valley area in 1920. Reports of large coyote-like animals continued to increase in the early 1930s in Ontario and as early as 1936 in Maine. Coyotes were considered common in the Adirondacks, New York during the 1950s. By the 1970s these animals had extended their range across southeastern Canada and the northeastern states, migrating to Newfoundland in 1987 (Moore and Parker 1992).

The larger body size of the "eastern coyote" differentiates it from the western coyote; i.e. skull measurements of eastern coyotes are intermediate between western coyotes and gray wolves (Lawrence and Bossart 1975, Nowak 1979). In addition, the behavior of eastern coyotes has been described as more aggressive than western coyotes (Silver and Silver 1969). White-tailed deer constitute as much as 75-90% the eastern coyote's (Chambers 1975, Messier et al. 1996).

Four main hypotheses have been proposed to explain the larger morphology and intermediate wolf-like characteristics of the eastern coyote. First, the eastern coyote represents a "coydog" resulting from dog (*C. l. domesticus*) and coyote interbreeding (Silver and Silver 1969, Mengel 1971, Lawrence and Bossart 1975). Second, the eastern coyote has undergone selection for a larger body size as an adaptive response to larger prey, specifically white-tailed deer (Kolenosky and Stanfield 1975, Schmitz and Kolenosky 1985, Schmitz and Lavigne 1987). Third, the eastern coyote has undergone a phenotypic response to enhanced food supply in the eastern range of coyotes (Thurber and Peterson 1991). Lastly, the eastern coyote is the result of hybridization between gray wolves (*C. lupus*) and expanding coyotes with subsequent selection for larger prey, specifically white-tailed deer (Silver and Silver 1969, Mengel 1971, Lawrence and Bossart 1975, Nowak 1978, Lariviere and Crete 1993).

We have found little evidence for coyote/dog inter-breeding resulting in hybrid coydog populations. Breeding experiments between coyotes and dogs (Silver and Silver 1969, Mengel 1971) revealed breeding asynchrony between the canid species and F1 hybrids, little or no parental care from coydog males, and deformities in several of the offspring. The authors concluded that viable coydog populations were not likely under natural conditions in the wild. Recent genetic evidence suggests that even wolves and dogs, which are the same species (*C. lupus*), do not readily inter-breed under natural conditions (Vila and Wayne 1998). An additional line of evidence discounting the viability of natural coydog populations is based on geography. The larger morphology of the coyote is observed in specific eastern regions of North America. However, one would predict that the ubiquitous presence of dogs throughout the US and Canada should result in similar hybridization elsewhere.

The second hypothesis (adaptation to larger prey size) and third hypothesis (phenotypic response to food supply) have generated some debate (Schmitz and Kolenosky 1985, Schmitz and Lavigne 1987, Thurber and Peterson 1991, Lariviere and Crete 1993). The debate stems from the role that genetic selection may have on the morphology of the eastern coyote and whether hybridization with wolves is necessary to explain the increased morphology of eastern coyotes. Laviviere and Crete (1993) identify a number of critical points in the approach taken by Thurber and Peterson (1991) in their suggestion that food supply, in the absence of genetic selection, can account for the size differential observed in the eastern coyote. One point of agreement in the debate is the need to apply genetic markers to confirm or refute the presence of wolf genetic material introgressed into the eastern coyote.

Considerable genetic evidence exists that wolves (identified as gray wolves at the time) in the Great Lakes and eastern regions of Canada have hybridized with coyotes (Lehman et al. 1991, Wayne and Lehman 1992, Roy et al. 1994). A major conclusion from these studies was that hybridization did not affect coyote populations (i.e., the introgression of genetic material through inter-breeding was unidirectional (coyote-to-gray wolf). These results do not support the introgression of gray wolf genetic material into coyote populations that expanded into southeastern Canada and the northeastern U.S. One possible reason that *C. lupus* wolf mtDNA has not been observed within eastern coyote populations (Lehman et al. 1991, Wayne and Lehman 1992) is the evidence of the North American history of eastern Canadian wolf compared with the gray wolf (*C. lupus*) (Wilson et al. 1999). The mtDNA of eastern wolves (*C. lycaon*) is related to coyote mtDNA and may have been misdiagnosed as originating from coyote and not from *C. lycaon*. An additional problem in the analysis of the populations included in the Roy et al. (1994) study that represent the range of the eastern coyote (southern Quebec and Maine) is that canid samples from these two regions were *a priori* classified as wolf or coyote based on morphology. This classification potentially biased the taxonomic designation of these canids in the interpretation of the genetic data.

We examined 8 microsatellite loci in eastern coyotes from New York the Frontenac Axis of southern Ontario and New Brunswick. The eastern coyote samples were compared to a population of eastern Canadian wolves from Algonquin Provincial Park, to a Texan coyote population, and to other North American canid populations (Roy et al. 1994). In an analysis of the genetic distance of eastern coyotes from New York (n=20) and New Brunswick (n=20) coyotes, the eastern coyote population grouped together and appear more distinct from other coyote populations that do not demonstrate hybridization with wolves (Fig. 1). The coyote populations from Minnesota and Maine contain samples from animals defined as coyote-like based on morphology with the more wolf-like animals from these regions classified as Minnesota and southern Quebec "hybridizing wolves," respectively (Roy et al. 1994).

We also applied an Individual-Index (I_I) that provides an individual-specific genetic score that describes an animal as originating from one of two populations or describes the animal as a hybrid between the two. An individual index (I_I) was calculated for each

individual animal DNA profile using the following equation: $\Sigma \log (p_A/p_B)$, where p_A and p_B are the allele frequencies of a specific allele from population A and B, respectively. This LOD score value assesses the origin of the alleles in each animal based on a ratio of the frequencies from two populations. If there are similar allele frequencies in both populations, then the I_I values of individuals from both populations will follow a distribution around zero. An increasing positive score indicates an individual originated from population A, and a decreasing negative score indicates an individual originated from population B. In this application populations are representing canids from specific species.

I_I values for canids from New York, the Frontenac Axis, Ontario and New Brunswick were assessed using two database comparisons. The first two databases used in the analysis were Algonquin wolves versus Texas coyotes to assess whether the eastern coyotes represent pure *C. latrans*. Using these two databases, the eastern coyotes appear in the range predicted for hybrids and more wolf-like animals compared to Texas coyotes. The second analysis used the Algonquin wolves versus New York canids to assess at a finer scale whether individual canids demonstrated more wolf-like or coyote-like genetic profiles. Scatterplots of both database comparisons were generated (Fig. 2). New York (Fig. 2A) and New Brunswick (Fig. 2B) canids demonstrate I_I values in the range predicted for hybrids. The Frontenac Axis canids (Fig. 2C) revealed animals in the range of hybrid canids with a number of animals in the range observed for Algonquin wolves.these results support the introgression of eastern Canadian wolf genes into the expanding eastern coyote populations. This would not have been observed if wolf/coyote hybridization resulted in no introgression of wolf genetic material into coyote populations, as concluded in other genetic studies (Roy et al. 1994). Furthermore, the population structure of North American coyote populations was previously described as panmictic (Roy et al. 1994) with extensive gene flow throughout the continent. It is unlikely that population differentiation among coyote populations is sufficient to explain the differences observed between eastern and Texas coyotes using the I_I index. The above data support the fourth hypothesis listed. We conclude that eastern coyotes represent a hybrid between the eastern Canadian wolf (*C. lycaon*) and the coyote (*C. latrans*). Previous authors proposed the hybridization of coyotes specifically with *C. lycaon* (then described as *C. l. lycaon*) (Mengel 1971, Kolenosky 1971, Moore and Parker 1992). Despite the genetic evidence for hybridization, the introgression of wolf genes into eastern coyotes is not independent of selection acting on the eastern coyote hybrids based on prey size. In our opinion these hypotheses on natural selection acting on eastern coyotes are not mutually exclusive from wolf/coyote hybridization.

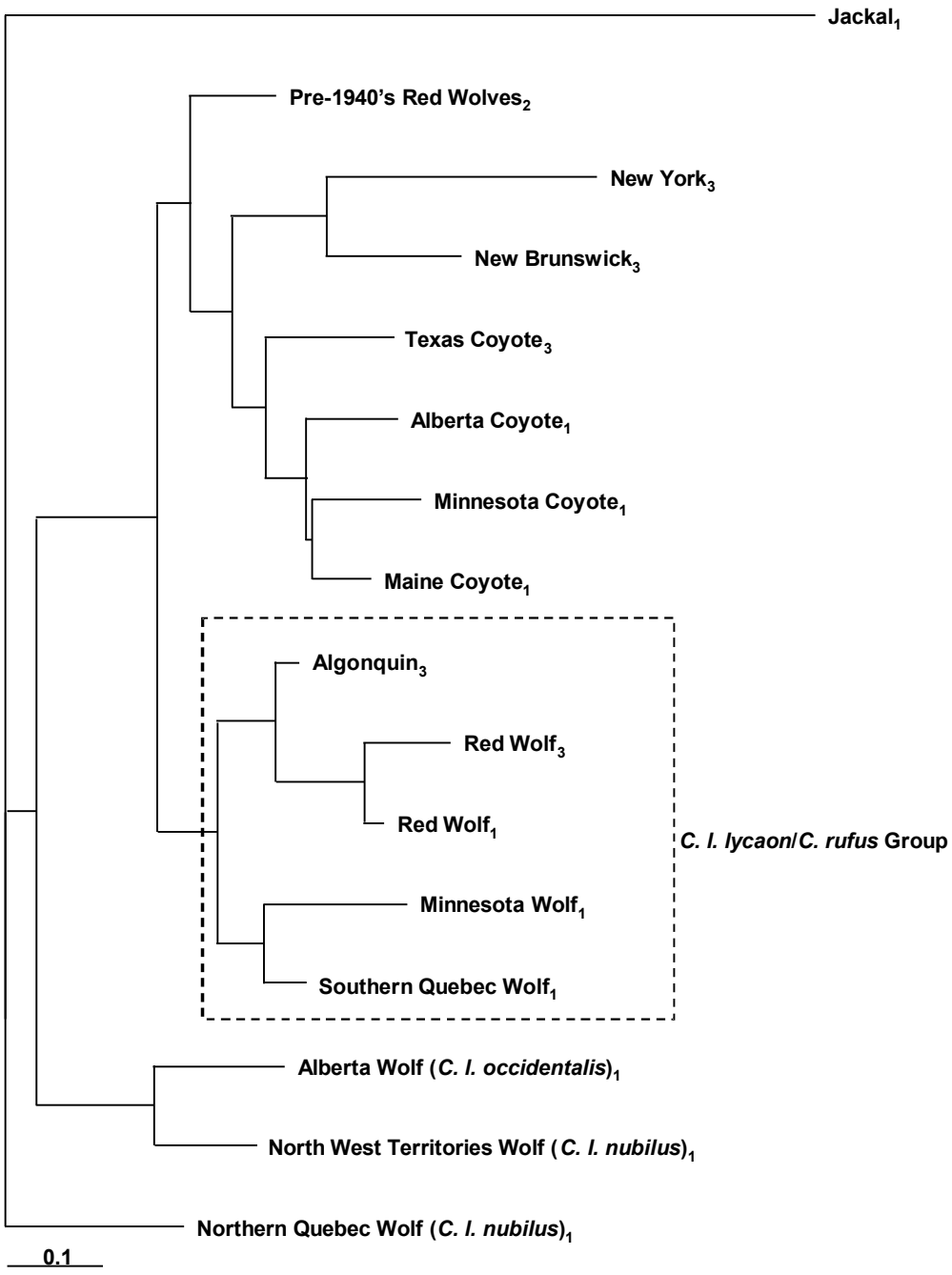


Figure 1. Neighbor-joining tree of Nei's unbiased genetic distances for allele frequencies from eight microsatellite loci. Number codes are provided to indicate the source of the allele frequencies from Roy et al. 1994 ($_1$), Roy et al. 1996 ($_2$) and this study ($_3$). Samples added in this study include: offspring from the red wolf breeding program (n=9); Algonquin Provincial Park (n=49); New York canids (n=20); New Brunswick canids (n=20); and Texas (n=20).

Fiure 2A. New York Canids

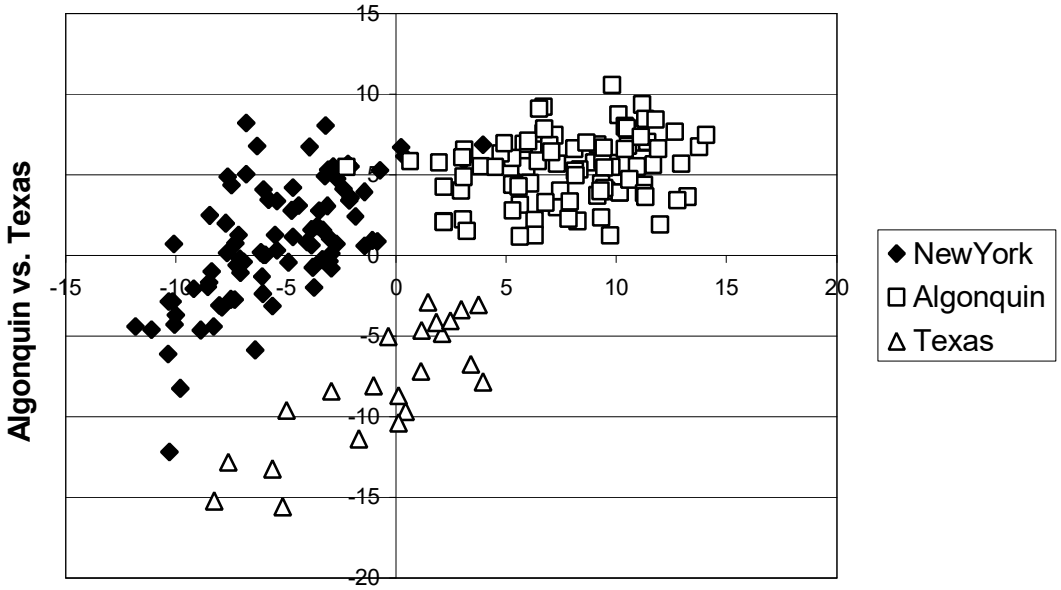
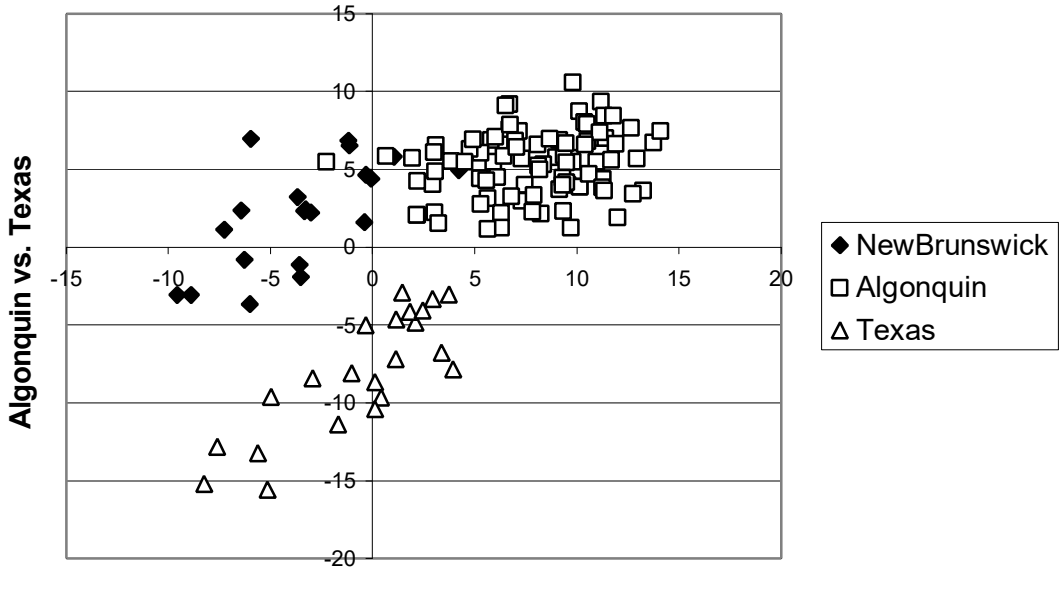


Figure 2B. New Brunswick Canids



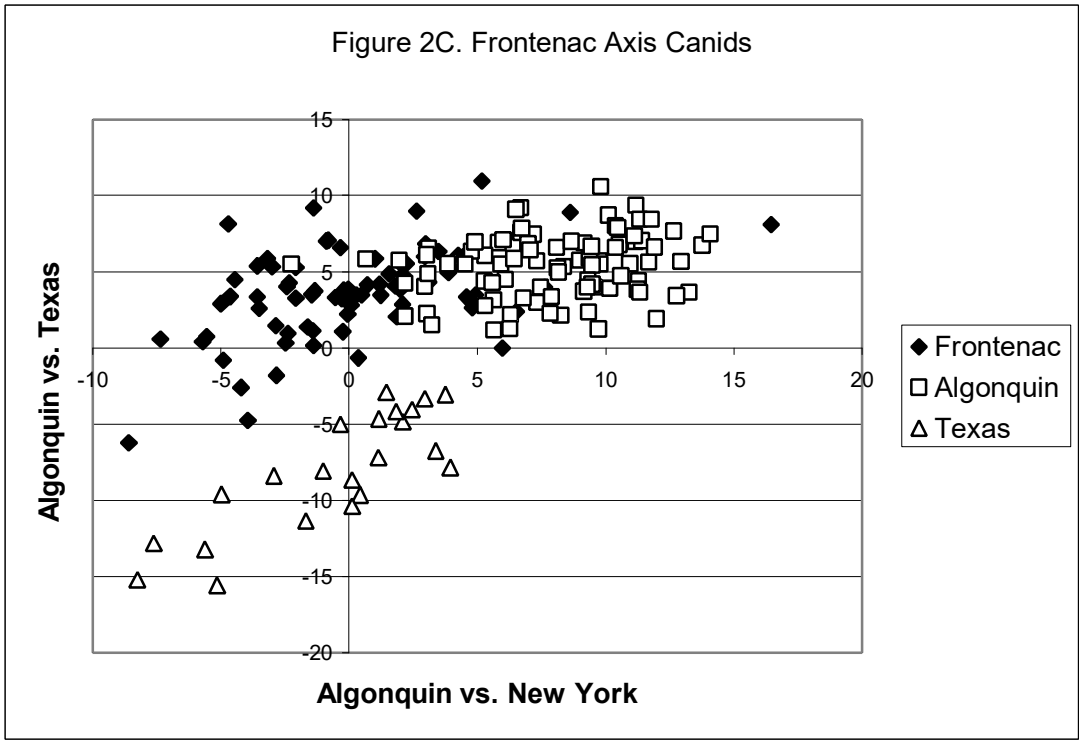


Figure 2. Log-likelihood individual indices (I_l) from eastern coyote canids, wolves from Algonquin Park and Texas coyotes. The I_l were calculated for each individual animal DNA profile at 8 microsatellite loci using the allele frequencies from the Algonquin Park/Texas coyote population and the Algonquin Park/New York populations. **A.** New York canids plotted on a scatterplot using the two comparisons. **B.** New Brunswick canids plotted on a scatterplot using the two comparisons. **C.** Frontenac Axis canids plotted on a scatterplot using the two comparisons.

MODELING WOLF HABITAT SUITABILITY

The recent development of spatially explicit theoretical models suggests that habitat selection by wolves is predictable at various spatial scales (Paquet et al. 1996, Alexander et al. 1996, and Mladenoff and Sickley 1998). Extensive fieldwork has verified the efficacy of these models (Appendix A). By generalizing site-specific empirical models, potential wolf habitat can be modeled in areas where wolves have been extirpated. However, important inputs for these models must be modified to reflect local conditions. Though modeling precisely how wolves might behave to a new environment is impossible (nature works under the laws of probability not absolutism), we can assess the feasibility of wolf reintroduction by building spatially explicit models based on field research.

Potential wolf habitat has been recently modeled for the northeastern US, including the Adirondack Park region, at a coarse spatial scale using only a few key criteria (Mladenoff and Sickley 1998). Using this modeling approach, favorable habitat conditions for wolves were identified in the Adirondack Park region (16,020 km ^{2}). The total area was considerably less than a previous estimate of 24,280 km ^{2} by the US Fish and Wildlife Service (1992).

In constructing a new habitat suitability model for the Adirondack Park, we derived model attributes from radiotelemetry and snow-tracking field data collected in the Rocky Mountains, Riding Mountain National Park (Manitoba), Pukaskwa National Park (Ontario), Minnesota, Wisconsin, and Italy. These areas differ significantly in landscape complexity, prey abundance, prey diversity, and extent of human development. The Adirondack Park, however, contains elements representative of all these areas. We supplemented these model attributes with habitat descriptors extracted from the relevant ecological literature. Where necessary, expert opinion was used to modify some model attributes. We also employed spatially explicit data sets at various scales (as fine as 1:24,000) and examined many additional aspects of wolf ecology not considered previously.

The Data

To conduct GIS-based (geographic information systems) analyses and models, spatially explicit digital (or computer readable) data must be assembled. With the help of many individuals throughout the Adirondack Park region, we were able to locate most of the datasets needed to construct reliable spatial models (see Table 1).

In GIS, data are usually discussed as a series of data layers (or themes). Layers are assembled as rasters (grid cells) or vectors (points, lines, and polygons). These layers are often referred to as the data "type." Resolution (the size of the smallest visible unit) is associated with raster data, and scale (relationship between distance on a map and distance on the ground) with vector data. For this study, some data layers were available only for the Adirondack Park (e.g., 1:24,000 roads), whereas other layers were available for the larger regional extent. Sources for the various data layers and timeliness of availability were varied. For the purposes of wolf habitat suitability and connectivity modeling, we also attempted to assess the quality of the data,

which helps us evaluate the certainty of various modeled components. We used three GIS software packages: Arc/Info® and ArcView® by ESRI, and ERDAS Imagine® by ERDAS.

The goal of our study was to provide ecological information necessary to assess the potential of the Adirondack region to support gray wolves. The primary objective was to construct a series of spatially explicit gray wolf habitat suitability models. Output from the model identifies areas with high biological capacity to support wolves, most probably wolf travel routes, areas with low human presence, and sites where wolf-human conflict might occur.

We constructed this model by evaluating, and where possible integrating, the results of four submodels (core security area, den suitability, physical, prey base, and displacement). Because snow dramatically influences habitat use by wolves, we decided to model winter and summer seasons independently in some cases. Summer was defined as 15 April to 15 September and winter as 16 September to 14 April. These periods reflect important biological events that influence wolf movements (e.g., denning activity and pups travelling with adults as a pack). We also chose to model wolf habitat suitability under pristine conditions ("pristine" defined here as the absence of modern humans) in the AP. Though speculative, this retrospective view helps us understand how humans influence the distribution and viability of regional wolf populations. The basic spatial models created also provided the necessary information to produce a surface for simulating the movements of wolves in the AP and between the AP and the surrounding region.

The data layers used in the models were organized as physical, biological, and cultural factors. Figure 1 shows how the different data layers (shown as trapezoids) were used to generate the results for the summer season under current conditions. Note that shaded trapezoids represent data layers that resulted from additional analyses (e.g., the determination of slope from elevation data or the calculation of road density from a road layer). The winter model flowchart excluded den suitability, added snowfall as an important physical factor and snowmobile trails under the cultural heading. Whenever pristine conditions were examined, all of the cultural influences were omitted.

Core Security Area Submodel

As explained in the natural history section, in human dominated landscapes wolf survival largely depends on reducing contact with people. Therefore, we assessed the spatial distribution of human influences within Adirondack Park to identify areas of core security for wolves. We defined core security areas as sites where wolves are least exposed to humans and their activities. Lacking a human use layer, we evaluated all the cultural data layers as potential surrogates of human activities. We concluded the roads layer was the best proxy available for the analysis. Accordingly, we delineated l core security areas by buffering all 1:24,000 roads by 1km (see Plate 1). The 1-km buffer reflects the distance human activities are known to disturb wolves (Chapman 1977, Paquet et al. 1996, and the distance wolves try to maintain between humans and themselves (Singleton 1995 , Paquet et al. 1996).

After applying the buffer, 420 landscape polygons totalling 2,317,241 ha were identified. Polygons less than 15,000 ha were eliminated because we considered them too small to support a lack of gray wolves over time. We did not screen for polygon shape, distance between polygons, or condition of the matrix between polygons. Consequently, wolves may not have access to some sites because of impediments to movement. Therefore, wolves might not use some core areas identified as secure.

We identified eighteen core security areas that, depending on size, could function independently or collectively as linked habitat patches. The areas range in size from 15,051 ha to 202,998 ha. Land ownership (see Plate 2, Table 2) characterizes each site. We consider these sites the most secure areas for wolves within the AP. Note that our analysis accounts only for habitat security and not habitat quality. In most instances, wolves are attracted to high quality habitats and repulsed by human activities. In human dominated landscapes, these two factors interact to create a dynamic tension that wolves must balance to secure necessary life requisites. In some cases wolves are willing to sacrifice security for the benefits associated with high quality habitat. Conversely, wolves are easily displaced from poor quality habitats when exposed to low levels of human activities. All models were evaluated using these 18 core security areas as a landscape mask. In total, 1,100,775 ha (or 47%) of the AP is sufficiently secure to support wolves.

Table 2. Size and ownership composition of the 18 core security areas mapped for the Adirondack Park, NY.

Core Security #	Area (ha)	Area (ac)	Percent Private	Percent Easement	Percent Public
1	19,792	48,886	93.90	0.00	6.10
2	15,435	38,124	82.27	0.00	17.73
3	20,477	50,578	38.21	0.00	61.79
4	94,085	232,390	39.50	39.44	21.06
5	15,675	38,717	24.84	69.93	5.23
6	41,035	101,356	65.54	29.11	5.35
7	15,051	37,176	4.60	0.00	95.40
8	167,265	413,144	33.49	2.52	63.99
9	197,263	487,240	35.66	4.96	59.38
10	49,808	123,026	42.91	0.00	57.09
11	20,594	50,867	3.34	0.00	96.66
12	17,588	43,442	10.52	0.00	89.48
13	55,210	136,369	39.05	3.48	57.47
14	202,998	501,405	16.65	2.15	81.20
15	52,846	130,530	16.05	0.00	83.95
16	41,073	101,450	19.86	0.00	80.14
17	46,342	114,465	3.33	0.00	96.67
18	28,238	69,748	19.71	0.00	80.29
Totals	1,100,775	2,718,913	32.75	8.42	58.83

Physical Submodel

Although ecosystem generalists, wolves in mountainous regions concentrate activities in forested valley bottoms due to the effects of physiography, weather, prey distribution, and prey abundance (Paquet 1993, Paquet et al. 1996, Weaver 1994, Singleton 1995, and others). Wolves respond to movements of their prey, using valleys during winter, and increasing their range to more upland habitats during summer. Travel routes are usually composed of adjoining habitats or patches of habitat linked by natural linear features. Travel and habitat selection is influenced by availability of prey and location and connectivity of optimal inter-patch travel routes. Rugged topography severely limits the number of landscape linkages in mountainous areas by restricting movements. Although wolves are highly mobile, they cannot reach all areas of potential habitat if landscape connectivity is limited. Dispersal and immigration also are critical to the persistence of populations in marginal habitat. Data on characteristics of dispersal habitat are limited, but studies in the Rockies have identified topographic "funnels," prey patches, distance from centers of human development, and low human population density as factors favoring north-south dispersal along the Rockies from Banff to Montana (Boyd et al. 1995). Slope, aspect and elevation were finer-scale constraints on wolf movement within the Banff area and regions of Ontario (Paquet et al. 1997). In areas such as Ontario and Minnesota, where larger source populations are found in gentler terrain, effective dispersal occurs through semi-developed habitat (Mech et al. 1995, S. Fritts pers. comm.). Wolves have a preference for more gentle terrain and a tendency to prefer flat, west and southwest aspects during summer and winter months.

For the AP model, we created a map that reflects the suitability of the physical environment to support wolves. The initial physical model assumes no human activities have occurred. The probability that a species will use a certain area or travel a particular path is expressed as a function of known behavioral characteristics of wolves, the physical environment, and distribution of physical resources. For the summer season, we derived slope and aspect from the 1:250,000 DEM (Digital Elevation Model). We assigned wolf suitability scores and descriptions for slope and aspect based on radiotelemetry studies conducted in other regions. Table 3 provides suitability scores for the slope values and Table 4 provides the same for aspect. Slope and aspect suitability scores were then combined providing an overall physical use score (see Table 5).

Table 3. Slope wolf use probabilities, suitability descriptions, and scores.

Slope use probability	Suitability	Score
.5 – 6	Very low	1
6 – 11	Low	2
11 – 17	Moderate	3
17 – 22	High	4
22 – 28	Very high	5

Table 4. Aspect wolf use preferences, suitability descriptions, and scores.

Aspect in degrees	Suitability	Score
0 – 90	Poor	1
90 – 180	Fair	2
180 – 270	Good	3
270 – 360	Fair	4
-1 (flat)	Good	5

Table 5. Combined scoring of slope and aspect preferences to model probable wolf use in the Adirondack Park, NY.

Slope Score + Aspect Score	Suitability
2	Very low
3 – 4	Low
5 – 6	Moderate
7 – 8	High
9 – 10	Very high

Summer results for physical habitat suitability based on slope and aspect are provided in Plate 3. Note that the 18 core security areas are also shown. Relative amounts of each suitability class are distributed in the same proportions in the core security areas as with the entire AP (see Figure 2).

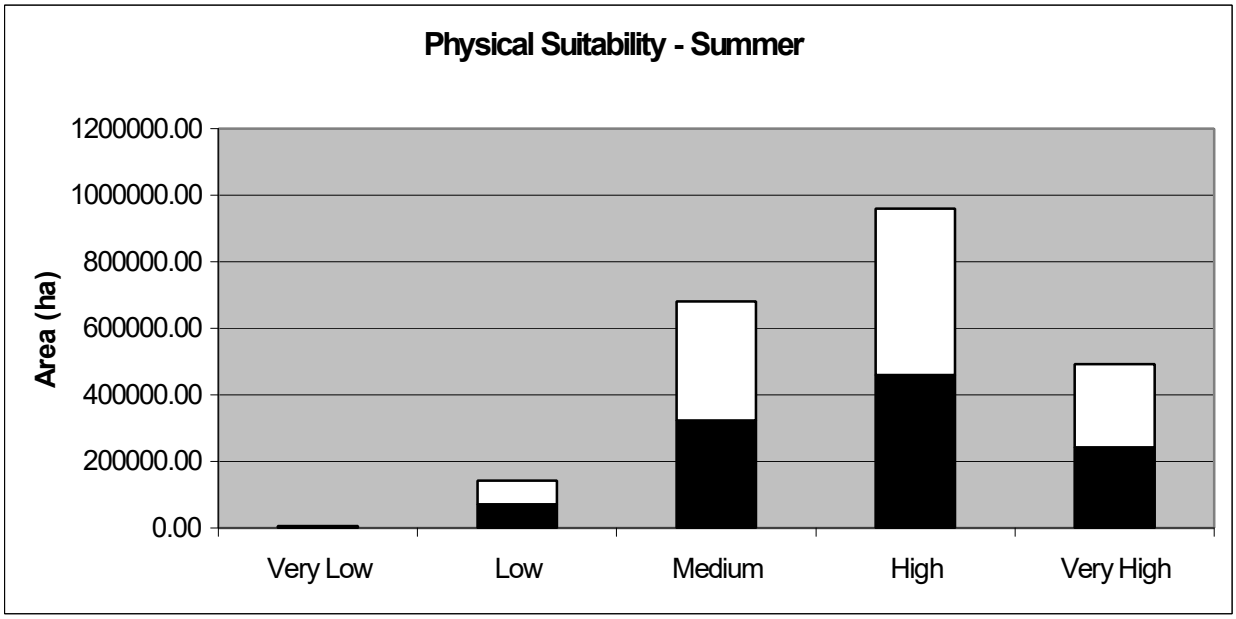


Figure 2. Physical wolf habitat suitability histogram for the entire Adirondack Park, NY for the summer. Black bars represent core security areas and white bars areas outside of core areas.

Given the relatively gentle terrain of the Adirondacks much of the area is physically suitable for wolf habitation. Topographic restrictions (e.g., steep slopes) prevent wolves from using only a small portion of the AP. When considering core security areas, approximately half the area of each histogram is not available to wolves.

Under winter conditions, snowfall impedance was introduced into the physical habitat model. Few studies have addressed the direct effects of snow on movements of wolves (Formozov 1946, Telfer and Kelsall 1984, Paquet et al. 1996). Fuller (1991) monitored wolf activity in north central Minnesota and found that wolves traveled farther and more often and spent less time with other pack members in mild than in severe winters. Wolves used conifer cover less when snow was shallow. The chest height of wolves is so low (approximately 40 cm) they have difficulty moving in snow deeper than 50 cm (Pulliainen 1982, Paquet et al. 1996).

We cannot accurately model the amount of precipitation that falls as snow over the various regions of the AP. Consequently, we assumed most November through March precipitation would fall as snow and estimated the degree of snow impact spatially. To approximate where snowfall would have its greatest influence on wolves in the AP, we scored mean monthly precipitation data (1961 – 1990) from the PRISM dataset for the months of November through March. Precipitation totals were mapped from this database using 3km x 3km grid cell sizes. Precipitation amounts were ranked 1 – 5 (1 = lowest precipitation; 5 = highest precipitation) for each month. To obtain a composite snowfall score, we totaled the ordinal (or ranked) scores for the five months. Final scores ranged from 5 – 25 and were assigned a final suitability description and score (see Table 6). This information was then factored into the existing slope-aspect model previously described by subtracting the snowfall score from the combined slope-aspect score. Before that was done, the combined slope-aspect scores ranging from 2 – 10 were reassigned values ranging from 1 – 5 according to the order shown in Table 7. This method heavily weights the impact of snowfall on wolf use and, because of the coarse nature of the precipitation data, over-generalizes precipitation patterns.

Table 6. Precipitation ranking using mean monthly precipitation data from 1961-1990 for November through March in the Adirondack Park, NY. Values under the "Score" heading were subtracted from the slope-aspect results from the summer model.

Total precipitation score	Suitability	Score
5 – 9	Very high	0
10 – 13	High	1
14 – 16	Moderate	2
17 – 20	Low	3
21 – 25	Very low	4

In comparison with the summer model, our winter model shows a very different distribution of habitat that is physically suitable for wolves. A much larger proportion of the AP area is undesirable during winter, particularly the High Peaks and greater West Canada Lakes regions (see Plate 4). The histogram for the various suitability classes also differs markedly between summer and winter.

During the winter months, the most suitable wolf habitat is concentrated in the northeastern quarter of the AP with moderately good conditions in the northwest quarter. If we eliminate areas with road densities >0.6 km/km ^{2} (see Plate 5), a value chosen from a number of empirical studies (see Displacement Model – Road Effects), a large portion of the best winter habitat becomes unsuitable. We used road density as a proxy for human activity instead of core security areas because wolf packs are more mobile in winter than summer as a result of denning. We believe wolves would prefer core security areas with favorable snow conditions during winter, but their increased mobility makes road density a better predictor of human disturbance.

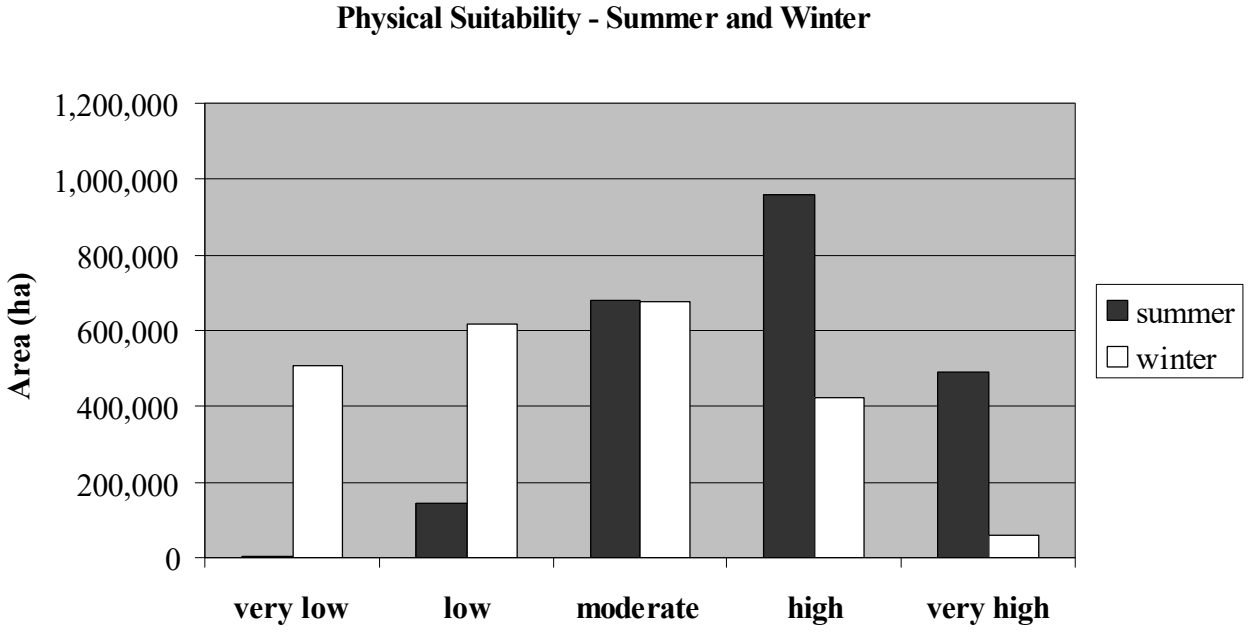


Figure 3. Physical wolf habitat suitability histogram for the entire Adirondack Park, NY for the summer and winter seasons.

Den Suitability Model

We modeled den suitability using two data layers (1:24,000 hydrology and 1:62,500 soils). Denning wolves prefer deep soils with adequate drainage near water. Denning wolves often prey on beaver (Carbyn 1983). Thus, availability of beaver may also influence selection of densites. In the AP as in other places, water is a reliable indicator of beaver. We modeled den suitability as follows:

1. Soil depth information was extracted from the soils database and assigned a suitability score (1 = poor; 5 = very good).
2. Soil drainage information was extracted from the soils database and assigned suitability scores (1 = poor; 5 = very good).
3. The 1:24,000 hydrology layer was buffered and suitability assigned to distance ranges according to Table 8.
4. Soils and hydrology scores were added providing a final suitability score (Table 8).

Table 7. Assigned den suitability based on distance from water for the Adirondack Park, NY.

Distance from water (m)	Den Suitability	Score
0 – 1	Unsuitable	No Data
1 – 100	Good	5
100 – 500	Fair	3
500 – 1,000	Poor	1
>1,000	Unsuitable	No Data

Table 8. Final den suitability scoring for the Adirondack Park, NY.

Hydrology + Soils	Den Suitability
No Data	Unsuitable
1 – 9	Poor
10 – 12	Fair
13 – 15	Good

The resulting map showing wolf den suitability is provided in Plate 6. The associated histogram for the entire AP under pristine conditions and within the mapped core security areas is provided in Figure 4.

Comparing den site suitability under pristine conditions versus core security areas showed a 52 percent loss of suitable den sites due to human displacement. A disproportionate amount of this loss (71%) came from the "good" category (see Table 9). What effect that would have on denning wolves is unknown, but the magnitude of the difference is noteworthy. Wolf denning habitat was found in all 18 core security areas. However, core areas in the northwestern quarter of the AP contained the largest contiguous denning sites.

Table 9. Comparison between pristine condition and present condition and den site suitability.

	Total Area (Pristine)	Core Security Area	Den Area Loss	Percent Loss
Poor	1360048.50	713231.50	646817.00	47.56%
Fair	497985.50	209417.00	288568.50	57.95%
Good	150237.25	43446.00	106791.25	71.08%
	2008271.25	966094.50	1042176.75	51.89%

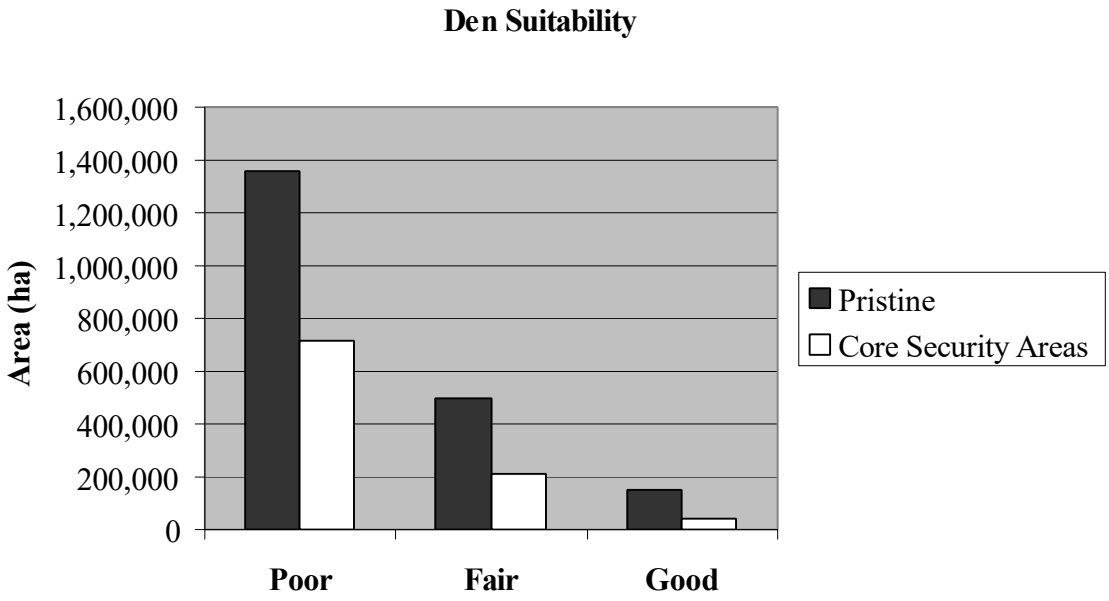


Figure 4. Den suitability for the Adirondack Park, NY under pristine conditions and for mapped core security areas.

Prey Base Submodel

Several studies suggest that a primary factor limiting wolves where they are present and tolerated by humans is adequate prey density (Fuller et al. 1992). Ungulates such as elk, deer, moose, and bighorn sheep make up most of a wolf's diet (Mech 1970, Fuller 1989), although they may eat smaller prey such as snowshoe hares and beaver. Ungulate biomass (Keith 1983, Fuller 1989), ungulate density, and ungulate species diversity (Boitani et al. 1997) have been significantly correlated with wolf density in some regions. For example, in a review of wolf demographics, prey density was shown to explain 72% of the variation in wolf density (Fuller 1989). A smaller core area, such as Riding Mountain NP (Manitoba), can support a viable wolf population if prey biomass per unit area is high (Fritts and Carbyn 1995). Ultimately, viable, well-distributed wolf populations are dependent on abundant and stable ungulate populations. Minimum deer density required to support a wolf pack is about 1 deer per square km (derived from Messier 1994). However, if given a choice, higher densities are sought out by wolf packs (Huggard 1991).

High prey biomass in biologically productive matrix lands could compensate for higher rates of human-caused mortality if connectivity is maintained with core areas (Fritts and Carbyn 1995, Haight et al. 1998). However, excessive mortality can cause these prey patches to become population sinks. For example, in areas such as the Banff/Jasper park complex, ungulates concentrate on winter range near human development, leading to high levels of mortality for wolves (Paquet et al . 1997). In the Greater Yellowstone Ecosystem, most ungulate winter range is outside of core protected areas, with seven of nine elk herds wintering outside the park (Fritts 1990, Fritts and Carbyn 1995). In Glacier National Park (US), the scarcity of ungulate winter

range limits wolves to the western edge of the park (Fritts and Carbyn 1995). These wintering areas may function as "keystone" habitats if seasonal availability limits wolf population density (Fritts and Carbyn 1995). Similar "keystone habitats" may also exist in the AP.

We created a landscape surface that reflects the abundance and distribution of the current prey base within the AP. However, we consider this model weak because of the inherent difficulty in monitoring prey numbers and distribution. For example, we could not include moose data in the prey model because of sighting biases. In addition these points were not of the same quality as the deer density estimates. Deer density estimates were provided by the New York Department of Environmental Conservation (DEC). Density estimates were organized by township using a formula based on male deer killed by hunters in 1996. Some members of our advisory panel suggested that this technique under-estimates deer numbers, is organized at too coarse a level, is skewed by hunting effort, and does not consider recent landscape changes (e.g., 1998 winter storm damage and 1995 microburst damage) that could affect deer numbers. Based on the data acquired (including storm damage), we are much more confident in the spatial pattern of deer densities than population numbers.

Although deer would constitute the largest portion of a wolf's diet in the AP, beaver would be important during warmer seasons. Beaver become a significant prey item only when active. Wolves most frequently take them to feed young. Beaver density data are assembled by the New York Department of Environmental Conservation (DEC) according to wildlife management units. In the Adirondack region these units are quite large. The AP contains portions of three of these management units. Because beavers are intimately linked to water, we expressed their densities as number of colonies per km of river (or Lake Margin).

Our prey base model is based on the 1996 deer density estimates by township and number of beaver colonies per km from 1993 – 1994 management unit estimates. Plate 7 shows the deer density for the AP. Note that all classes represented have sufficient deer densities to support a pack of wolves except for the polygons colored dark red (0.5 – 0.9 deer per square km). Wolves would undoubtedly be attracted to the areas of high deer density. Also note, that most of the high-density areas in the eastern portion of the AP lack adequate security for wolves. Wolves attracted to these areas would likely be killed or displaced by human caused disturbances.

A map of the 1995 microburst and 1998 ice storm damage is provided in Plate 8. The large disturbed areas in north and northeastern AP are from the 1998 ice storm. The bands of damage in the western portion of the AP are from the microburst event in 1995. Most of the ice damage occurred outside of wolf core security areas resulting in little benefit to wolves. Therefore, the increased deer populations in these areas will not be readily accessible to wolves. The microburst damage, on the other hand, largely occurred within core security area #9 (the Five Ponds Wilderness region) and should result in higher deer densities over the next decade. The beaver density estimates reflect a similar pattern as the deer. That is, higher densities in the southeast and northwest portions of the AP (see Plate 9).

Summer wolf habitat suitability based on prey density was compiled using the following scores for deer densities (Table 10) and beaver densities (Table 11). Final results were scored

according to the information provided in Table 12 and mapped (see Plate 10). Please note that only the high prey base areas in the northwestern corner of the AP are sufficiently secure for long-term wolf survival.

Table 10. Scoring of deer density for the Adirondack Park, NY.

Deer density per km ^{2}	Suitability	Score
0.5 – 0.9	Unsuitable	0
1.0 – 1.3	Low	1
1.4 – 1.8	Moderate	3
1.9 – 2.9	High	4
3.0 – 8.7	Very high	5

Table 11. Scoring of beaver density for the Adirondack Park, NY.

Colonies per km river	Suitability	Score
0.09	Low	1
0.16	Moderate	3
0.34 – 0.38	High	5

Table 12. Final scoring of wolf prey base for the Adirondack Park, NY.

Deer density + Beaver density score	Suitability
1 – 4	Low
5 – 7	Moderate
8 – 10	High

Plate 10 also shows prey densities at a relatively coarse resolution. The amount of each suitability class found in all the AP and in core security areas is provided in Figure 5. This figure differs from the den suitability figure, which describes the entire AP as pristine. In the former case, humans have little influence on the factors used in that model (i.e., hydrology and soils). Humans, however, profoundly influence prey populations. Before European settlement, beaver densities were probably higher in the southeastern section of the AP than today. Changes in deer density are less clear.

Nevertheless, we have a reasonable understanding about the distribution and abundance of prey in the AP. Populations of white-tailed deer and beaver appear more than adequate to sustain wolves. Moreover, recovering moose populations could augment an already substantial prey base. As might be expected distribution and abundance of prey varies considerably throughout the AP. Wolf populations would not likely reflect levels indicated by prey biomass because some prey populations occupy areas inhabited by humans and would thus not be available to wolves.

Overall, 44 percent of the AP shows low prey suitability, followed by 30 percent for moderate and 26 percent for high. Assuming wolves prefer core security areas, then we estimate

a 36 percent loss in the low suitability area, a 78 percent loss in the moderate category, and a 54 percent loss in the high suitability class. For the core security areas considered collectively, 60 percent of the land area is classified as having low prey suitability, 14 percent moderate, and 26 percent high. All the sites classified as high are in the northwestern core areas (most or all of #5, #4, #6, #9, and #13).

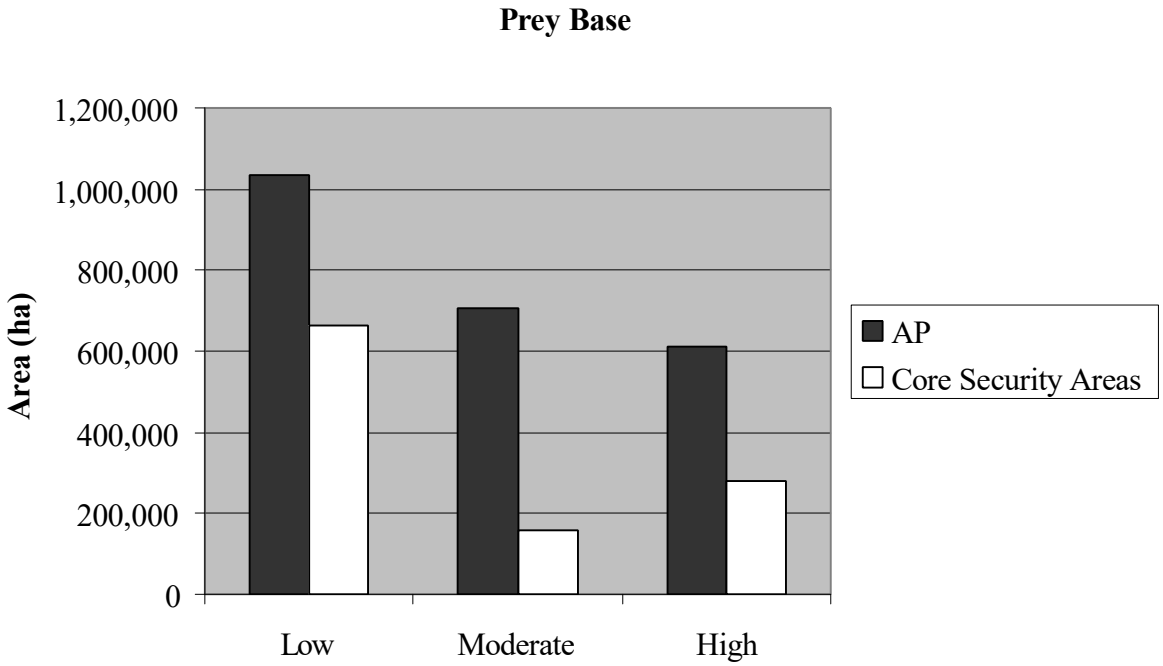


Figure 5. Prey base for all of the Adirondack Park, NY and for mapped core security areas.

Ranking Core Security Areas

We ranked core security areas based on the composite results of summer physical suitability, den suitability, and prey suitability. We did not consider winter physical conditions because wolf pack survival depends on the successful rearing of pups, which is a summer activity. However, wolves would be less attracted to some core security areas (even excluded) in harsh winter conditions. For example, based on the precipitation data, areas #14 and #18 would be unsuitable for wolves during winter, which lowers the overall value of these sites. That does not mean these areas could not, or would not, be used by wolves in the summer – these areas are just less suitable than other sites within the AP. Table 13 summarizes each core security area and how it scored for each criterion.

Table 13. Core security area ranking based on summer physical suitability, den suitability, and prey suitability for the Adirondack Park, NY.

Core Security Area	Physical Suitability Percent very high & high	Physical Suitability Ranking	Den Suitability Percent good & fair	Den Suitability Ranking	Prey Suitability Percent high	Prey Suitability Percent medium	Prey Suitability Ranking
1	64.8	3	38.0	4	0.0	99.7	4
2	61.4	3	26.6	3	0.0	99.8	4
3	68.8	3	24.4	3	44.3	55.5	4
4	75.9	4	33.0	4	99.9	0.0	5
5	72.1	4	29.1	3	99.8	0.0	5
6	81.4	5	45.2	5	99.9	0.0	5
7	42.0	1	22.0	3	0.0	53.4	3
8	47.8	1	17.0	2	4.3	4.7	1
9	73.0	4	26.4	3	30.6	18.4	4
10	55.8	2	17.1	2	0.0	0.0	1
11	47.2	1	16.4	2	0.0	5.3	1
12	50.7	2	20.0	3	0.0	99.8	4
13	87.0	5	32.3	4	95.2	0.0	5
14	65.4	3	19.0	2	0.2	0.4	1
15	49.1	1	15.4	2	0.0	0.0	1
16	50.5	2	19.2	2	0.1	53.7	3
17	50.3	2	9.5	1	0.0	11.1	2
18	79.1	4	21.0	3	0.0	40.3	3

We added the three rankings together to generate a composite score for each core security area. Results ranged from 4 – 15 and were partitioned into three classes – poor (4-5), fair (6-10), and good (11-15). Six of the eighteen areas were ranked as good, seven as fair and five as poor (see Plate 11). The biophysical and human elements that collectively determine habitat quality of core areas vary markedly throughout the AP. As a result, habitats likely to be occupied by wolves are often discontinuous with one another. This means wolves need to move between habitat patches to survive. The intervening matrix between these patches might not be hospitable to wolves, which could adversely affect survivorship. In summary:

1. We have more confidence in the location of prey densities than we do in the density values.
2. Core security areas are the likely places for successful wolf presence.
3. Not all core security areas score the same based on physical suitability, den suitability, and prey densities.
4. Without humans, wolves would likely prefer most of the areas where towns exist today.

Displacement Submodel

Road Effects

Roads, by increasing human access, have been documented to negatively affect wolf populations at local, landscape (Fuller 1989, Thurber et al. 1994, Paquet et al. 1997), and regional (Mladenoff et al. 1995, Boitani et al. 1997) scales. Roads may act as mortality sinks through highway deaths or by providing easier access for hunters and poachers. In severe cases, roads can cause population changes through mortalities, loss and alteration of habitat, and disturbing activities. Besides functioning as a source of direct mortality, roads also may be physical or psychological impediments to wolf movement. Although researchers have documented dispersal across major highways for wolves in Minnesota (Mech et al. 1995), Montana (D. Boyd pers. comm.), and Alberta (Boyd et al. 1996), some may function as partial barriers or filters (Paquet et al. 1997). Roads also may function as disturbance factors (Paquet and Callaghan 1996, Paquet et al. 1997). Road data can be incorporated into a model as distance from road, size of contiguous roadless area, or road density (using a variety of computer mapping techniques). The "distance from road" metric may be more appropriate at finer scales. An avoidance zone of 500 m was documented in Banff National Park (Paquet et al. 1996). Thurber et al. (1994) showed a negative response up to 5 km from roads in Alaska. In winter, wolves also are attracted to roads for ease of travel (Thurber et al. 1994, Paquet et al. 1996).

Human activities that compact or clear snow (e.g., snowmobiling, cross-country skiing, and maintenance of winter roads) may alter winter movements of wolves by providing economic travel routes into areas that are usually inaccessible because of deep snow. This may distort winter home ranges, affect the rate of wolf predation on ungulates (Okarma et al. 1995), and change the pattern of selection for species and cohorts (Paquet 1989). In areas where forest cover and human activities adjoin, travel routes that are efficient to follow may attract wolves to agricultural and urban areas (E. Pullianen, pers. commun.).

In human dominated landscapes, road density becomes the more relevant metric at landscape and regional scales (Mladenoff et al. 1995, Boitani et al. 1997). Studies in Wisconsin, Michigan, Ontario, and Minnesota have shown a strong relationship between road density and the absence of wolves (Thiel 1985, Jensen et al. 1986, Mech et al. 1988, Fuller 1989). Wolves generally are not present where the density of roads exceeds 0.58 km/ km² (Thiel 1985 and Jensen et al. 1986, cf. Fuller 1989). Landscape level analysis in Wisconsin, Minnesota, and Michigan found mean road density was much lower in pack territories (0.23 km/ km² in 80% use area) than in random nonpack areas (0.74) or the region overall (0.71). Road density was the strongest predictor of wolf habitat favorability out of five habitat characteristics and six indices of landscape complexity (Mladenoff et al. 1995). Few areas of use exceeded a road density of >0.45 km/ km² (Mladenoff et al. 1995). Notably, radio collared packs were not bisected by any major federal or state highway. In Minnesota, densities of roads for the primary range, peripheral range, and disjunct range of wolves were all below a threshold of 0.58 km/ km².

These results, however, probably do not apply to areas on which public access is restricted. Mech (1989), for example, reported wolves using an area with a road density of 0.76

km/km², but it was next to a large, roadless area. He speculated that individuals that dispersed from the adjacent roadless area compensated for excessive mortality experienced by wolves in the roaded area. Wolves on Prince of Wales Island, Alaska currently use areas with road densities greater than 0.58 km/ km². This may reflect the limited options wolves have to relocate when they live on islands or insularized landscapes. Road density thresholds in the more open landscapes of the Rockies may differ from those reported in the above studies (Weaver et al. 1996). Topographic effects also influence how road densities influence wolves. For example, in mountainous landscapes roads and usable wolf habitats converge in low elevation valley bottoms. Effective road densities calculated only for valley bottoms differ dramatically from densities calculated using the full areal extent of a wolf pack's home range.

There are several plausible explanations for the absence of wolves in densely roaded areas. Wolves may behaviorally avoid densely roaded areas depending on the type of use the road receives (Thurber et al. 1994). In other instances, their absence may be a direct result of mortality associated with roads (Van Ballenberhe et al. 1975, Berg and Kuehn 1982).

However, even in areas where nominal protection of wolves is high, 90% of mortality is human-caused (Pletscher et al. 1997). Despite legal protection, 80% of known wolf mortality in a Minnesota study was human-caused (30% shot, 12% snared, 11% hit by vehicles, 6% killed by government trappers, and 21% killed by humans in some undetermined manner) (Fuller 1989). Mech (1989) reported 60% of human-caused mortality in a roaded area (even after full protection), whereas human-caused mortality was absent in an adjoining region without roads. On the east side of the central Rockies between 1986 and 1993, human-caused mortality was 95% of known wolf death. Thirty-six percent (36%) of mortality was related to roads (Paquet 1993). Though offering only partial protection, parks such as Banff and Glacier have historically played a critical role as sources for recolonization (Boyd et al. 1995).

Wolves in Minnesota and Wisconsin are now occupying ranges formerly assumed to be marginal because of prohibitive road densities and high human populations (Mech 1993, Mech 1995, D. Shelly pers. comm.). Legal protection and changing human attitudes are cited as the critical factor in the wolf's ability to use areas that have not been wolf habitat for decades. Nonetheless, wolves in Minnesota continue to avoid populated areas, occurring most often where road density and human population are low (Fuller et al. 1992). Dispersers or marginalized individuals may be pushed into suboptimal habitat as dominant animals or packs saturate more suitable and safe habitat

Clearly, the influence of road density on wolves has been well documented, and the resulting spatial models from a number of studies have been proven to be very dependable. The AP contains approximately 8,195 km (5,092 miles) of roads. We modeled road density using the 1:24,000 roads data layer from the AP GIS. A 1-km x 1-km grid cell array was made for the entire AP and road density calculated for each cell. These results were then generalized using a moving window function 5 km x 5 km in size (see Plate 12). Class cut- offs were chosen based on empirical data from similar analyses from other parts of the United States and Canada. High suitability was mapped for road densities of 0-0.23 km/km ^{2}, medium for densities of 0.23-0.45 km/ km², and low for densities of 0.45-0.6 km/ km ^{2}. Areas with road densities >0.6 km/ km ^{2}

were considered unsuitable for wolf survival. Note the location of the core security areas and the relative wolf habitat suitability based on road density between areas. These areas become particularly important when modeling the likely inter-regional movement corridors.

Human Population Effects

Human activities have been shown to influence the distribution (Thiel 1985, Fuller et al.1992, Paquet 1993, Mladenoff et al.1995) and survival of wolves (Mech et al.1995, Mladenoff et al. 1995, Paquet 1993, Paquet et al. 1996). Although human-caused mortality is consistently cited as a major cause of displacement (Fuller et al. 1992, Mech and Goyal 1993, and others), we have limited empirical information on tolerance of wolves to indirect human disturbance. However, information is available on human population densities that displace wolves. We have incorporated these data into our model.

We are aware of only four studies that have systematically and explicitly examined human population density and wolf distribution. In all studies, the absence of wolves in human-dominated areas may have reflected high levels of human-caused mortality, displacement resulting from behavioral avoidance, or some combination of both. All were conducted at a landscape scale and assessed population or pack level responses of wolves to humans. In Wisconsin, human population density was much lower in pack territories than in nonpack areas. Wolf pack territories also had more public land, forested areas with at least some evergreens, and lower proportion of agricultural land. Overall, wolves selected those areas that were most remote from human influence (Mladenoff et al.1995) using areas with fewer than 1.54 humans/ km². Most wolves in Minnesota (88%) were in townships with <4 individuals/ km² or with <8 individuals/km². High human densities likely precluded the presence of wolf packs in several localities within contiguous, occupied wolf range (Fuller et al. 1992). However, road density, a highly correlated variable, may provide greater predictive power in a multivariate model (Mladenoff et al. 1995), especially in regions characterized by high levels of recreational hunting mediated by road access.

Boitani (1995) analyzed the record of human/wolf coexistence in southern Europe versus that of wolf extirpation in northern Europe. Human population density was only one of several factors determining the ability of the two species to coexist. A settled agricultural, rather than pastoral culture, lack of organized governmental eradication efforts, and high topographic heterogeneity contributed to the survival of wolves in southern Europe. In Italy, wolf absence was related to human density, road density, urban areas, cultivated areas, and cattle and pig density. However, because human density, road density, and urbanized areas were highly intercorrelated no specific human effect was established (Duprè et al. in press).

In the Bow River Valley, Alberta the selection or avoidance of particular habitat types was related to human use levels and habitat potential (Paquet et al. 1996). Wolves used disturbed habitats less than expected, which suggests the presence of humans altered their behavior. Very low intensity disturbance (<100 people/month) did not have a significant influence on wolves, nor did it seriously affect the ecological relationships between wolves and their prey. At low to

intermediate levels of human activity (100-1,000 people/month), wolves were dislocated from suboptimal habitats. Higher levels of activity resulted in partial displacement but not complete abandonment of preferred habitats. As disturbance increased, wolves avoided using some most favorable habitats. In portions of the valley where high elk abundance was associated with high road and/or human population density, wolves were completely absent. Overall, habitat alienation resulted in altered predator/prey relationships.

The degree of human influence probably varies according to the environmental context. If a particular habitat is highly attractive, wolves appear willing to risk exposure to humans, at least within some limits (Chapman 1977). The presence of artificial food sources (e.g., carrion pits, garbage dumps) also attracts wolves and reduces avoidance of human activity (Chapman 1977, L. D. Mech pers. comm., Paquet 1996).

For our analysis, we depended on roads and land use to predict exclusion of wolves by humans and for creating a movement cost surface. We examined 1990 census data, but dropped it from the analysis for two reasons. First, the data are 10 years old. Second, human use of the AP varies widely from 130,000 permanent residents to seasonal visitation of over 10 million each year (Schneider 1997). The Census data did not adequately account for this human population dynamism.

Wolves do not necessarily avoid roads. For example, wolves in the central part of Eurasia moved seasonally from the mountains where snow was deep to valleys with little snow, preferred to use plowed roads (Formozov 1946, D. Bibikov pers. comm.). Zalozny (1980) found that road networks cleared of snow allowed wolves to travel farther and thereby increased access to prey over a larger area. In Sweden, wolves avoided high snowfall areas above 1,000 m and traveled primarily along valleys with roads and across plateaus (Bjarvell and Isakson 1982, A. Bjarvell pers. comm.). Roads are problematic because they are a direct cause of mortality via collisions with vehicles. Equally important, roads provide access for humans to wildlands and thus increase opportunities for direct persecution of wolves. In other words, it is the lethality of roads that influences survival of wolves.

Other Anthropogenic Influences

There are numerous anthropogenic influences in and around the AP. These influences were integrated to create a cost surface that was used to predict the most likely travel corridors for wolves within the AP. Plate 13 shows the cultural features that would affect wolves.

Snowmobile Trails

Snowmobile trails have mixed influences on wolves. Access provided by winter trails may lead to harassment or killing of wolves. Conversely, wolves travel more efficiently through areas with deep snow by using winter wildlife trails or other compacted travel routes such as snowmobile trails (Mech 1970). The total length of registered snowmobile trails in the AP is 2,381 km (1,479 miles). These trails are concentrated in several places. Among the core security areas, snowmobile trail density is highest in Core Area #6. That area also rated the highest habitat

suitability of all 18 core areas evaluated in the composite model. Accordingly, the likelihood of winter encounters with wolves would be high in this region.

Railroads

With one possible exception, railroads pose minimal threat to wolves in the AP. The AP has four railroad spurs penetrating the region with 520 km (323 miles) of rail line leading to four terminal destinations – Ausable Forks, Newton Falls, Tahawus, and Lake Placid. The track leading to Ausable Falls enters the region from the southeast and hugs the Lake Champlain shoreline until it approaches Ausable Falls where it heads west. The entire length of this spur is in poor wolf habitat. The tracks leading to Tahawus enter the AP from the southeast and also stay largely in poor wolf habitat. Tracks leading to Newton Falls enter the AP from the west just above the Five Ponds area. The only length of track that could pose a serious threat to wolves is the one leading to Lake Placid. It enters the AP from the southwest, cuts between the Ha-De-Ron-Dah Wilderness and the Canada Lake Wilderness. As it travels north and then northeast, it bisects the core security area containing the Five Ponds Wilderness. The threat posed by railroads is associated with location and traffic frequency.

Land Use

In Plate 13, we classify land use into five categories of wolf suitability. The various land classifications provided by the AP GIS were recoded as low, medium, or high wolf suitability (see Table 14). In general, the lowest scores were assigned to developed areas inside the AP, medium scores for resource management lands, and high scores to most public lands. One fairly good size area was not classified. Using land use as the discriminator, 3.25% (76,579 ha, 189,227 ac) of the AP was classified as low wolf suitability, 49.52% (1,166,639 ha, 2,882,765 ac) as medium, and 40.89% (963,368 ha, 2,380,482 ac) as high. The remaining 6.34% (149,195 ha, 368,661 ac) is occupied by water and a small unclassified area.

Table 14. Land classifications from the AP GIS land use data layer and wolf suitability ranking for the Adirondack Park, NY.

Land Classification	Wolf Suitability
Canoe Area	High
Hamlet	Low
Historic	Low
Industrial Use	Low
Intensive Use	Low
Low Intensity Use	Medium
Moderate Intensity Use	Low
Pending Classification	Unclassified
Primitive	High
Resource Management	Medium
Rural Use	Medium
State Administrative	Low

Water	Water
Wild Forest	High

WOLF CONNECTIVITY MODELING

We used least-cost path analysis for examining landscape connectivity for wolves in the AP for summer and winter conditions. Different landscape elements, human activities, and physical structures variably inhibit movements of animals including wolves. Other features enhance movements by attracting different species (e.g., high prey densities for wolves) or allowing them to move more efficiently through the landscape (e.g., plowed winter roads, highway underpasses). Linear developments such as roads and railways function as potential barriers to movement. The extent to which a particular impediment blocks movement varies. Thus, the range in permeability depends on the type of linear development, physical location, and amount of associated human activity. (Appendix B summarizes briefly current thinking about movement corridors.) Specific attributes for all features are expressed within the model as landscape coefficients collectively assigned to individual pixels. The values combine to create a landscape surface with a variable resistance to the movement of wolves. Each value represents how easily a wolf can move through a 1-km x 1-km pixel. Table 15 summarizes the cost assignments based on land class, road density, water, towns, and slope. Total summer cost was calculated by adding the components together (summer cost surface = land class surface + road density surface + water surface + towns surface + slope surface). Table 16 includes those changes/additions to the winter cost surface. In the winter, ice replaced water, and two other factors were added including snowmobile trails and probable snowfall. The formula used to produce the winter cost surface was winter cost = land class surface + road density surface + towns surface + ice surface + snowmobile surface + snowfall surface + slope surface. Cost to wolves ranged from 0 (no cost) to 10 (high cost). Cells assigned as "no data" were cost prohibitive for use by wolves.

Table 15. Summer cost surface assignment for the Adirondack Park, NY.

Land Class Surface	**Cost**
Canoe Area	1
Hamlet	No Data
Historic	No Data
Industrial Use	No Data
Intensive Use	No Data
Low Intensity	5
Moderate Intensity	No Data
Pending Classification	0
Primitive	1
Resource Management	5
Rural Use	5
State Administrative	No Data
Water	No Data

Wild Forest	1
Road Density Surface (road density km/km ^{2})	**Cost**
0 – 0.23	0
0.23 - 0.45	5
0.45 – 0.6	10
>0.6	No Data
Towns	**Cost**
All towns buffered by 500m	No Data
Slope Surface (probability of slope use)	**Cost**
0.6 – 7.5	10
7.5 – 14.4	5
14.4 – 21.3	2
21.3 – 28.2	0

Table 16. Winter cost surface assignment for the Adirondack Park, NY.

Land Class Surface	**Cost**
Canoe Area	1
Hamlet	No Data
Historic	No Data
Industrial Use	No Data
Intensive Use	No Data
Low Intensity	5
Moderate Intensity	No Data
Pending Classification	0
Primitive	1
Resource Management	5
Rural Use	5
State Administrative	No Data
Water	2
Wild Forest	1
Road Density Surface (road density km/km ^{2})	**Cost**
0 – 0.23	0
0.23 - 0.45	5
0.45 – 0.6	10
>0.6	No Data
Towns	**Cost**
All towns buffered by 500m	No Data

Slope Surface (probability of slope use)	**Cost**
0.6 – 7.5	10
7.5 – 14.4	5
14.4 – 21.3	2
21.3 – 28.2	0
Snowmobile Trail Surface	Cost
Present	1
Absent	2
Snow Surface (total precipitation score)	**Cost**
5 – 9	2
10 – 13	4
14 – 16	6
17 – 20	8
21 – 25	10

To simulate wolf movement in the AP, we ran four iterations using the summer and winter cost surfaces. We selected the three largest core security areas and one in the northern section of the AP. Four departure points exiting the AP (north, south, east, and west) were identified and used as destination points from each of the core security area polygons. Least cost path travel route simulations were run. The results provide multiple possible routes with weighting on the least expensive avenue from a defined starting point to a defined destination point. Simulated wolf packs should select travel routes that provide an optimal combination of security, habitat quality, and energetic efficiency. Conversely, wolves would variably avoid human facilities and activities, terrain that is difficult to negotiate, and habitat of low quality. In reality, wolves could move in many different ways – some dispersing wolves would be killed, others would find their way through the landscape. The least-cost path analyses delineate the optimal pathways for travel as defined by the cost surface (or friction) layer. We assume wolves would preferentially use these pathways given. Other (more sophisticated) connectivity modeling techniques are available, but the least-cost path analysis is a good first approximation. Pathways identified are similar to those derived using more complicated procedures and reflect closely the movements of wolves (Paquet et al. 1996).

The results for the summer and winter simulations are provided in Plate 14 and Plate 15. Several general observations can be made about the model outcomes:

1. Movement patterns differ between summer and winter conditions.

2. Winter movement patterns are more direct.

3. During the summer, movement out of the AP to the east (as we have defined it) is not possible.

4. Movement during the winter (when it is more likely) is more costly for wolves than during the summer.

5. A large percentage of the land area within the AP is prohibitively costly to wolf movement.

We considered the question of connectivity from a regional perspective (between the AP and the surrounding region) by calculating road densities for the surrounding region. We used 1:100,000 U.S. Geological Survey roads and calculated road density based on a 5-km x 5-km grid cell size. Our results (Plate 16) show the AP is isolated from the nearest potential wolf habitat, which concurs with the findings by Mladenoff and Sickley (1998). Even using these coarse level roads data (1:24,000 scale data usually show twice as many roads), the probability of wolves surviving very far into the matrix lands surrounding the AP is very low. This conclusion leads to the important issue of population viability in the AP if wolves were reestablished.

CONCLUSIONS AND RECOMMENDATIONS

Providing minimally roaded "core areas," keeping legal harvest within sustainable limits, and providing adequate habitat for an abundant, stable ungulate population, are all-important components of an effective wolf reintroduction and conservation strategy. We believe the goal of a reintroduction program is to establish wolf packs and not individual wolves. This is because packs are the essential social and biological units necessary for long term survival of wolf populations. From the literature and our own studies, we have identified the following essential ecological requirements necessary to sustain a breeding population of wolves within the Adirondack region:

- **The ultimate factor determining population viability for wolves is human attitude** . Regional planning can facilitate human/wolf coexistence by identifying spatial refugia or core areas with a level of protection sufficient to buffer populations against conflicts with humans. It also can identify optimal locations of buffer zones and corridors that will expand the effective size of core areas by allowing use of semi-developed lands while reducing the probability of human-caused mortality. Potential zones of human -wolf conflict often are in areas of highly productive habitat that have above -average human use, are spatial buffers between large core habitat areas and zones of high human use, or are likely to experience increased human influence in the future based on land-use and population trends. The interaction between food resource availability, carnivore movement patterns, and consequent mortality risks implies that the requirements for viability are location-specific, needing spatially-explicit analysis and an integrated approach to viability modeling that incorporates habitat requirements across multiple scales. Whether humans in the AP are tolerant of wolves or not is the focus of the companion social assessment. Based on other wolf reintroductions (e.g., Mexican wolf in the southwestern U.S.), a relatively few individuals can cause a reintroduction effort to fail.

- **Wolves require an adequate and accessible prey base** . At a minimum, wolves require a prey biomass equivalent to about 100-kg prey/ km^2. Adult prey species equivalents are

approximately 0.25 moose/ km², or 1.0 deer/km². In multi-prey systems, which the Adirondacks are becoming, different prey may combine to provide the total biomass necessary to sustain wolves. Importantly, prey also must be available to wolves. For example, in Banff National Park, prey biomass east of the Town of Banff is adequate to sustain wolves, but the town and highway block access to the area. Mladenoff and Sickley (1998) reported similar distributions of wolves and white-tailed deer in Minnesota and Wisconsin. Our assessment suggests that prey numbers in the AP are sufficient to sustain wolves, though some prey associated with human development may not be available.

- **Wolf packs require well distributed patches of secure and high-quality habitat exposed to fewer than 1,000 people or events/month** . We have identified these potential core areas using our habitat models and road densities. The latter was used as a substitute for human activity because we lacked site specific information. Our results suggest the Adirondacks comprises adequate secure core areas and other high-quality habitats to maintain a small population of wolves. However, this assumes wolves will have access to these secure, quality habitats. The insular nature of the core areas can reduce the usefulness for wolves as shape, size, and distance between patches influences habitat quality. Nevertheless, the sum of partially connected habitat patches combined with larger contiguous habitats should provide wolves adequate security from humans and the life requisites necessary to sustain them.

- **Wolf packs must have opportunities to move safely among high-quality habitats contained within their home ranges** . This means protecting the network of trails that link these habitats. Thresholds for disturbance within travel linkages are not yet known, though standards can be temporarily inferred from habitat displacement values used in this report. Our models show the AP is highly fragmented. As a result, the spatial arrangement of secure habitats may preclude use of some areas by wolves because human activities and developments could impede access.

- **In human-dominated landscapes, regional subpopulations of wolves need to interact via dispersal or long distance forays** . Intra- and inter-refuge travel corridors reduce the possibility of local extinction and potential genetic isolation. Therefore, regions and habitats (interconnected) must be linked to allow for exchange and long-distance dispersal. Ensured connectivity also is important because wolves face a high risk of mortality from humans or vehicles when travelling across settled landscapes . This means regional corridors that provide linkages among subpopulations must be secure. We believe corridors connecting high-quality habitats within the Adirondacks are reasonably secure to ensure wolf packs can move about freely. However, linkages between the AP and other areas are tenuous. We doubt these linkages can be relied upon to maintain wolves over time. The extended distance between the AP and other populations of gray wolves amplifies the insecurity of these linkages.

- **Undisturbed and secure denning and rendezvous sites are necessary to sustain a population of wolves** . If wolves are reintroduced to the AP, known denning and rendezvous sites would need to be seasonally protected following confirmation of denning (i.e., buffered by 1.6 km (1 mi) restricted entry zones from 15 April through 30 July). We identified

adequate denning areas for wolves living within the AP. Seasonal protection of these sites should not be a problem.

- **Annual sustained mean mortality for a population of wolves should be less than 30% of adult mortality**. Wolves can likely sustain higher mortality for short periods (e.g., 1-2 years). Mortality includes natural deaths and deaths by hunting, trapping, highway collisions, and railway collisions. We believe annual mortality would be high within the AP, possibly exceeding 30%. Combined with other causes of mortality, road and management related deaths could significantly affect population persistence, particularly during establishment phases of reintroduction. Before wolves occupy and secure home ranges, travel patterns will be exaggerated. Thus, exposure to roads and other causes of mortality will be increased. Highway mortality was the major cause of low survival for reintroduced lynx in New York State (Brocke et al. 1991). Clearly, this is an important lesson not to be ignored. If a reintroduction of gray wolves proceeds in the AP, we believe the initial population will need to be augmented annually to help offset mortality.

- **Within the primary home range of a wolf pack, permanent human densities should be < 0.4 people/km².** Again, using road densities as a proxy, we identified areas in the AP that meet this criterion. However, access to these areas is not assured because of impediments to wolf movements. In addition, human densities increase outside the AP, which limits the potential regional distribution of wolves. In the short term, this may benefit wolves by restricting them to non-agricultural areas where conflicts with humans are less likely. Yet, from a population perspective, reduced geographical distribution and fewer packs threaten persistence. We believe that over time, the adverse affects will outweigh the benefits.

- **Wolf packs require a road density < 0.27 km/ km² within core use areas**. Road density is calculated after removing areas that wolves are physically restricted from using. For example, wolves do not often use slopes more than 45°. In winter wolves avoid areas where they sink more than 45 cm in the snow. Road densities in most secure core areas identified for the AP are below the threshold. Assuming the presence of suitable habitat, we are confident wolves would use these areas. Notably, few areas of this type exist outside the AP. As elaborated above, the contrast between the AP and the regional landscape does not favor persistence of wolves.

- **In areas outside protected landscapes, access provided by roads increases exposure of wolves to people with guns**. Thus, the potential "lethality" of a road network modifies the density of roads that affects wolf survival. Where killing wolves is allowed, the density of traversable roads should be less than 0.6 km/ km² within the entire home range of a wolf pack. Again, regional road density is substantially higher than in the AP.

- **Where wolves are protected, the density of paved roads and railways should be less than 1.2 km/ km² within the entire home range**. Within the AP, wolf packs would be able to establish home ranges that meet this criterion.

- **Traffic volume on highways accessible by wolves should be below 2,000 vehicles/day, which allows wolves to move across the roads** . Mortality increases rapidly as vehicles/day approach 4,000. We have not calculated traffic volumes for the AP or the region.

- **Speed limits on roads and railroads accessible to wolves should be less than 70 km/hr** . Currently, speed limits on many roads and railroads exceed this threshold. If wolves are re-established in the AP, critical crossing sites will need to be identified and speed limits adjusted. Several such 'speed zones' are already in place as crossings for white-tailed deer, which may coincide with the needs of wolves. Based on experience elsewhere, we are concerned about the adverse effects of road-related mortalities and injuries, especially during reestablishment when population numbers are low.

- **Ideally, major highways that exceed traffic volumes and speed limits should be elevated or buried where important wolf habitat or travel linkages are traversed** . Other less expensive, and less effective, types of passageways include underpasses and overpasses. All wildlife would benefit from these mitigations.

- **Diseases introduced by domestic animals are a potential threat to the viability of wolf populations** . This is a particularly difficult issue to address regionally. Generally, owners of domestic animals assure their animals are disease-free. However, new diseases can infect wild populations before being controlled domestically. The spread of Parvovirus into wild wolves in North America is a recent example of this occuring. Protection from possible exotic wildlife diseases (e.g., viruses of genus *Morbillivirus*) also needs to be considered.

Based on the above assessment, we do not believe gray wolves can be permanently reestablished in the AP. Though our analyses suggest that the AP comprises sufficient habitat to support a small population of gray wolves, regional conditions are not conducive to sustaining wolves over the long term (e.g., 100 years). Given current trends in regional development, we anticipate environmental conditions necessary to maintain wolves will deteriorate over the next 100 years. Most development occurs in areas preferred by wolves, and human activities will unavoidably increase the risk of death and injury for wolves. Increased development will decrease opportunities for wolves to move freely about, displace or alienate wolves from preferred ranges, and interrupt normal periods of activity — all detrimental to long-term wolf survival.

Indirect human influences can affect a wolf pack's chance to survive and reproduce. As wolves approach their limits of tolerance, they become increasingly susceptible to what would otherwise be minor influences. In the AP, natural landforms and the condensed arrangement of potential habitats in some areas may make wolves highly susceptible to the adverse effects of human disturbance. In less physiographically complex environments, such as the Great Lakes region, multiple travel routes link blocks of wolf habitat. Destruction or degradation of one or two routes usually is not critical because safe alternative routes are available. In contrast, wolves living in the AP may not be able to avoid valley bottoms or use other travel routes without affecting their fitness. Therefore, tolerance of disturbance may be lower than in other human-

dominated environments (e.g., Minnesota, Wisconsin) where wolves can avoid disturbed sites without seriously jeopardizing their own survival.

Lacking an unambiguous commitment by governments to protect wolves in and outside the Adirondack Park, we doubt a reintroduction of gray wolves could be successful. The support by conservation biologists for large reserves—especially when they are isolated from other areas with similar habitat—stems from considerations of population viability for species with large home ranges and/or low population densities (e.g., gray wolves). Typically, a larger block of suitable habitat will contain a larger population of a particular species. All else being equal, large populations are less vulnerable than small populations to extinction as a result of deterministic or stochastic factors. In the AP, regional isolation would expose reintroduced gray wolves to the perils that threaten survival of all small populations. Lacking a source population of gray wolves to augment the local population, wolves in the AP would be subject to genetic problems that depress reproduction and accelerate mortality. More importantly, a small and isolated population of wolves would not be buffered against random catastrophic events such as disease, thus increasing the probability of extinction.

As described above, ecological conditions in the AP dictate against a successful reintroduction of gray wolves. A small population might exist for, say 50 years. However, we should not confuse existence with persistence. The latter implies perpetuity, which we believe is the unstated objective of most reintroductions. Even if conditions were correct for establishment of wolves, the issue of which canid species originally occupied the AP is unresolved. Recent evidence strongly suggests red wolves were endemic and the current dominant canid is a coyote hybrid. We believe that if gray wolves were never present, or existed only in low numbers, or as occasional visitors, then introduction of the species would be inappropriate. From an ecological perspective, the functional niche of a summit predator may be more important than which species fills the role. At present, that trophic position is putatively occupied by a hybrid canid.

The identification of coyote hybrids within New York State has important implications for the potential reintroduction of gray wolves into the Adirondacks. It is unknown whether expanding coyotes inter-bred with remnant wolves within New York that resulted in the large coyote hybrids or whether hybridization between eastern Canadian wolves and coyotes in Ontario was followed by the southern migration of hybrids into New York. Despite these two possibilities, historical accounts and genetic data from historic samples suggest the eastern Canadian wolf/red wolf (*C. lycaon*) was common within the State before extirpation. However, according to the 1800s account of De Kay (1842), wolves of gray wolf (*C. lupus*) origin may have been present, although rare. The recommendation for any relocation of wolves into the Adirondacks based on the genetic data would be to reintroduce the eastern Canadian wolf (*C. lycaon*). This assumes that relocation is feasible.

At present, the coyote hybrids inhabiting New York State are functioning as apex predators with a predominantly white-tailed deer diet. Specific questions should be addressed as to the additional role the eastern Canadian wolf would add to the Adirondack ecosystem. A comparison of the ecological differences between eastern Canadian wolves and eastern coyotes

should be undertaken to determine what differences exist between the two predators. If the re-introduction of eastern Canadian wolves is intrinsically important because the species existed in New York State and was extirpated as a result of human activities, then the feasibility of maintaining a population of *C. lycaon* must be addressed.

Whether the relocation of eastern Canadian wolves into the Adirondacks will result in cohesive pack structures that will prevent inter-breeding with neighboring hybrid coyotes is unknown. Ongoing research programs on an eastern Canadian wolf population in Algonquin Provincial Park and a red wolf reintroduction program may provide insights. A genetic analysis of Algonquin wolves and neighboring Frontenac Axis canids has shown limited gene flow between the park and nearby canids (Grewal et al. in prep.). Conversely, the red wolf re-introduction program at Alligator River, North Carolina has confirmed hybridization between released red wolves and coyotes migrating into the area (Red Wolf PVHA). Moreover, this hybridization is occurring at low coyote densities. A comparison of these two systems is important to properly assess the effectiveness of maintaining the eastern Canadian wolf within the Adirondacks. We strongly recommended an initial study examine the variables influencing hybridization between *C. lycaon* and *C. latrans* before implementing a relocation program. The U.S. Fish & Wildlife Service red wolf reintroduction program has documented the effects of hybridization on reintroduced eastern wolves. The program has identified hybridization as its highest priority and is undertaking intense management actions to reduce the influence of hybridization.

If conditions are not right for the reintroduction of wolves today, what would it take to return wolves sometime in the future?

We agree with representatives of state agencies that a structured, well-organized, regionally integrated, and ongoing management plan is needed if wolves are ever introduced to the AP. Without such a plan, the long-term protection of biological assets necessary to sustain wolves is impossible.

The following section outlines considerations for development of a biologically defensible conservation strategy for wolves. The overarching theme is to sustain the natural environment and meet human needs by reducing the potential for one seriously to encroach upon the other. We hope our observations are viewed as a contribution to a comprehensive conservation plan for wolves and associated prey. Such a plan also might capture the needs of many other species. In formulating these comments, we tried to distinguish between information having some quantitative basis and that originating from subjective appraisals and intuition. Our comments are not intended to supercede or second-guess those individuals, organizations, and agencies who have given the subject of wolf reintroduction into the AP considerable thought. Following, in point form, are general observations regarding the establishment of wolves in the AP:

- Conservation efforts for wolf recovery should reflect biological/ecological time frames rather than social/political ones.

- Because wolves have such large spatial habitat requirements, management across regions and disjunct areas of suitable habitat is necessary. Therefore, conservation plans must address

community, ecosystem, and landscape level issues . This requires cooperation among multiple government jurisdictions and private landowners.

- Unified regional management requires a broad systems approach that transcends the boundaries of Adirondack Park. To be effective, a wolf conservation strategy must consider the status of the entire regional metapopulation over an area that encompasses both source and sink populations.

- An essential first step is interagency cooperation based on a specific set of shared goals (e.g., ensure viability of all native species). This will require coordinating resource management and research with government with agencies and private interests managing adjacent lands.

- Biological science must be at the heart of any strategy to conserve carnivores, but social science, economics, law, education, and many other disciplines must be involved while finding politically acceptable solutions. The proximal threats to wolf recovery are related to habitat, but the ultimate threats are human population, behaviors, and attitudes.

- An outstanding challenge is the need to understand if and how we can preserve wolves within lands of multiple uses, including intense human activity.

- Recognizing that ideas about ecosystem management are still in a state of flux, future options should not be foreclosed by planning decisions that result in permanent removal of habitat .

- Although management should be based upon the best information available, unrecognized changes or events may occur. For example, population dynamics always contain an important (sometimes dominating) random component. Thus, predicting the future status of a regional population can be virtually impossible. Or, the discovery of a new rare species might require maintenance of a specific habitat to prevent extinction of the species. This unanticipated event could result in conflicts with other established management objectives. Accordingly, a fundamental principle of ecosystem management is that management should be adaptive, learning from experience, and changing in response to new ideas, information, and conditions.

- Many ecologists believe that some form of temporal and/or spatial refugia is prudent and perhaps necessary for persistence of wolf populations. The role of refugia in population persistence has emerged as one of the most robust concepts of modern ecology. Much remains to be known, however, about the actual size, dispersion, and spatio-temporal dynamics for effective refugia. We need further to assess the role of Adirondack Park as a potential core reserve for the region. Emphasis needs to be placed on identifying landscape connections with other nearby reserves.

- Ideally, conservation efforts should focus on the viability of the terrestrial carnivore guild, of which the gray wolf is a part. We suggest that a community approach to management, rather than single species management, is necessary to ensure persistence of all native carnivores and associated prey species.

- Develop a wolf conservation strategy (within the context of other species) based on empirical evidence of habitat requirements and tolerance of human activities to ensure that future development is compatible with the ecological requirements of wolves.

- Protect habitat quality in areas where there is potential for wolf populations to exist (i.e., "hold the line against additional degradation").

- Preserve linkages among potential subpopulations of wolves by protecting probable movement and dispersal corridors.

- Expand the width of "pinch points" along potential travel linkages to maintain the free flow of movement. Specifically, reduce human activities in and near constrictions and remove facilities that block or constrain movements along preferred routes.

- Provide for secure latitudinal and elevational movements in response to seasonal and long-term climate change. Winter travel routes often differ from summer pathways because of snow accumulation and effects of human activities. Managers need to consider the dispersion of humans on the landscape and types of activities being pursued.

- Restore impaired areas that wolves could use but that are marginally suitable because of disturbance. This may require managing human activities at different spatial and temporal scales (e.g., regionally, locally, seasonally, and daily). For example, managers can control the type and season of public use to reduce conflicts with wolves. Where necessary, alter patterns of human use by moving trails or facilities away from areas important for wolves (and other species).

- Specific management actions necessary to sustain wolves include increasing ungulate habitat capability, minimizing fragmentation of winter ungulate range, controlling potential sources of direct mortality on wolves, and providing additional unroaded or minimally roaded refugia for wolves. Significant progress toward these objectives is necessary to assure the viability and regional distribution of wolves.

- Managers need to assess critically the effects of human activities that modify natural snow cover. Non-essential roads and trails should not be maintained during periods of snow cover. In addition, activities that compact snow (e.g., snowmachines, dog sleds, snow shoeing, skiing) must be considered in relation to the distribution of prey, highways, towns, and other landscape features.

- Consider the need for habitat manipulation to mimic natural processes such as fire. Fire may be critical for sustaining a variety of successional habitats that support ungulates used by wolves.

- Highway and railway related mortality could be a threat to wolf survival in the Adirondack region. Anticipating future expansion of the regional road network, decision-makers should consider elevating and burying extensive sections of highways that pass through critical wolf habitat and travel corridors. In mountain landscapes, fencing, underpasses, and overpasses used to mitigate adverse highway effects have failed to provide adequate protection for wolves. However, in more homogenous landscapes (e.g., Great Lakes region), highway mortality has presented fewer problems. The Adirondack region is intermediate between western mountains and the Great Lakes.

- If trains are deemed a problem, we recommend that the speed of trains be reduced to 70 km/hr. During periods of heavy snow accumulation, speeds should be further reduced and trains should be preceded by 'rail scooters' to clear the track of wildlife. If suggested railway mitigations fail, then tracks should be strategically elevated for distances of at least 100 m to permit passage of wildlife underneath.

APPENDIX A

Modeling Approaches and Basic Literature Background

Several modeling methods have been used to analyze species/habitat relationships in wolves. A static predictive model of potential wolf distribution in the north-central U.S. used multiple logistic regression to analyze correlations between pack distribution and such landscape-level attributes as road density and fractal dimension (Mladenoff et al. 1995, 1997). The analysis scale, a moving window of 150 km^2, was based on mean pack territory size. Boitani et al. (1997) used a similar approach to predict the potential distribution of wolves in Italy. They conducted discriminant function analysis (DFA), using a Mahalanobis distance metric, with a moving window of 100 km^2 (the mean pack territory size in Italy). The significant variables included: number of ungulate species, landscape diversity, human population density, road density, land use (percent farmland, forest, and urban settlement), and dump site density. Elevation and sheep population density were found to be non-significant in this analysis.

Boyd (1997) analyzed landscape attributes selected by six colonizing wolves that dispersed from protected refugia into northwestern Montana, southeastern British Columbia, and southwestern Alberta. Wolves selected landscapes with relatively low elevations, flatter terrain, and closer proximity to water and roads than expected based on availability inside and outside their new home ranges. A logistic regression model was derived using elevation, slope, and distance to roads to predict wolf presence in areas of potential colonization.

A modified "least-cost path" model of landscape connectivity was used to identify critical barriers to dispersal in Banff National Park (Paquet et al. 1997). The least-cost path can be modeled in GIS (geographic information systems) as a combination of the attraction to preferred habitats minus energetic costs (due to topography, snow depth, etc.), security costs (exposure to humans or roads), and physical impediments to movement (Paquet et al. 1997). The Banff study used a time-series analysis to project effects of increased development and road creation on landscape connectivity. Dynamic diffusion models also have been developed using road density and vegetation type to simulate wolf dispersal in U.S. Rockies (Walker and Craighead 1998).

Boyce (1992b, 1995a) developed a simulation model based on stochastic difference equations to explore wolf-prey interactions in the Greater Yellowstone Ecosystem (GYE). This was a "psuedospatial" model in that separate models for three areas in the GYE were created and linked by dispersal. The main prey species for wolves in the GYE are elk, mule deer, moose, and bison. In this model, both hunter harvest and climate influenced prey populations. When human-caused mortality was held constant in the model, the effect of elk population dynamics dominated wolf population dynamics. Elk population dynamics were in turn dominated by the density-independent effects of winter severity, although summer forage production also was important. Although not directly applicable to map-based conservation planning, this type of model affords qualitative insights concerning predator-prey interactions.

Haight et al. (1998) used a simulation model to analyze wolf population dynamics in a semi-developed landscape. They found that low levels of immigration allowed the persistence of isolated wolf populations inhabiting the landscape matrix. Wolves can inhabit areas with high levels of mortality risk (40%) if either spatial refugia (protected populations) exist or if dispersal is possible between buffer populations. This suggests that regional planning incorporating core, buffer, and dispersal can increase habitat the effective size of reserves and allow the distribution of wolves to expand to include much of the landscape matrix (Fritts and Carbyn 1995, Craighead et al. 1997). This message and the limited size of existing protected areas have led several authors to stress the importance of cross jurisdictional planning (Salwasser et al. 1987, Bath et al. 1988, Mladenoff et al. 1995, Boyd et al. 1995, Paquet and Hackman 1995).

We can divide components of wolf habitat models into biological attributes and human-associated disturbance factors. Because of the wolfs' inherent behavioral variability, it is unlikely that all wolves react equally to human-induced change. Moreover, many extraneous factors contribute to variance in behavior of individual wolves. Because we have developed no reasonable expression of those differences, assessment is best applied at the pack and population levels. Solitary individuals (i.e., lone wolves) may show different habitat associations than packs.

APPENDIX B

Connecting Linkages (Corridors)

Many ecologists believe we can reduce the adverse effects of human disturbance with the maintenance or provision of landscape linkages among subpopulations. Much recent literature in conservation biology supports the idea of providing "corridors" of suitable habitat between population centers (Forman and Godron 1986, Harris and Gallagher 1989, Noss 1993). Corridors provide travel lanes to accommodate daily, seasonal, and dispersal movements from one large habitat block to another. In theory, corridors greatly reduce the possibilities of inbreeding and chance environmental catastrophes by providing opportunity for the introgression of new genetic materials and the exchange of individuals from source populations.

Wildlife movement corridors facilitate the biologically effective transport of animals between larger patches of habitat. Corridors are linear habitats whose primary wildlife function is to connect two or more significant habitat areas. Although corridors may have intrinsic wildlife value, their salient value is that they connect more substantive patches of habitat. Corridors generally are used to maintain connectivity among formerly contiguous wildlands, not to connect naturally isolated units. Conservation theory suggests that by protecting landscape linkages between the remaining patches of habitat, we can prevent or forestall the future loss of species, but at population levels lower than in pristine conditions. When human activities threaten to disrupt natural patterns of wildlife movement, we must take measures to avoid impacts or create a wildlife movement corridor out of another area.

We can categorize most species into one of two types of corridor users. "Passage species" need corridors to allow individuals to pass directly between two areas in discrete events of brief duration (e.g., dispersal of a juvenile, seasonal migration, or moving between parts of a large home range). For passage species, corridors may function as transitional habitats that provide only those ecological services and resources required when individuals move between patches. Large herbivores and medium to large carnivores are typically passage species, as are many migratory animals. These species do not have to meet all of their life requirements within the corridor, but the corridor must provide conditions that motivate the animal to enter and use the corridor. In other cases, corridors may comprise habitats that are critical for day to day survival. In contrast to passage species, "corridor dwellers" need several days to several generations to pass through the corridor (e.g., plants, insects, amphibians, and small mammals).

In pristine conditions, wildlife movements are the product of the individual or group's search for life requisites. Species adaptations, population size, demographic structure, interspecific relations, the abundance and distribution of food, availability of habitat for security, physiography, climate, disturbance activities, and wildlife management actions affect movements. Moreover, some movements seem learned behaviors. In unaltered environments, large mammals move between preferred habitats in response to seasonal forage availability and stages in their life cycle. There is, for example, good evidence that among long-lived species such as wolves or bears (*Ursus sp.*), knowledge of travel routes is passed down by tradition from generation to

generation (Mech 1970, Curatolo and Murphy 1986, Thurber et al. 1994, S. Herrero pers. comm., S. Minta pers. comm.).

Ecological factors that determine the availability and quality of wildlife corridors are dynamic and these elements can be expected to change seasonally and among years. Corridors appear to follow "paths of least resistance" (e.g., topography and habitat) that have greatest visibility and fewest obstructions. Corridors seem to be established along routes characterized by low disturbance and escape terrain. Observed travel routes for wolves include human trails, wildlife trails, ridges, open edges, riparian valley bottoms, shorelines, open forest, and roads. Major river and creek valleys, and interconnecting passes, function as local and regional travel corridors (Paquet 1993).

Studies have shown that the width of a corridor is particularly important to allow for unimpeded movement of wildlife. Whereas narrow corridors may work well for small mammals and some bird species, corridors several kilometers in width may be necessary for use by large mammal species such as wolves (Harrison 1992, Merriam and Lanoue 1990). The width required for a corridor to be effective may depend upon its length. Effective corridors may be narrow if they are short enough that dispersers may pass through without foraging.

In human dominated landscapes, competing land uses that may directly or indirectly conflict with species requirements limit the availability and quality of movement corridors. The presence of human facilities (physical impediments) along natural routes may displace wildlife from traditional paths, force them to adopt alternative routes, or lead to permanent abandonment of habitat that was once contiguous or connected by the route. Obstructions to movements may be physical or psychological, consisting of physical impediments, sensory impediments, and the loss of forest cover in travel corridors and in adjacent areas. For example, divided highways ≥ 90 m wide were considered the equivalent of bodies of water twice as wide in obstructing movements of small forest animals (Oxley et al. 1984). Concrete embankments, highway fences, urban communities, and motor vehicle traffic were barriers to cougar movement in Southern California (Beier in press, via K. Heuer pers. comm.). Many animals perceive darkness as a form of cover, travelling in open areas during the night. Wolves in Italy, for example, living in a densely populated and highly fragmented landscape shifted to nocturnal behavior to avoid humans (Boitani 1982). Night lighting was identified as a factor that compromised the potential effectiveness of a corridor for cougars in Southern California (Beier in press, via K. Heuer pers. comm.).

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Risk Problems

Red Wolf Taxonomic Workshop
SE Regional Office, Atlanta, GA
30 August 2017



[Speaker's notes were written by Nicole Athearn in March 2016.]
Still here in trade-offs and exploring the six problem classes that Mike talked about yesterday.

Classifying Uncertainty

- Pr: framing uncertainty
- O: values uncertainty
- A: engineering uncertainty
- C: scientific uncertainty
- T: optimization uncertainty



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2

Since risk problems are characterized by uncertainty, let's talk a little bit about it and how it can make its way into the PrOACT process.

We can have uncertainty in how to frame the problem.
When we're developing objectives, we can have a lack of clarity of what values need to be represented or maybe even how we feel about the problem.
Maybe we don't really know what opportunities may be available to us.
We have uncertainty about how to find the right alternative, or optimization uncertainty.

Usually when we think of uncertainty as the main thing that makes a decision hard, we're talking about predicting consequences, or scientific uncertainty. This is when you need to understand how your alternatives perform when compared against your objectives. Scientific Uncertainty is what we will focus on in this module and the next. The next module will go into how to make decisions about reducing some of that uncertainty.

In this module, we discuss how to structure your problem to help make a decision in the face of uncertainty.

3 Major Types of Uncertainty

- Linguistic
- Aleatory
- Epistemic



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3

I'm going to briefly touch on these 3 classes of uncertainty and how they relate to the decision process.

Linguistic Uncertainty

- Reducible through clarification
  - Measurable attributes help clarify!
- Types:
  - Vagueness
  - Context-dependence
  - Ambiguity
  - Under-specificity
  - Indeterminacy of terms



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4

Linguistic uncertainty is just confusion that can be caused by our use of language. Sometimes it just isn't clear what certain words or terms mean, and they can be misunderstood or they can be interpreted in a way that we didn't intend. For example, if we say we want to restore streamflow to "historic" conditions, what time period exactly does that refer to? What particular conditions are we talking about? If this isn't made clear and we're trying to get information from experts, there could be a real mismatch in the information we get and what we needed.
Luckily, we can reduce this kind of uncertainty if we make an effort.

Aleatory Uncertainty

- Irreducible (or practically so)
- Sources
  - Environmental stochasticity
  - Demographic stochasticity
- How to deal with it
  - The focus of this presentation



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5

That isn't the case with Aleatory Uncertainty, which how we describe chance events. This is the stuff we really can't control.
Stochasticity just means that there is some element of randomness.

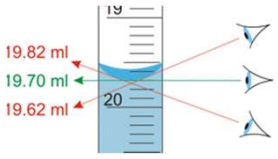
Environmental stochasticity is things that happen that we can't control or even predict very easily. These are things like weather events. Being from California I think of earthquakes, living in Oklahoma I think of tornadoes – oh, and also earthquakes.

Demographic stochasticity is the chance events that happen to individuals in a population, and this is the kind of thing we tend to only worry about when a population is very small. For example, if you are down to 5 breeding pairs and they end up producing 12 males and 3 females, that is a problem. But a larger population is better able to absorb these chance events.

This kind of uncertainty that we can't do much about is what we're talking about in this module.

Epistemic Uncertainty

- Potentially reducible through learning
- Sources
  - Measurement error
  - Sampling error
  - Systematic error
  - Model uncertainty
  - Subjective judgment





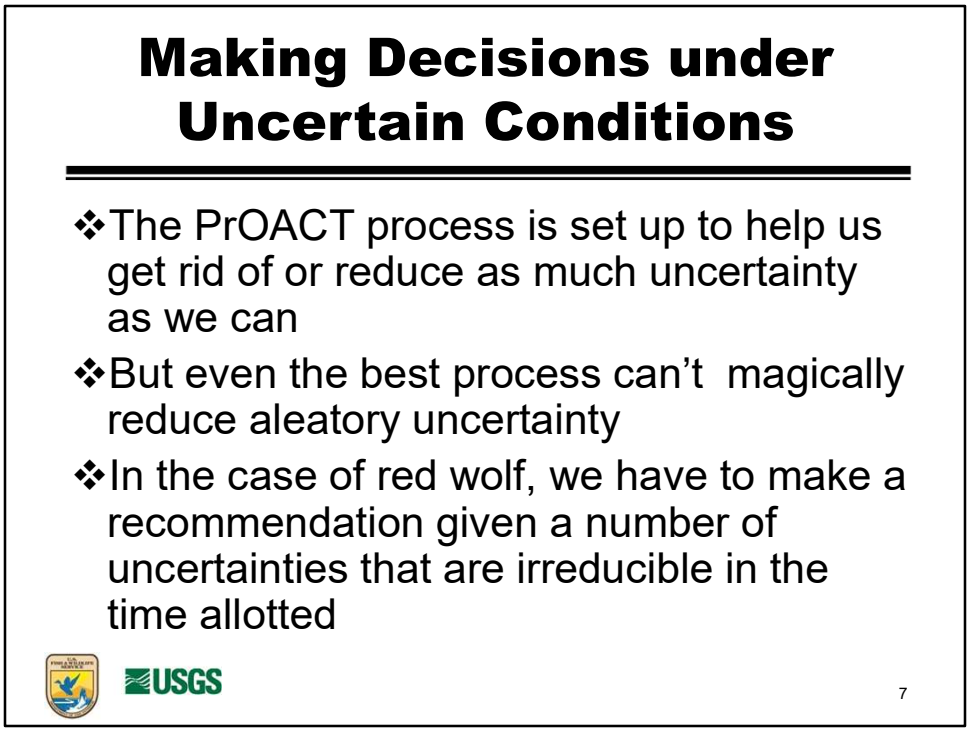
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6

And then there's the stuff that we could know, but we just don't yet. We COULD know it because it's not a random event – there is an answer out there somewhere.

But it will take some time and effort and we need to decide if it is worth it.

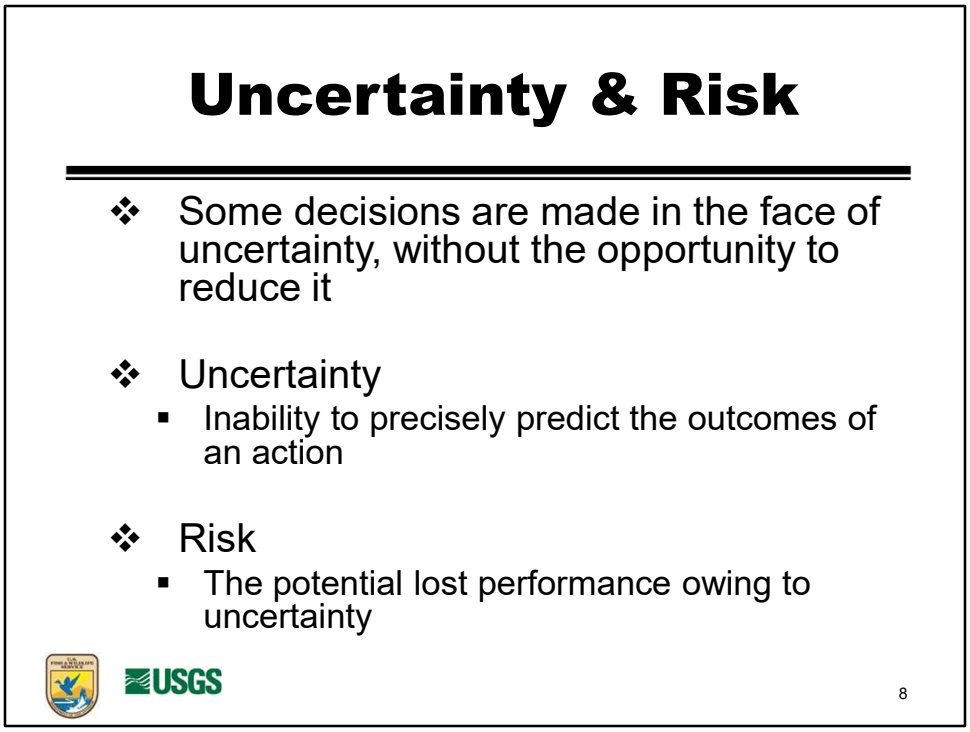
This the kind of uncertainty that Eric will be talking about in the next module.



This PrOACT process is set up to help us get rid of or reduce as much uncertainty as we can. That includes linguistic uncertainty and the uncertainty around how to frame a problem and set objectives. It's really the reason that we have this iterative process and why we encourage going back to previous steps, because every time we do that we're reducing some uncertainty and making the decision process stronger.

But, even Mike Runge can't predict chance events, or magically provide you with all the data you need to make your decision. But he did develop this module, so there's that.

So let's assume that we are dealing with a problem that depends on some factor that we can't know– either because we're dealing with chance events that we can't predict, OR because we're making a decision that involves something that we just don't know a whole lot about.



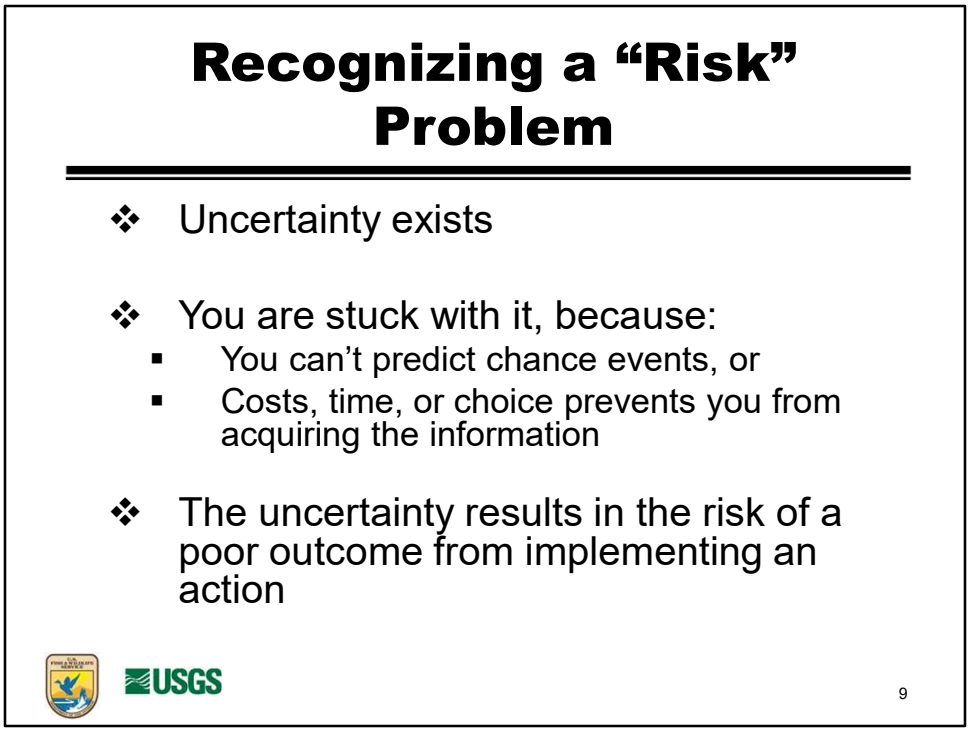
And, we are forced to make a decision anyway.

I want to pause for a second because this module is called “Risk” and we’re talking a lot about “Uncertainty.” Let’s reduce our own linguistic uncertainty here and discuss the difference.

When we talk about uncertainty in this module, we mean that we can’t pin down exactly how some action that we’re considering is going to turn out.

When we have to make a decision under uncertainty, that decision involves risk. Risk is when there are several possible outcomes that our action might have, and when we take that action, we risk getting the outcome that would be the worst of those possible outcomes.

Uncertainty in itself is not necessarily a problem. If the uncertainty in the outcome wouldn’t change the decision, then it’s not something we need to worry about. But when uncertainty also carries a RISK of getting a different, and not so great, outcome from taking an action, then it becomes something that we need to deal with.

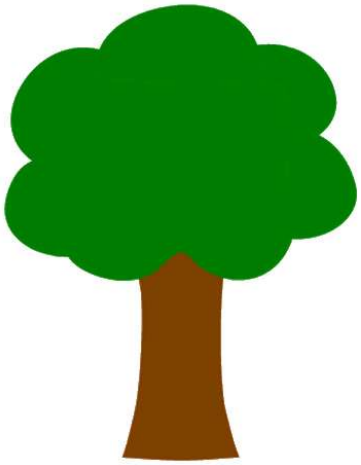


We just finished talking about uncertainty and how you know when you have a risk problem.

To summarize, there are 3 things that you look for.
First, that you have uncertainty that is related to how your potential actions will perform with respect to your objectives.
Second, that you either can't reduce that uncertainty or have chosen not to.
And finally, that there is Risk associated with that uncertainty – meaning that the uncertainty could cause you to get a worse outcome than you might have been able to get if you had chosen some other action.

So the action that will give you the best outcome really depends on something you don't know.

Decision Trees



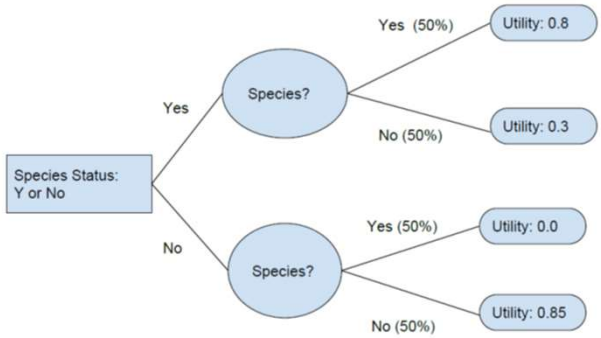
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10

Decision trees are a tool that you can use to help you structure your risk problem. We're going to work through some examples.

The Species Problem

EU = (0.5*0.8)+(0.5*0.3) = 0.53



EU = (0.5*0.0)+(0.5*0.85) = 0.425

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11

Here's an example of a linked decision tree. In some cases, our decisions may result in other decisions later.

A manager wants to minimize the number of acres lost to fire. Lower numbers are better.
Solve from right to left. The steps are shown in your book.

Risk Attitude

- Risk-averse
  - You would trade a gamble for a sure amount that is less than the expected value of the gamble
  - E.g., buying insurance
- Risk-seeking
  - You would trade a sure amount for a gamble that has a smaller expected value (but the chance of a larger payout)
  - E.g., buying lottery tickets



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Approach to Risk

- The decision-maker's approach to risk is a values decision
  - Individual-based risk preferences
  - Context-specific risk preferences
- For public decisions, the approach to risk may be a combination of factors
  - Legal mandates (e.g., ESA)?
  - Western science (5% p-values)?
  - DM risk preference?



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Who's values matter?

Summary

- Challenge: irreducible uncertainty
- Analysis
  - Scientific: express uncertainty with probability, evaluate alternatives using expected value
  - Values-based: consider risk tolerance



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Analyzing a Prospective Red Wolf (*Canis rufus*) Reintroduction Site for Suitable Habitat

by Jon Shaffer
April, 2007

Abstract

Since its declared extinction in the wild in 1980, the red wolf has been reintroduced into two areas of the South. The reintroduction in Northeastern North Carolina has been quite successful, while the reintroduction into the Great Smoky Mountains National Park was unsuccessful. The USFWS Red Wolf Recovery Plan calls for the additional establishment of two more wild populations of wolves. I analyzed the potential of one prospective release site to contain enough suitable habitat to support a reintroduction of red wolves. The Central Coastal North Carolina area was chosen for analysis as it met general criteria for the likely success of reintroduction, including a similar geography to the successful Northeastern North Carolina site, and a large amount of land in conservation. ArcGIS 9.2 was used to identify core patches of potential habitat within the study area and calculate the amount of their areas occurring on protected lands. The patches were examined for connectivity using least-cost path analysis, and optimal corridors containing the top 5th percentile best paths between patches were calculated. Three patches, that combined would provide suitable habitat for wolf reintroduction, were identified. Together these patches contained an area larger than the 68,800 hectares of habitat required for red wolf reintroductions. And over 75 % of this area occurred on conservation lands. It is therefore possible that the Central Coastal North Carolina area contains enough suitable habitat for the reintroduction of red wolves. The approach used in this analysis could by applied to other prospective red wolf release sites.

Introduction:

The red wolf (*Canis rufus*) was declared extinct in the wild in 1980. As a result of the Endangered Species Act of 1973, the U.S. Fish and Wildlife Service (USFWS) initiated the Red Wolf Recovery Program. It established a captive breeding program, and a reintroduction plan with a goal of establishing at least three wild populations of wolves totaling 220 animals; each population should occupy at least 178,000 acres (68,800 hectares) of contiguous habitat (USFWS 1990). Red wolves have been successfully reintroduced into Northeastern North Carolina; there is currently a population of approximately 100 centered among the Alligator River and Pocosin Lakes National Wildlife Refuges. However, a similar reintroduction effort was unsuccessful in the Great Smoky Mountains National Park (Kelly et al. 2004).

The USFWS is considering other prospective release sites for establishing additional red wolf populations. Thirty one prospective release sites have been identified throughout the former range of the red wolf (Van Manen et al. 2000). I will examine one of these potential sites, the Central Coastal North Carolina area. The goal of my analysis is to determine if this site contains enough physically suitable habitat to support a reintroduction of red wolves. The site will be analyzed for the amount of core habitat it contains, the connectivity of these areas, and the protection status of the core areas' land. An approach similar to that taken by Paquet et al. (1999) in their determination of habitat suitability for gray wolf reintroduction in the Adirondacks will be used, with some modifications to the methodology.

Methods:

Choice of site:

The Central Coastal North Carolina area consists of the land area, excluding barrier islands, of four counties: Carteret, Craven, Jones, and Onslow (Figure 1). This site was chosen for several reasons. First, it is geographically very similar to the northeastern North Carolina site where red wolves have been successfully reintroduced. Next, it contains several large protected areas of conservation lands including the Croatan National Forest and the Hofmann State Forest. Third, the site has a low coyote density compared to other areas of the state, and as much of the area is bounded by water, it may be possible to exclude coyotes from the site. Coyotes present one of the greatest challenges to the success of red wolf reintroductions as they readily hybridize with the wolves, and can quickly dilute the gene pool (Kelly et al. 2004, Phillips et al. 2003). Finally, the close proximity of the study site to the successful reintroduction site in Northeastern North Carolina will allow for easier exchange of resources, expertise, and personnel between reintroduction areas.

Data:

The National Elevation Dataset (1 arc second) and National Land Cover Dataset 2001 from the USGS were used to determine elevation and land cover at the site. Highway, county boundary, state boundary, and waterbody vector data were obtained from the USGS National Atlas of the United States. Vector data on municipal town boundaries and roads were obtained from the North Carolina Flood Mapping Program. Vector data on

protected conservation lands were obtained from the North Carolina Corporate Geographic Database's "Lands Managed for Conservation and Open Space" data layer (NCCGDB 2003). Deer density data were obtained from the North Carolina Wildlife Resources Commission. The ranges of red wolf populations reintroduced into the Great Smoky Mountains and Northeastern North Carolina were obtained in the form of vector data from NatureServe (Patterson et al. 2003). All data were projected to NAD 1983 UTM Zone 18N and most layers were clipped to the four county research site. All raster data throughout the analysis were set to a 30 by 30 meter resolution.

Analysis:

Analysis was conducted in ArcMap 9.2 (See Appendix for models and Python Scripts).

Patches of core habitat for red wolves were identified in the study area based on the following criteria:

1. Road density of less than 0.25 km/km^2.
2. 1 km from highways.
3. 2 km from incorporated towns.
4. Land cover of one of the following classes: deciduous, evergreen, or mixed forest, shrub/scrub, grassland/herbaceous, woody wetlands, or emergent herbaceous wetlands.
5. Deer density of at least 5 deer/km^2.
6. Slopes no greater than 20^o.
7. Patch area of at least 45.6 km^2.

Low human density and distance from roads are among the most important predictors of potential red wolf habitat in North Carolina (Kelly et al. 2004). Following the model of Patterson et al. (2003), road density was used as an approximation of human density. Road density was calculated by converting the roads data into a raster and calculating focal statistics on a moving 1km by 1km window. The highway and town data were buffered and combined into a raster of unsuitable habitat. The land cover data were reclassified to reflect the habitat preferences of red wolves depicted above. Deer are the most important prey item for red wolves, accounting for 43% of the biomass digested by wolves in Northeastern North Carolina (Phillips et al. 2003). As such, a raster was created from the deer data identifying areas with a deer density of at least 5 deer/km^2. As slopes greater than 20^o may be avoided by wolves (Callaghan 1999), a slope raster was created from the elevation data.

The above raster layers were combined to create a raster of potential habitat patches. Then habitat patches with an area of at least 45.6 km^2 were extracted from this raster to create the core habitat patches raster. The area of 45.6 km^2 represents the minimum home range size for a pack of red wolves (Phillips et al. 2003). The area of core habitat patches existing on protected conservation land was then extracted and tabulated.

Least-cost path analysis was used to examine functional connectivity between core habitat areas. A raster cost surface reflecting the variable resistance to wolf movement was created. Each value of the raster represented how much relative cost a wolf would

face when traveling through each 30 by 30 meter pixel. The cost surface was generated from a composite of three different cost rasters: land cover cost, road density cost, and highways cost. Table 1 displays the features associated with these rasters and their respective costs. Estimates of the relative costs of different features were adapted from Paquet et al. (1999) when possible and estimated from knowledge gleaned from the literature on wolves. The minimal cost distance from core habitat patches was then calculated through the cost surface. Allocation boundaries were drawn at the locations where the maximum least-cost distance occurred between any two core patches. The cells along each allocation boundary with the minimum 5% of cost distance values were then used (as described by Theobald 2006) to create multiple pathways and a corresponding corridor containing the top 5^{th} percentile best paths between patches.

Results:

Nine core patches of habitat were identified in the study area (Fig. 2). These ranged in size from 48 to 432 km^2 (Table 2). Three of the core patches (4, 5, and 7) were better connected to each other than the other patches; these other patches tended to lay along the periphery of the study area. The lower cost distances between these three patches can be seen in Figure 3. Much of the land in patches 4, 5, and 7 had the added benefit of existing under conservation protection (Croatan National Forest and Hofmann State Forest), while almost none of the land in the other core patches was protected (Table 2). Most of the

likely corridors between core patches did not lie on protected land. The exception to this was the corridor between patches 5 and 7, which occurred almost completely on conservation lands (Fig. 4).

Discussion:

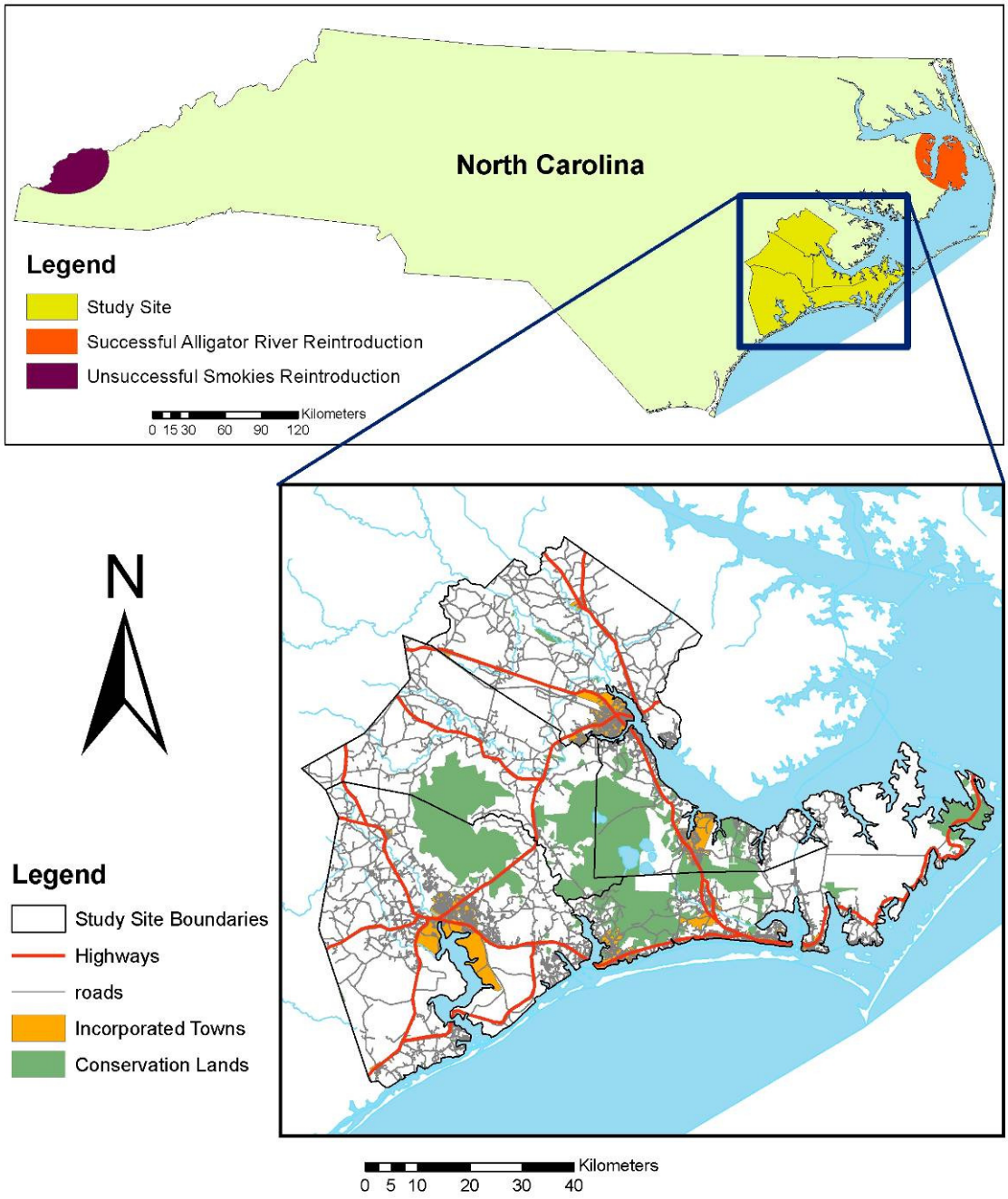
In light of the large cost distances between many of the potential core habitat patches, their relatively small size, and their peripheral location where they may be less protected from coyote immigration, it is recommended that only the three central, connected patches be considered as suitable habitat (patches 4, 5, and 7). This selection includes the two largest habitat patches and has the added benefit of being mostly contained within conservation lands. Taken together these patches have an area of 84.0 km^2 (Table 3). This meets the reintroduction requirement of 170,000 acres (68.8 km^2) of wolf habitat. Especially encouraging is that over 75% of this suitable habitat occurs on protected conservation lands, and the most likely corridors between two of the patches are protected.

There were several limitations to this analysis. First, it did not take coyote density into account. Hybridization with coyotes is the one of the greatest challenges to successful red wolf reintroduction, and it was one of the main factors preventing the success of the Great Smoky Mountain reintroduction effort (Kelly et al. 2004, Phillips et al. 2003). Anecdotally, coyote density is low in the study area, but actual numbers need to be

accurately surveyed. Another limitation to the study was the use of land cover data that is several years old. Although this is the most recent data available, the study site is located in a fast growing area of North Carolina and faces continuing development pressure. A third limitation is the subjectivity involved in the estimation of cost for the cost surfaces. Actual costs of movement for wolves over certain surfaces may be much different than those estimated. Also, it is tough to determine the magnitude of cost distance at which travel between two core patches of habitat becomes unlikely or impossible. But, as more information is gleaned from telemetry and behavioral studies we can update the relative costs of movement in the model.

Though there are limitations, this geospatial approach provides a useful framework for determining if the prospective reintroduction site will provide suitable wolf habitat. It is flexible in that costs can be adjusted and more variables added as more data are obtained regarding the habitat needs of the red wolf. On the basis of this study, it appears quite possible that the Central Coastal North Carolina area contains enough suitable habitat for the reintroduction of red wolves. I recommend that this site be analyzed further for consideration for red wolf reintroduction. The models used in this approach may be useful when analyzing other prospective reintroduction sites for the red wolf.

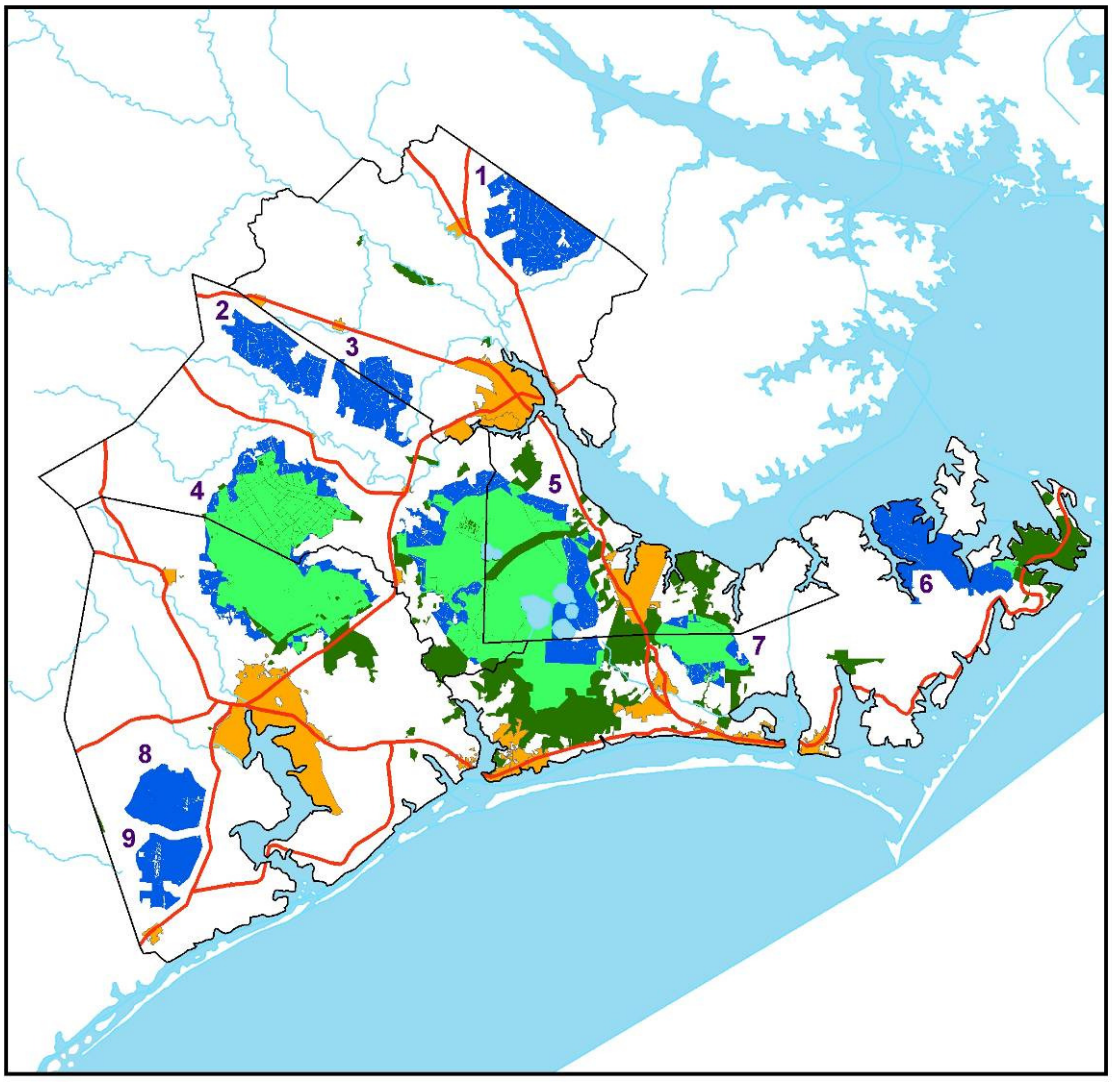
Figure 1. Study Site Location and Overview



Projection: NAD 1983 UTM Zone 18N.

Map Produced by Jon Shaffer, April 2007.

Figure 2. Identified Core Red Wolf Habitat Patches



Legend

- Core habitat patches
- Core habitat protected in Conservation Lands
- Non core habitat Conservation Lands
- Study Site Boundaries
- Highways
- Incorporated Towns

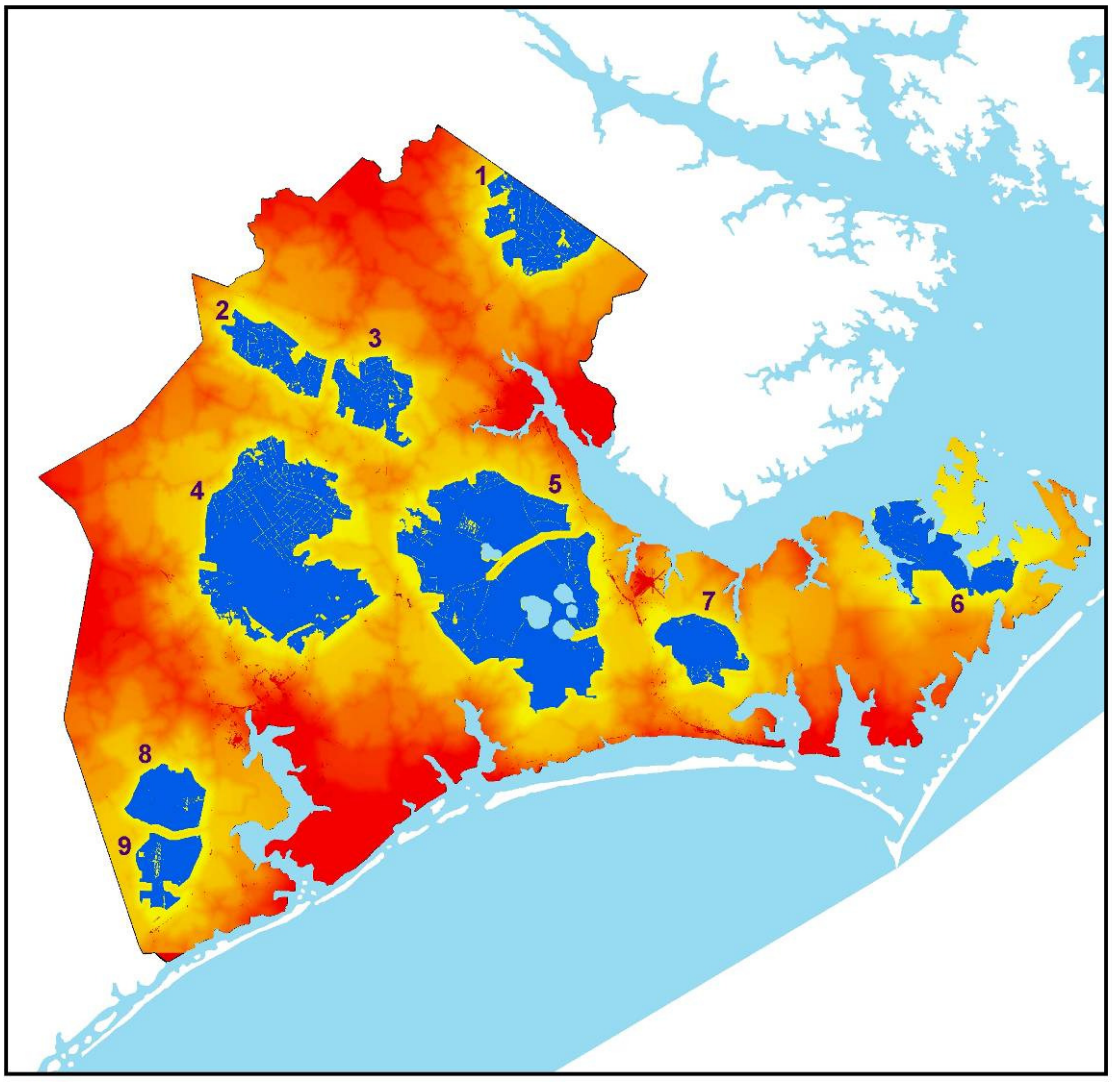
0 5 10 20 30 40 Kilometers

Projection: NAD 1983 UTM Zone 18N.

N

Map Produced by Jon Shaffer, April 2007.

Figure 3. Travel Cost from Core Habitat Patches



Legend

Core habitat patches

Travel Cost

High

Low

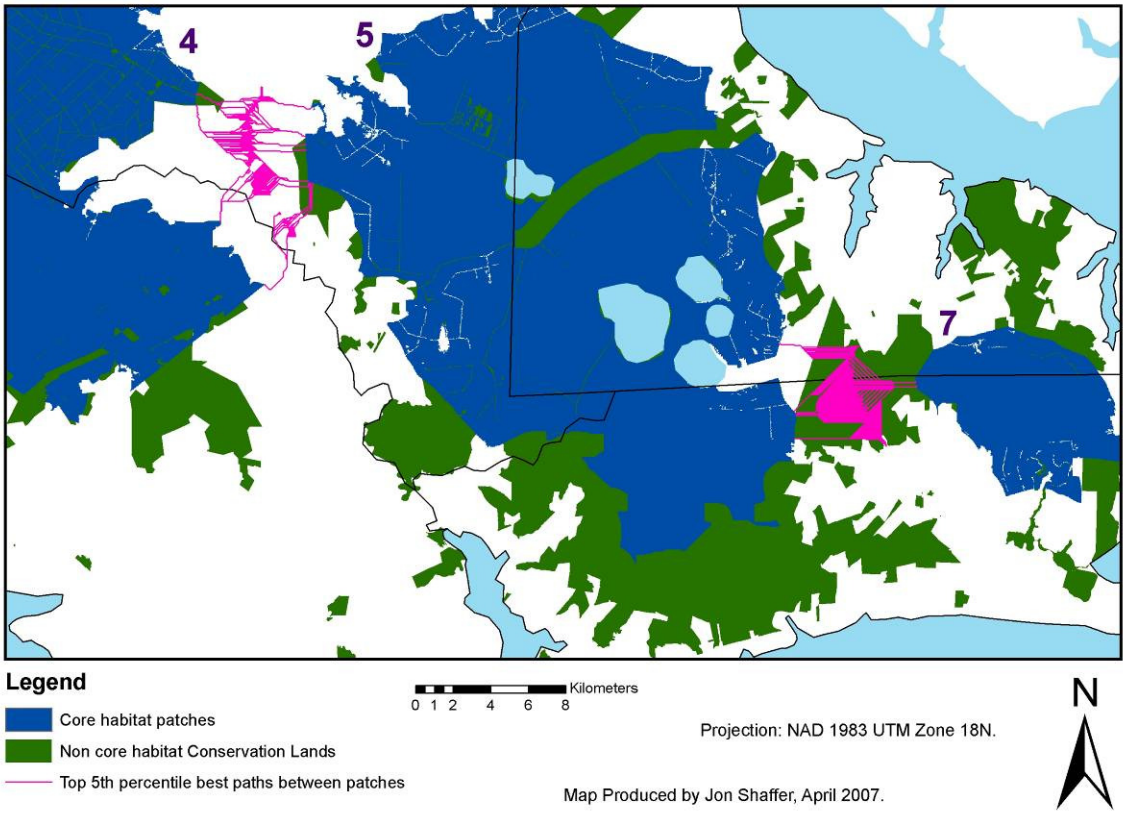
0 5 10 20 30 40 Kilometers

N

Projection: NAD 1983 UTM Zone 18N.

Map Produced by Jon Shaffer, April 2007.

Figure 4. Optimal Corridors between Habitat Patches 4, 5, and 7.



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Acknowledgements:

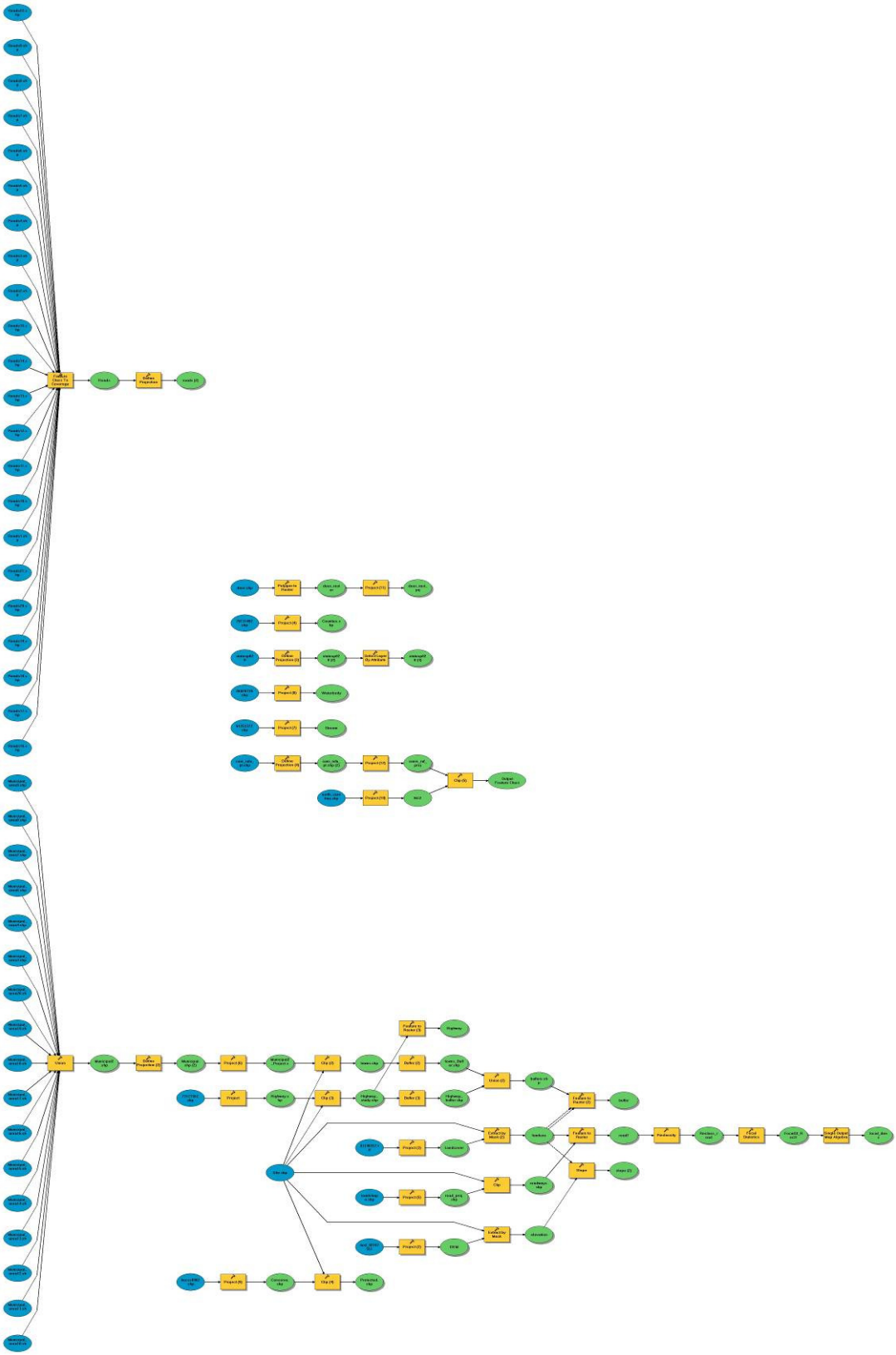
I would like to thank the North Carolina Wildlife Resources Commission for providing me with deer density data. I would also like to thank Dr. Jennifer Swenson for allowing me to turn this report in late.

Table 1. Cost Surface Assignment for Study Site	
Landcover Surface	***Cost***
Open Water	10
Developed, Open Space	8
Developed, Low Intensity	10
Developed, Medium Intensity	No Data
Developed, High Intensity	No Data
Barren Land	8
Deciduous Forest	1
Evergreen Forest	1
Mixed Forest	1
Shrub/Scrub	1
Grassland/Herbaceous	3
Pasture/Hay	6
Cultivated Crops	7
Woody Wetlands	1
Herbaceous Wetlands	1
Road Density Surface (km/km^2)	***Cost***
0 - 0.25	0
0.25 - 0.5	5
> 0.5	10
Highway Surface	***Cost***
Highway Presence	5
Highway Absence	0

Table 2. Summary Statistics of Core Habitat Patches			
Core Patch #	*Area (ha)*	*Area (ha) in Conservation*	*% Protected*
1	9,063.18	-	0.0%
2	5,996.70	-	0.0%
3	6,593.04	-	0.0%
4	34,496.28	27,775.26	80.5%
5	43,184.25	31,142.79	72.1%
6	9,181.17	368.64	4.0%
7	6,334.92	4,547.43	71.8%
8	5,918.67	-	0.0%
9	4,796.73	-	0.0%
Total	125,564.94	63,834.12	50.8%

Table 3. Summary Statistics of Suitable Habitat Patches			
Core Patch #	*Area (ha)*	*Area (ha) in Conservation*	*% Protected*
4	34,496.28	27,775.26	80.5%
5	43,184.25	31,142.79	72.1%
7	6,334.92	4,547.43	71.8%
Total	84,015.45	63,465.48	75.5%

Appendix A: Data Preparation Model and Scripts



```
# Import system modules
import sys, string, os, arcgisscripting

# Create the Geoprocessor object
gp = arcgisscripting.create()

# Set the necessary product code
gp.SetProduct("ArcInfo")

# Check out any necessary licenses
gp.CheckOutExtension("spatial")

# Load required toolboxes...
gp.AddToolbox("C:/Program Files/ArcGIS/ArcToolbox/Toolboxes/Spatial
Analyst Tools.tbx")
gp.AddToolbox("C:/Program Files/ArcGIS/ArcToolbox/Toolboxes/Conversion
Tools.tbx")
gp.AddToolbox("C:/Program Files/ArcGIS/ArcToolbox/Toolboxes/Data
Management Tools.tbx")
gp.AddToolbox("C:/Program Files/ArcGIS/ArcToolbox/Toolboxes/Analysis
Tools.tbx")

# Set the Geoprocessing environment...
gp.cellSize = "z:\\classes\\ENV261\\Project\\Data\\landuse"
gp.mask = "z:\\classes\\ENV261\\Project\\Data\\landuse"


# Local variables...
Roads = "z:\\classes\\ENV261\\Project\\scratch\\roads"
roads__2_ = "z:\\classes\\ENV261\\Project\\scratch\\roads"
Municipal2_shp =
"z:\\classes\\ENV261\\Project\\scratch\\Municipal2.shp"
Municipal_shp__2_ =
"z:\\classes\\ENV261\\Project\\scratch\\Municipal2.shp"
ned_92187551 = "ned_92187551"
v61246557_tif = "61246557.tif"
Highway_shp = "z:\\classes\\ENV261\\Project\\Highway.shp"
DEM = "z:\\classes\\ENV261\\Project\\dem"
Landcover = "z:\\classes\\ENV261\\Project\\Landcover"
Counties_shp = "z:\\classes\\ENV261\\Project\\Counties.shp"
Roads16_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads16.shp"
Roads17_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads17.shp"
Roads18_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads18.shp"
Roads19_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads19.shp"
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Roads21_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads21.shp"
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```

```
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Site_shp = "z:\\classes\\ENV261\\Project\\Data\\Site.shp"
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towns_shp = "z:\\classes\\ENV261\\Project\\Data\\towns.shp"
v61253372_shp =
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Stream = "z:\\classes\\ENV261\\Project\\Data\\Stream"
Highway_study_shp =
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Waterbody = "z:\\classes\\ENV261\\Project\\Data\\Waterbody"
Roads22_shp = "z:\\classes\\ENV261\\Project\\NC_flood\\Roads22.shp"
roadshape_shp = "z:\\classes\\ENV261\\Project\\scratch\\roadshape.shp"
road1 = "z:\\classes\\ENV261\\Project\\scratch\\road1"
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FocalSt_Recl1 = "z:\\classes\\ENV261\\Project\\scratch\\focalst_recl1"
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towns_Buffer_shp =
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slope__2_ = "z:\\classes\\ENV261\\Project\\Data\\slope"
Highway_buffer_shp =
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canis_ruf_proj =
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cani_rufu_pl_shp__2_ = "z:\\classes\\ENV261\\Project\\shapefiles\\red
wolf\\cani_rufu_pl.shp"
Output_Feature_Class =
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north_carolina_shp__2_ =
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# Process: Feature Class To Coverage...
gp.FeatureclassToCoverage_conversion("z:\\classes\\ENV261\\Project\\NC_
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ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads19.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads20.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads21.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads1.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads10.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads11.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads12.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads13.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads14.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads15.shp
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```

```
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ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads9.shp
ROUTE;z:\\classes\\ENV261\\Project\\NC_flood\\Roads22.shp ROUTE",
Roads, "", "DOUBLE")

# Process: Define Projection...
gp.DefineProjection_management(Roads,
"PROJCS['NAD_1983_StatePlane_North_Carolina_FIPS_3200_Feet',GEOGCS['GCS
_North_American_1983',DATUM['D_North_American_1983',SPHEROID['GRS_1980'
,6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['Degree',0.0174
532925199433]],PROJECTION['Lambert_Conformal_Conic'],PARAMETER['False_E
asting',2000000.002616666],PARAMETER['False_Northing',0.0],PARAMETER['C
entral_Meridian',-
79.0],PARAMETER['Standard_Parallel_1',34.33333333333334],PARAMETER['Sta
ndard_Parallel_2',36.16666666666666],PARAMETER['Latitude_Of_Origin',33.
75],UNIT['Foot_US',0.3048006096012192]]")

# Process: Project (4)...
gp.Project_management(v79131492_shp, Counties_shp,
"PROJCS['NAD_1983_UTM_Zone_18N',GEOGCS['GCS_North_American_1983',DATUM[
'D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['T
ransverse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER['Fal
se_Northing',0.0],PARAMETER['Central_Meridian',-
75.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0
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"GEOGCS['GCS_North_American_1983',DATUM['D_North_American_1983',SPHEROI
D['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['De
gree',0.0174532925199433]]")

# Process: Project (7)...
gp.Project_management(v61253372_shp, Stream,
"PROJCS['NAD_1983_UTM_Zone_18N',GEOGCS['GCS_North_American_1983',DATUM[
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RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['T
ransverse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER['Fal
se_Northing',0.0],PARAMETER['Central_Meridian',-
75.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0
.0],UNIT['Meter',1.0]]", "",
"GEOGCS['GCS_North_American_1983',DATUM['D_North_American_1983',SPHEROI
D['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['De
gree',0.0174532925199433]]")

# Process: Project (8)...
gp.Project_management(v26828739_shp, Waterbody,
"PROJCS['NAD_1983_UTM_Zone_18N',GEOGCS['GCS_North_American_1983',DATUM[
'D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['T
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75.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0
.0],UNIT['Meter',1.0]]", "",
"GEOGCS['GCS_North_American_1983',DATUM['D_North_American_1983',SPHEROI
D['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['De
gree',0.0174532925199433]]")
```

```
# Process: Project (5)...
gp.Project_management(roadshape_shp, road_proj_shp,
"PROJCS['NAD_1983_UTM_Zone_18N',GEOGCS['GCS_North_American_1983',DATUM[
'D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['T
ransverse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER['Fal
se_Northing',0.0],PARAMETER['Central_Meridian',-
75.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0
.0],UNIT['Meter',1.0]]", "",
"PROJCS['NAD_1983_StatePlane_North_Carolina_FIPS_3200_Feet',GEOGCS['GCS
_North_American_1983',DATUM['D_North_American_1983',SPHEROID['GRS_1980'
,6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['Degree',0.0174
532925199433]],PROJECTION['Lambert_Conformal_Conic'],PARAMETER['False_E
asting',2000000.002616666],PARAMETER['False_Northing',0.0],PARAMETER['C
entral_Meridian',-
79.0],PARAMETER['Standard_Parallel_1',34.33333333333334],PARAMETER['Sta
ndard_Parallel_2',36.16666666666666],PARAMETER['Latitude_Of_Origin',33.
75],UNIT['Foot_US',0.3048006096012192]]")

# Process: Clip...
gp.Clip_analysis(road_proj_shp, Site_shp, roadways_shp, "")

# Process: Project (3)...
gp.ProjectRaster_management(v61246557_tif, Landcover,
"PROJCS['NAD_1983_UTM_Zone_18N',GEOGCS['GCS_North_American_1983',DATUM[
'D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
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CS_North_American_1983',DATUM['D_North_American_1983',SPHEROID['GRS_198
0',6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['Degree',0.01
74532925199433]],PROJECTION['Albers'],PARAMETER['False_Easting',0.0],PA
RAMETER['False_Northing',0.0],PARAMETER['Central_Meridian',-
96.0],PARAMETER['Standard_Parallel_1',29.5],PARAMETER['Standard_Paralle
l_2',45.5],PARAMETER['Latitude_Of_Origin',23.0],UNIT['Meter',1.0]];-
16901100 -6972200 266467840.990852;#;#;0.001;#;#;IsHighPrecision")

# Process: Extract by Mask (2)...
gp.ExtractByMask_sa(Landcover, Site_shp, landuse)

# Process: Feature to Raster...
gp.FeatureToRaster_conversion(roadways_shp, "LPOLY_", road1, landuse)

# Process: Reclassify...
gp.Reclassify_sa(road1, "VALUE", "0 1;NODATA 0", Reclass_road, "DATA")

# Process: Focal Statistics...
gp.FocalStatistics_sa(Reclass_road, FocalSt_Recl1, "Rectangle 1000 1000
MAP", "SUM", "DATA")

# Process: Single Output Map Algebra...
```

```
gp.SingleOutputMapAlgebra_sa("z:\\classes\\ENV261\\Project\\scratch\\fo
calst_recl1*0.03", local_dens,
"z:\\classes\\ENV261\\Project\\scratch\\focalst_recl1")

# Process: Project (2)...
gp.ProjectRaster_management(ned_92187551, DEM,
"PROJCS['NAD_1983_UTM_Zone_18N',GEOGCS['GCS_North_American_1983',DATUM[
'D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['T
ransverse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER['Fal
se_Northing',0.0],PARAMETER['Central_Meridian',-
75.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0
.0],UNIT['Meter',1.0]];-5120900 -9998100
450445547.391054;#;#;0.001;#;#;IsHighPrecision", "NEAREST", "<Null>",
"", "",
"GEOGCS['GCS_North_American_1983',DATUM['D_North_American_1983',SPHEROI
D['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['De
gree',0.0174532925199433]],VERTCS['Unknown VCS from ArcInfo
Workstation',VDATUM['Unknown'],PARAMETER['Vertical_Shift',0.0],PARAMETE
R['Direction',1.0],UNIT['Meter',1.0]];-400 -400
11258999068426.2;#;#;8.98315284119521E-09;#;#;IsHighPrecision")

# Process: Extract by Mask...
gp.ExtractByMask_sa(DEM, Site_shp, elevation)

# Process: Slope...
tempEnvironment0 = gp.cellSize
gp.cellSize = "z:\\classes\\ENV261\\Project\\Data\\landuse"
gp.Slope_sa(elevation, slope__2_, "DEGREE", "1")
gp.cellSize = tempEnvironment0

# Process: Union...
gp.Union_analysis("z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_ar
ea10.shp #;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area11.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area12.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area13.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area14.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area15.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area16.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area17.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area18.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area19.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area20.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area3.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area4.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area6.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area7.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area8.shp
#;z:\\classes\\ENV261\\Project\\NC_flood\\Municipal_area9.shp #",
Municipal2_shp, "ALL", "", "GAPS")

# Process: Define Projection (2)...
gp.DefineProjection_management(Municipal2_shp,
"PROJCS['NAD_1983_StatePlane_North_Carolina_FIPS_3200_Feet',GEOGCS['GCS
_North_American_1983',DATUM['D_North_American_1983',SPHEROID['GRS_1980'
,6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['Degree',0.0174
532925199433]],PROJECTION['Lambert_Conformal_Conic'],PARAMETER['False_E
```

```
asting',2000000.002616666],PARAMETER['False_Northing',0.0],PARAMETER['C
entral_Meridian',-
79.0],PARAMETER['Standard_Parallel_1',34.33333333333334],PARAMETER['Sta
ndard_Parallel_2',36.16666666666666],PARAMETER['Latitude_Of_Origin',33.
75],UNIT['Foot_US',0.3048006096012192]]")

# Process: Project (6)...
gp.Project_management(Municipal_shp__2_, Municipal2_Project_shp,
"PROJCS['NAD_1983_UTM_Zone_18N',GEOGCS['GCS_North_American_1983',DATUM[
'D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['T
ransverse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER['Fal
se_Northing',0.0],PARAMETER['Central_Meridian',-
75.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0
.0],UNIT['Meter',1.0]]", "",
"PROJCS['NAD_1983_StatePlane_North_Carolina_FIPS_3200_Feet',GEOGCS['GCS
_North_American_1983',DATUM['D_North_American_1983',SPHEROID['GRS_1980'
,6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['Degree',0.0174
532925199433]],PROJECTION['Lambert_Conformal_Conic'],PARAMETER['False_E
asting',2000000.002616666],PARAMETER['False_Northing',0.0],PARAMETER['C
entral_Meridian',-
79.0],PARAMETER['Standard_Parallel_1',34.33333333333334],PARAMETER['Sta
ndard_Parallel_2',36.16666666666666],PARAMETER['Latitude_Of_Origin',33.
75],UNIT['Foot_US',0.3048006096012192]]")

# Process: Clip (2)...
gp.Clip_analysis(Municipal2_Project_shp, Site_shp, towns_shp, "")

# Process: Buffer (2)...
tempEnvironment0 = gp.newPrecision
gp.newPrecision = "SINGLE"
tempEnvironment1 = gp.XYResolution
gp.XYResolution = ""
tempEnvironment2 = gp.scratchWorkspace
gp.scratchWorkspace = "z:\\classes\\ENV261\\Project\\scratch"
tempEnvironment3 = gp.MTolerance
gp.MTolerance = ""
tempEnvironment4 = gp.randomGenerator
gp.randomGenerator = "0 ACM599"
tempEnvironment5 = gp.outputCoordinateSystem
gp.outputCoordinateSystem = ""
tempEnvironment6 = gp.projectCompare
gp.projectCompare = "NONE"
tempEnvironment7 = gp.outputZFlag
gp.outputZFlag = "Same As Input"
tempEnvironment8 = gp.qualifiedFieldNames
gp.qualifiedFieldNames = "true"
tempEnvironment9 = gp.extent
gp.extent = "DEFAULT"
tempEnvironment10 = gp.XYTolerance
gp.XYTolerance = ""
tempEnvironment11 = gp.outputZValue
gp.outputZValue = ""
tempEnvironment12 = gp.outputMFlag
gp.outputMFlag = "Same As Input"
tempEnvironment13 = gp.geographicTransformations
gp.geographicTransformations = ""
```

```
tempEnvironment14 = gp.ZResolution
gp.ZResolution = ""
tempEnvironment15 = gp.workspace
gp.workspace = "z:\\classes\\ENV261\\Project\\Data"
tempEnvironment16 = gp.MResolution
gp.MResolution = ""
tempEnvironment17 = gp.derivedPrecision
gp.derivedPrecision = "HIGHEST"
tempEnvironment18 = gp.ZTolerance
gp.ZTolerance = ""
gp.Buffer_analysis(towns_shp, towns_Buffer_shp, "2 Kilometers", "FULL",
"ROUND", "ALL", "")
gp.newPrecision = tempEnvironment0
gp.XYResolution = tempEnvironment1
gp.scratchWorkspace = tempEnvironment2
gp.MTolerance = tempEnvironment3
gp.randomGenerator = tempEnvironment4
gp.outputCoordinateSystem = tempEnvironment5
gp.projectCompare = tempEnvironment6
gp.outputZFlag = tempEnvironment7
gp.qualifiedFieldNames = tempEnvironment8
gp.extent = tempEnvironment9
gp.XYTolerance = tempEnvironment10
gp.outputZValue = tempEnvironment11
gp.outputMFlag = tempEnvironment12
gp.geographicTransformations = tempEnvironment13
gp.ZResolution = tempEnvironment14
gp.workspace = tempEnvironment15
gp.MResolution = tempEnvironment16
gp.derivedPrecision = tempEnvironment17
gp.ZTolerance = tempEnvironment18

# Process: Project...
gp.Project_management(v73121562_shp, Highway_shp,
"PROJCS['NAD_1983_UTM_Zone_18N',GEOGCS['GCS_North_American_1983',DATUM[
'D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['T
ransverse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER['Fal
se_Northing',0.0],PARAMETER['Central_Meridian',-
75.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0
.0],UNIT['Meter',1.0]]", "",
"GEOGCS['GCS_North_American_1983',DATUM['D_North_American_1983',SPHEROI
D['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['De
gree',0.0174532925199433]]")

# Process: Clip (3)...
gp.Clip_analysis(Highway_shp, Site_shp, Highway_study_shp, "")

# Process: Buffer (3)...
gp.Buffer_analysis(Highway_study_shp, Highway_buffer_shp, "1
Kilometers", "FULL", "ROUND", "NONE", "")

# Process: Union (2)...
gp.Union_analysis("z:\\classes\\ENV261\\Project\\scratch\\towns_Buffer.
shp #;z:\\classes\\ENV261\\Project\\scratch\\Highway_buffer.shp #",
buffers_shp, "ALL", "", "GAPS")
```

```
# Process: Feature to Raster (2)...
tempEnvironment0 = gp.cellSize
gp.cellSize = "z:\\classes\\ENV261\\Project\\Data\\landuse"
tempEnvironment1 = gp.mask
gp.mask = "z:\\classes\\ENV261\\Project\\Data\\landuse"
gp.FeatureToRaster_conversion(buffers_shp, "Id", buffer, "30")
gp.cellSize = tempEnvironment0
gp.mask = tempEnvironment1

# Process: Project (9)...
gp.Project_management(lmcos0902_shp, Conserve_shp,
"PROJCS['NAD_1983_UTM_Zone_18N',GEOGCS['GCS_North_American_1983',DATUM[
'D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['T
ransverse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER['Fal
se_Northing',0.0],PARAMETER['Central_Meridian',-
75.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0
.0],UNIT['Meter',1.0]]", "",
"PROJCS['NAD_1983_StatePlane_North_Carolina_FIPS_3200',GEOGCS['GCS_Nort
h_American_1983',DATUM['D_North_American_1983',SPHEROID['GRS_1980',6378
137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['Degree',0.017453292
5199433]],PROJECTION['Lambert_Conformal_Conic'],PARAMETER['False_Eastin
g',609601.22],PARAMETER['False_Northing',0.0],PARAMETER['Central_Meridi
an',-
79.0],PARAMETER['Standard_Parallel_1',34.33333333333334],PARAMETER['Sta
ndard_Parallel_2',36.16666666666666],PARAMETER['Latitude_Of_Origin',33.
75],UNIT['Meter',1.0]]")

# Process: Clip (4)...
gp.Clip_analysis(Conserve_shp, Site_shp, Protected_shp, "")

# Process: Feature to Raster (3)...
gp.FeatureToRaster_conversion(Highway_study_shp, "NAME", Highway, "30")

# Process: Define Projection (3)...
gp.DefineProjection_management(statesp020,
"GEOGCS['GCS_North_American_1983',DATUM['D_North_American_1983',SPHEROI
D['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['De
gree',0.0174532925199433]]")

# Process: Select Layer By Attribute...
gp.SelectLayerByAttribute_management(statesp020__2_, "NEW_SELECTION",
"\"STATE\" = 'North Carolina'")

# Process: Polygon to Raster...
gp.PolygonToRaster_conversion(deer_shp, "Dens_km", deer_raster,
"CELL_CENTER", "NONE", "30")

# Process: Project (11)...
gp.ProjectRaster_management(deer_raster, deer_rast_prj,
"PROJCS['NAD_1983_UTM_Zone_18N',GEOGCS['GCS_North_American_1983',DATUM[
'D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['T
ransverse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER['Fal
se_Northing',0.0],PARAMETER['Central_Meridian',-
75.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0
.0],UNIT['Meter',1.0]];-5120900 -9998100
```

```
450445547.391054;#;#;0.001;#;#;IsHighPrecision", "NEAREST", "30", "",
"",
"PROJCS['NAD_1983_UTM_Zone_17N',GEOGCS['GCS_North_American_1983',DATUM[
'D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['T
ransverse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER['Fal
se_Northing',0.0],PARAMETER['Central_Meridian',-
81.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0
.0],UNIT['Meter',1.0]];-5120900 -9998100
450445547.391054;#;#;0.001;#;#;IsHighPrecision")

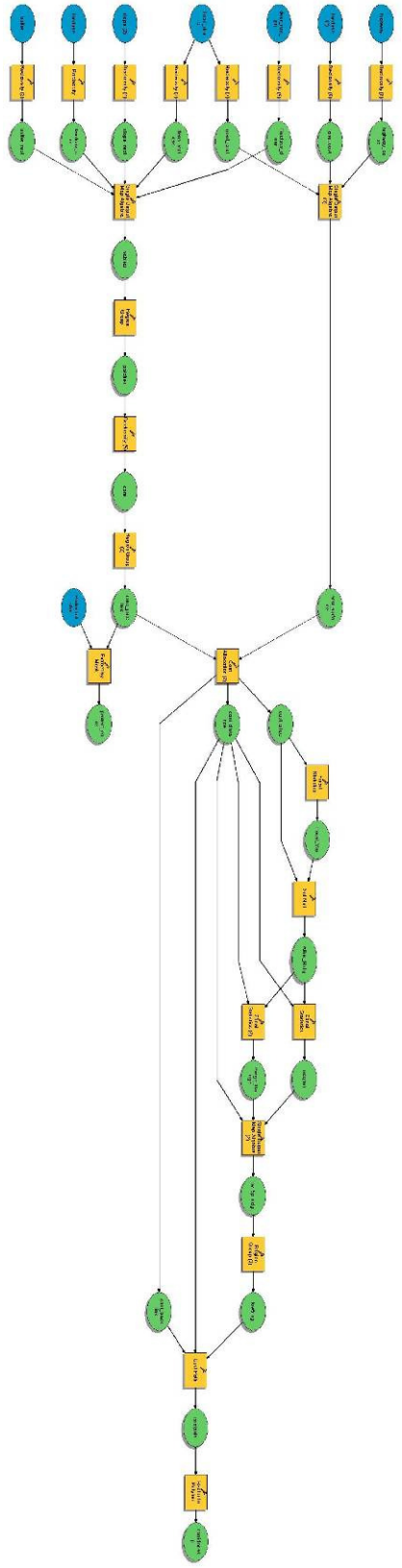
# Process: Define Projection (4)...
gp.DefineProjection_management(cani_rufu_pl_shp,
"GEOGCS['GCS_North_American_1983',DATUM['D_North_American_1983',SPHEROI
D['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['De
gree',0.0174532925199433]]")

# Process: Project (12)...
gp.Project_management(cani_rufu_pl_shp__2_, canis_ruf_proj,
"PROJCS['NAD_1983_UTM_Zone_18N',GEOGCS['GCS_North_American_1983',DATUM[
'D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['T
ransverse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER['Fal
se_Northing',0.0],PARAMETER['Central_Meridian',-
75.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0
.0],UNIT['Meter',1.0]]", "",
"GEOGCS['GCS_North_American_1983',DATUM['D_North_American_1983',SPHEROI
D['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['De
gree',0.0174532925199433]]")

# Process: Project (10)...
gp.Project_management(north_carolina_shp__2_, NC2,
"PROJCS['NAD_1983_UTM_Zone_18N',GEOGCS['GCS_North_American_1983',DATUM[
'D_North_American_1983',SPHEROID['GRS_1980',6378137.0,298.257222101]],P
RIMEM['Greenwich',0.0],UNIT['Degree',0.0174532925199433]],PROJECTION['T
ransverse_Mercator'],PARAMETER['False_Easting',500000.0],PARAMETER['Fal
se_Northing',0.0],PARAMETER['Central_Meridian',-
75.0],PARAMETER['Scale_Factor',0.9996],PARAMETER['Latitude_Of_Origin',0
.0],UNIT['Meter',1.0]]", "",
"GEOGCS['GCS_North_American_1983',DATUM['D_North_American_1983',SPHEROI
D['GRS_1980',6378137.0,298.257222101]],PRIMEM['Greenwich',0.0],UNIT['De
gree',0.0174532925199433]]")

# Process: Clip (5)...
gp.Clip_analysis(canis_ruf_proj, NC2, Output_Feature_Class, "")
```

Appendix B: Analysis Model and Scripts



```
# Import system modules
import sys, string, os, arcgisscripting

# Create the Geoprocessor object
gp = arcgisscripting.create()

# Check out any necessary licenses
gp.CheckOutExtension("spatial")

# Load required toolboxes...
gp.AddToolbox("C:/Program Files/ArcGIS/ArcToolbox/Toolboxes/Spatial
Analyst Tools.tbx")
gp.AddToolbox("C:/Program Files/ArcGIS/ArcToolbox/Toolboxes/Conversion
Tools.tbx")

# Set the Geoprocessing environment...
gp.XYResolution = ""
gp.scratchWorkspace = "z:\\classes\\ENV261\\Project\\scratch"
gp.MTolerance = ""
gp.randomGenerator = "0 ACM599"
gp.outputCoordinateSystem = ""
gp.outputZFlag = "Same As Input"
gp.qualifiedFieldNames = "true"
gp.extent = "798393.534402281 3818666.10197191 931413.534402281
3926216.10197191"
gp.XYTolerance = ""
gp.cellSize = "30"
gp.outputZValue = ""
gp.outputMFlag = "Same As Input"
gp.geographicTransformations = ""
gp.ZResolution = ""
gp.mask = "landuse"
gp.workspace = "z:\\classes\\ENV261\\Project\\Data"
gp.MResolution = ""
gp.ZTolerance = ""


# Local variables...
buffer = "z:\\classes\\ENV261\\Project\\scratch\\buffer"
landuse = "z:\\classes\\ENV261\\Project\\Data\\landuse"
local_dens = "z:\\classes\\ENV261\\Project\\scratch\\local_dens"
landcov_cor = "z:\\classes\\ENV261\\Project\\scratch\\landcov_cor"
buffer_recl = "z:\\classes\\ENV261\\Project\\scratch\\buffer_recl"
dens_reclass = "z:\\classes\\ENV261\\Project\\scratch\\dens_reclass"
slope_recl = "z:\\classes\\ENV261\\Project\\scratch\\slope_recl"
habitat = "z:\\classes\\ENV261\\Project\\Data\\habitat"
patches = "z:\\classes\\ENV261\\Project\\scratch\\patches"
core = "z:\\classes\\ENV261\\Project\\Data\\core"
core_patches = "z:\\classes\\ENV261\\Project\\Data\\core_patches"
landuse__2_ = "z:\\classes\\ENV261\\Project\\Data\\landuse"
land_cost = "z:\\classes\\ENV261\\Project\\scratch\\land_cost"
cost_alloc = "z:\\classes\\ENV261\\Project\\scratch\\cost_alloc"
cost_distance = "z:\\classes\\ENV261\\Project\\Data\\cost_distance"
cost_backlink = "z:\\classes\\ENV261\\Project\\Data\\cost_backlink"
Focal_Var = "z:\\classes\\ENV261\\Project\\scratch\\Focal_Var"
Alloc_Ridg = "z:\\classes\\ENV261\\Project\\Data\\Alloc_Ridg"
ridgmin = "z:\\classes\\ENV261\\Project\\scratch\\ridgmin"
```

```
Ridge_Range = "z:\\classes\\ENV261\\Project\\scratch\\Ridge_Range"
lw_5p_ridg = "z:\\classes\\ENV261\\Project\\scratch\\lw_5p_ridg"
low5_rg = "z:\\classes\\ENV261\\Project\\scratch\\low5_rg"
costpath = "z:\\classes\\ENV261\\Project\\Data\\costpath"
road_cost = "z:\\classes\\ENV261\\Project\\scratch\\road_cost"
highway = "z:\\classes\\ENV261\\Project\\scratch\\highway"
highway_cost = "z:\\classes\\ENV261\\Project\\scratch\\highway_cost"
cost_surface = "z:\\classes\\ENV261\\Project\\scratch\\cost_surface"
slope__2_ = "z:\\classes\\ENV261\\Project\\Data\\slope"
protect_core = "z:\\classes\\ENV261\\Project\\scratch\\protect_core"
Protected_shp = "z:\\classes\\ENV261\\Project\\Data\\Protected.shp"
deer_rast_prj = "Z:\\classes\\ENV261\\Project\\scratch\\deer_rast_prj"
Reclass_deer = "z:\\classes\\ENV261\\Project\\scratch\\Reclass_deer"
corridor_shp = "z:\\classes\\ENV261\\Project\\Data\\corridor.shp"

# Process: Reclassify (2)...
gp.Reclassify_sa(buffer, "VALUE", "0 NODATA;NODATA 0", buffer_recl,
"DATA")

# Process: Reclassify (4)...
gp.Reclassify_sa(slope__2_, "Value", "0 20 0;20 30 NODATA", slope_recl,
"DATA")

# Process: Reclassify...
gp.Reclassify_sa(landuse, "VALUE", "11 NODATA;21 NODATA;21 24 NODATA;24
31 NODATA;41 43 0;43 52 0;52 71 0;81 82 NODATA;90 95 0", landcov_cor,
"DATA")

# Process: Reclassify (3)...
gp.Reclassify_sa(local_dens, "Value", "0 0.25 0;0.25 17.600000000000001
NODATA", dens_reclass, "DATA")

# Process: Reclassify (9)...
gp.Reclassify_sa(deer_rast_prj, "Value", "0 NODATA;0 5 NODATA;5
17.374500274658203 0", Reclass_deer, "DATA")

# Process: Single Output Map Algebra...
gp.SingleOutputMapAlgebra_sa("z:\\classes\\ENV261\\Project\\scratch\\bu
ffer_recl+z:\\classes\\ENV261\\Project\\scratch\\dens_reclass+z:\\class
es\\ENV261\\Project\\scratch\\slope_recl+z:\\classes\\ENV261\\Project\\
scratch\\landcov_cor +
z:\\classes\\ENV261\\Project\\scratch\\reclass_deer", habitat,
"z:\\classes\\ENV261\\Project\\scratch\\buffer_recl;z:\\classes\\ENV261
\\Project\\scratch\\slope_recl;z:\\classes\\ENV261\\Project\\scratch\\l
andcov_cor;z:\\classes\\ENV261\\Project\\scratch\\dens_reclass;z:\\clas
ses\\ENV261\\Project\\scratch\\Reclass_deer")

# Process: Region Group...
gp.RegionGroup_sa(habitat, patches, "FOUR", "WITHIN", "ADD_LINK", "")

# Process: Reclassify (5)...
gp.Reclassify_sa(patches, "COUNT", "1 50666 NODATA;50667 500000 0",
core, "DATA")

# Process: Region Group (2)...
gp.RegionGroup_sa(core, core_patches, "FOUR", "WITHIN", "ADD_LINK", "")
```

```
# Process: Extract by Mask...
gp.ExtractByMask_sa(core_patches, Protected_shp, protect_core)

# Process: Reclassify (7)...
gp.Reclassify_sa(local_dens, "Value", "0 0.25 0;0.25 0.5 5;0.5
17.600000000000001 10", road_cost, "DATA")

# Process: Reclassify (8)...
gp.Reclassify_sa(highway, "VALUE", "1 14 5;NODATA 0", highway_cost,
"DATA")

# Process: Reclassify (6)...
gp.Reclassify_sa(landuse__2_, "VALUE", "11 10;21 8;22 10;23 NODATA;24
NODATA;31 8;41 52 1;71 3;81 6;82 7;90 95 1", land_cost, "DATA")

# Process: Single Output Map Algebra (3)...
gp.SingleOutputMapAlgebra_sa("z:\\classes\\ENV261\\Project\\scratch\\hi
ghway_cost + z:\\classes\\ENV261\\Project\\scratch\\land_cost +
z:\\classes\\ENV261\\Project\\scratch\\road_cost", cost_surface,
"z:\\classes\\ENV261\\Project\\scratch\\road_cost;z:\\classes\\ENV261\\
Project\\scratch\\highway_cost;z:\\classes\\ENV261\\Project\\scratch\\l
and_cost")

# Process: Cost Allocation (2)...
gp.CostAllocation_sa(core_patches, cost_surface, cost_alloc, "", "",
"VALUE", cost_distance, cost_backlink)

# Process: Focal Statistics...
gp.FocalStatistics_sa(cost_alloc, Focal_Var, "Rectangle 3 3 CELL",
"VARIETY", "DATA")

# Process: Set Null...
gp.SetNull_sa(Focal_Var, cost_alloc, Alloc_Ridg, "\"VALUE\" = 1")

# Process: Zonal Statistics...
gp.ZonalStatistics_sa(Alloc_Ridg, "VALUE", cost_distance, ridgmin,
"MINIMUM", "DATA")

# Process: Zonal Statistics (2)...
gp.ZonalStatistics_sa(Alloc_Ridg, "VALUE", cost_distance, Ridge_Range,
"RANGE", "DATA")

# Process: Single Output Map Algebra (2)...
gp.SingleOutputMapAlgebra_sa("Con(cost_distance <= (ridgmin +
(Ridge_Range / 20)) , 1)
", lw_5p_ridg,
"z:\\classes\\ENV261\\Project\\scratch\\ridgmin;z:\\classes\\ENV261\\Pr
oject\\scratch\\Ridge_Range;z:\\classes\\ENV261\\Project\\Data\\cost_di
stance")

# Process: Region Group (3)...
gp.RegionGroup_sa(lw_5p_ridg, low5_rg, "EIGHT", "WITHIN", "ADD_LINK",
"")

# Process: Cost Path...
gp.CostPath_sa(low5_rg, cost_distance, cost_backlink, costpath,
"EACH_CELL", "VALUE")
```

```
# Process: Raster to Polyline...
gp.RasterToPolyline_conversion(costpath, corridor_shp, "ZERO", "0",

"SIMPLIFY", "VALUE").
```

Concept	Definition
Biological Species Concept (BSC)	"A biological species is an inclusive Mendelian population; it is integrated by the bonds of sexual reproduction and parentage." (Dobzhansky 1970, p. 354)
	"A species is a group of interbreeding natural groups that is reproductively isolated from other such groups." (Mayr and Ashlock 1991, p. 26)
Cohesion Species Concept	"...the most inclusive population of individuals having the potential for phenotypic cohesion through intrinsic cohesion mechanisms." (Templeton 1989, p. 12) Genetic or demographic cohesion
	"…the most inclusive group of organisms having the potential for genetic and/or demographic exchangeability." (Templeton 1989, p. 25)
Differential Species Concept	Groups of individuals that are reciprocally characterized by features that would have negative fitness effects in other groups and that cannot be regularly exchanged between groups upon contact." (Hausdorf 2011, p. 927)
Evolutionary Significant Unit	"...a population (or group of populations) that (1) is substantially reproductively isolated from other conspecific population units, and (2) represents an important component in the evolutionary legacy of species." (Waples 1991)
	"ESUs should be reciprocally monophyletic for mtDNA alleles and show significant divergence of allele frequencies at nuclear loci." (Moritz 1994, p. 373)
	"A lineage demonstrating highly restricted gene flow from other such lineages within the higher organizational level (lineage) of a species." (Fraser and Bernatchez 2001, p. 2742)
Evolutionary Species Concept	"A species is a single lineage of ancestral-descendent populations which maintains its identity from other such lineages and which has its own evolutionary tendencies and historical fate." (Wiley 1978, p. 18)
	"...a lineage, comprised of organisms, whose history of individuation has manifested in its unique evolutionary trajectory through space and time." (Cotterill 2005, p. 115)
Genetic Species Concept	"...population subdivisions concordantly identified by multiple independent genetic traits should constitute the population units worthy of recognition as phylogenetic taxa." (Avise and Ball 1990, p. 52)
Phylogenetic Species Concept, diagnosable version (PSC1)	"The smallest diagnosable cluster of individual organisms within which there is a parental pattern of ancestry and descent." (Cracraft 1983, p. 170). "the smallest population or group of populations within which there is a parental pattern of ancestry and descent and which is diagnosable by unique combinations of character states" (Cracraft 1997, p. 329).
Phylogenetic Species Concept, monophyly version	"...a geographically constrained group of individuals with some unique apomorphous character, is the unit of evolutionary significance" (Rosen 1978, p. 176). Equates with ISC (Internodal Species Concept) ofKornet (1993), which was termed the CSC by Brooks and McLennan (1999)
Phylogenetic Species Concept, diagnosable/monophyly version	"...the smallest diagnosable cluster of individual organisms forming a monophyletic group within which there is a parental pattern of ancestry and descent" (McKitrick and Zink 1988, defined by Mayden 1997, p. 407). This version of the PSC was termed PSC2 by Brooks and McLennan (1999)
Recognition Species Concept	"...the most inclusive population of individual biparental organisms that share a common fertilization system." (Paterson 1985, p. 25)

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Lauren Toivonen, University of Missouri, School of Natural Resources

Methods

Study area

The study area stretches across 17 states within the southeast United States. This area constitutes the majority of states that are part of the red wolf's historic range. Nine states were excluded because the majority of those land areas were not part of the historic range or those areas had a higher correlation of people to area available areas. While a red wolf population could fit within these states, it would be difficult for differing populations to intermix considering the condensed roads and populations within those areas and how they could easily serve as movement barriers.

Landcover

Habitat variables were obtained from the National Land Cover Database 2011 (further known as NLCD 2011). This data file contains 14 land cover classification types at a spatial resolution of 30 meters. For our research purposes, NLCD 2011 was reclassified within ArcMap to seven land cover classification types at a resampling resolution of 300 meters (Table 1). The open water type was not included.

Table 1: National Land Cover Database 2011 (NLCD 2011) classification types, the reclassified types are left column while the default classification types are the right column. Classification types were combined via the reclassify tool in ArcMap.

NLCD 2011 Land Cover Reclassification Type	NLCD 2011 Land Cover Classification Type
Wetland	Herbaceous wetland
	Woody wetland
Forest	Deciduous forest
	Evergreen forest
	Mixed forest
Pastureland	Pastureland
Cropland	Cultivated crops
Grassland	Grassland
Shrubland	Shrubland
Developed	Developed, open space
	Developed, low intensity
	Developed, medium intensity
	Developed, high intensity

Road cover

Because a majority of the southeastern United States is privatized and thus roads ranging from multi-lane paved surfaces to one-lane dirt pathways litter the landscape, I focused on interstates and highways. These two road types are the roads most utilized and thus could be the most susceptible to hosting red wolf mortality occurrences. Road data was obtained from TIGER 2014 shapefiles sourced from the US Census Bureau database. Primary and secondary (interstate and highway) road shapefiles

Commented [WE1]: Utilized by who? Wolves or humans?

were downloaded for each state and merged into one file on ArcMap. Instead of density, Euclidean distance was the tool utilized because I was wanting to look at how far away each individual 300mx300m point was from an interstate and a highway. Before processing, an index was created to help determine suitability of each individual point (Table 2). Landscape between 0-1km from a highway (Shaffer 2007, Jacobs 2009) and 0-2km from an interstate (Eggerman 2010) was deemed unsuitable. While you cannot stop a wolf from crossing a road, putting buffers into a model will help determine landscape that has minimal roads/can determine potential barriers.

Once each road type was separated and Euclidean distance was utilized, the Reclassify tool was utilized: Interstates were 0-2000m = 0 (unsuitable); >2000m = 1 (suitable). Highways were 0-1000m = 0 (unsuitable); >1000m = 1 (suitable). Meters were utilized within ArcMap in place of kilometers.

Human population

Because most of the southeast United States is privately owned and people are able to live within the borders of national forests, I examined human populations as those congregated within cities and towns. I defined a town as a location with a population between 500 and 99,999 while a city was defined as a location with a population of 100,000 people and more. Data was sourced from TIGER 2014 package. Because these cities and towns were defined by population, I wanted to examine how far an individual cell was from these locations so Euclidean distance was utilized. Reclassify was once again utilized as well with towns being 0-2000m = 0 (unsuitable); >2000m = 1 (suitable) (Jacobs 2009, Shaffer 2007). Cities being 0-5000m = 0 (unsuitable); >5000m = 1 (suitable). Meters were utilized within ArcMap in place of kilometers.

Putting it together

Each of the seven land cover classification types were reclassified individually so that new data layers were created to show each type as present (1) and absent (0). Then, those results were given a weight. This is done through Reclassify but instead of 0 and 1, they were varied from 9 to 1. The number in the 10s location (or the '1') is the weighted variable while the number in the 1s location (or the '0') takes the place of 0 by subtracting the 10s value from 10 (ex: Forest_91; 9 is the weighted variable, 10-9 = 1). The larger the range between the two numbers is, the heavier the weight. Additionally, the larger the number in the 10s position is, the heavier the weight.

Once the weights are identified, Raster Calculator is used to obtain results. Human development is a negative for the red wolf so all abiotic variables are considered negative. 19 is the lowest index possible. The model looks like this:

Forest_91 + Grassland_82 + Cropland_64 + Wetlands_73 + Shrubland_64 + Pasture_64 – Interstate_19 - City_19 – Highway_37 – Towns_28

Commented [WE2]: 10s = weighted variable
1s = 10 – 10s value

Where does the weighted value come from?

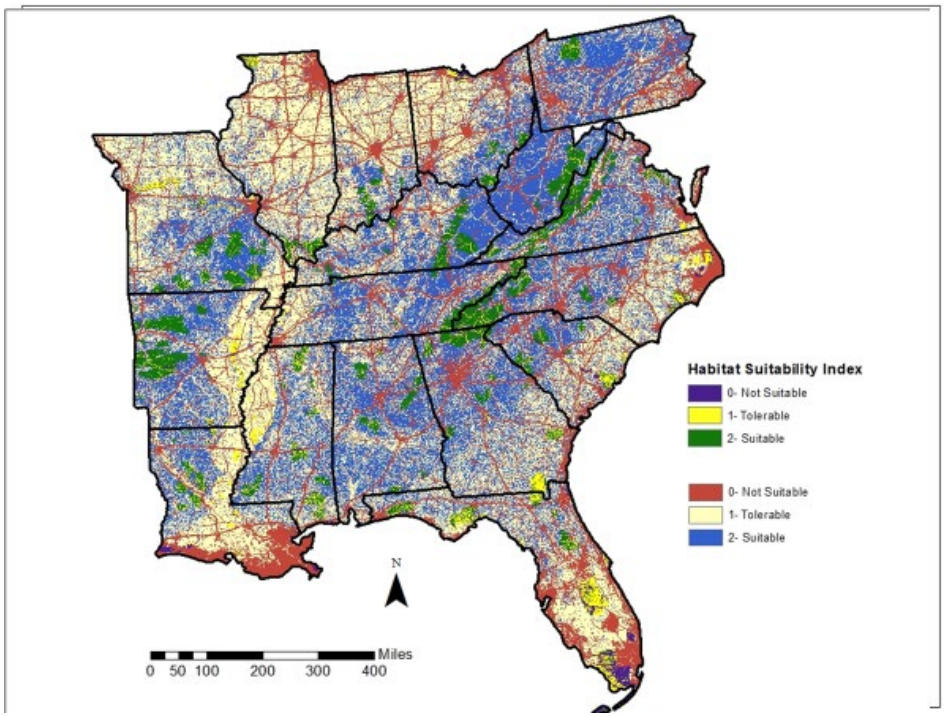
Commented [WE3]: The "present"?

Commented [WE4]: What does all of this mean?

Additionally I am exploring the inclusion of ecotone layers and the role of focal statistics but I am waiting to meet with my committee member, Dr. Hong He, who has been spending the summer in northern China performing GIS research. I aim to meet with him at the end of August/beginning of September.

The results are in the form of a map and a list. I am eager to hear your input in regards to this model for both methods and results. Please feel free to contact me for any clarification, questions, comments, etc. My email is LKT895@mail.missouri.edu and my cell phone is 314-799-2936 (but will be out of service August 9-21).

Results



Map 1: Overall results of my habitat suitability analysis. Purple/Yellow/Green indicate landscapes owned publicly, by the federal government. Red/White/Blue indicate overall landscape.

Next page ->

SUITABLE HABITAT <1,000 KM²

State	Agency	Area (km^2)	% **Suitable**/Tolerable/ Unsuitable
Kentucky/Tennessee	Big South Fork NP	525	**92.9**/3.4/3.7
Kentucky/Tennessee	Land Between the Lakes NF	687	**82.3**/10.6/7.5
Alabama	William B Bankhead NF	733	**79.8**/14.4/5.9
West Virginia	New River Gorge NP	283	**78.1**/3.7/18.2
Indiana	Hoosier NF	821	**74.2**/15.9/10.0
Virginia	Shenandoah NP	809	**73.2**/10.8/16.0
Arkansas	Fort Chaffee	275	**68**/13.5/18.5
Missouri	Fort Leonard Wood	246	**66.2**/6.5/27.3
Kentucky/Tennessee	Fort Campbell	424	**60.5**/18.8/20.6
Georgia	Fort Benning	736	**56.1**/29.6/14.3

SUITABLE HABITAT >1,000 KM²

State	Agency	Area (km^2)	% **Suitable**/Tolerable /Unsuitable
Arkansas	Ozark and Ouachita NFs	12,140	**87.1**/8.1/4.8
West Virginia	Monongahela NF	3,727	**86.5**/8.3/5.2
Virginia	Washington & Jefferson NFs	6,694	**80.9**/10.4/8.7
Kentucky	Daniel Boone NF	2,865	**80.7**/9.3/10.0
Pennsylvania	Allegheny NF	1,873	**80.6**/14.3/5.1
Alabama	Talladega NF	1,588	**79.8**/14.4/5.9
Georgia	Chattahoochee NF	3,508	**78.7**/12.8/8.6
Ohio	Wayne NF	974/3375	**78.6**/14.0/7.4
Missouri	Mark Twain NF	6,070	**78.5**/14.0/7.4
Tennessee	Cherokee NF	2,652	**77.5**/12.0/10.5

These tables indicate suitable habitat found in differing area types (over and under 1000km2). Red wolf pack size is estimated to be between 125km2 and 185km2 so areas <1000km2 could contain a few packs to jumpstart the wild population, but there is landscape available >1000km2 that can hold more wolf packs and thus increase movement within a protected area, population numbers, and genetic diversity. Habitats that have federal jurisdiction were observed. Because we can't purchase every private landscape, I looked at releasing wolves in areas that already have federal jurisdiction.

Thank you!

Lauren



WILEY

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PREDICTING RED WOLF RELEASE SUCCESS IN THE SOUTHEASTERN UNITED STATES

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Abstract: Although the red wolf (*Canis rufus*) was once found throughout the southeastern United States, indiscriminate killing and habitat destruction reduced its range to a small section of coastal Texas and Louisiana. Wolves trapped from 1973 to 1980 were taken to establish a captive breeding program that was used to repatriate 2 mainland and 3 island red wolf populations. We collected data from 320 red wolf releases in these areas and classified each as a success or failure based on survival and reproductive criteria, and whether recaptures were necessary to resolve conflicts with humans. We evaluated the relations between release success and conditions at the release sites, characteristics of released wolves, and release procedures. Although <44% of the variation in release success was explained, model performance based on jackknife tests indicated a 72–80% correct prediction rate for the 4 operational models we developed. The models indicated that success was associated with human influences on the landscape and the level of wolf habituation to humans prior to release. We applied the models to 31 prospective areas for wolf repatriation and calculated an index of release success for each area. Decision-makers can use these models to objectively rank prospective release areas and compare strengths and weaknesses of each.

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Key words: *Canis rufus*, landscape characteristics, logistic regression, red wolf, release procedures, release success, recovery, repatriation, southeastern United States.

The red wolf is one of 3 wild species of the genus *Canis* found in North America (Nowak and Paradiso 1983) and was listed as endangered in 1967 under provisions of the Endangered Species Preservation Act of 1966. The Red Wolf Recovery Program was initiated by the U.S. Fish and Wildlife Service shortly after passage of the Endangered Species Act of 1973. Officials determined that preservation of the red wolf could only be accomplished by removing the remaining individuals from the wild for captive propagation and future repatriation (U.S. Fish and Wildlife Service 1990). Consequently, >400 wild canids were captured in the coastal marshes of Texas and Louisiana from 1973 to 1980 (McCarley and Carley 1979); 14 of these animals successfully produced offspring that met the morphological criteria the U.S. Fish and Wildlife Service established for the species.

The captive breeding program was successful and the first mainland repatriation of red wolves occurred in 1987 on Alligator River National Wildlife Refuge (ARNWR) and adjacent U.S. Department of Defense land in northeastern North Carolina (Parker 1987). In addition, island propagation sites were established in South Carolina (1987), Mississippi (1989), and Florida (1990) to supply wild-reared wolves for the mainland restoration effort. Continued breeding success and population expansion established the ARNWR project as the first permanent red wolf recovery site (Phillips et al. 1995). A second mainland repatriation effort was initiated in Great Smoky Mountains National Park in 1991 (Lucash et al. 1998).

The U.S. Fish and Wildlife Service currently is in the process of evaluating prospective release sites for establishing additional wolf populations. With the accumulation of detailed records on red wolf releases, it may be possible to develop models to forecast the success of future releases of this species. This information could help wildlife biologists evaluate the logis-

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tics, costs, and success probability of future restoration efforts. With this in mind, our objectives were to (1) identify correlates of red wolf release success in the southeastern United States, and (2) use those correlates to evaluate prospective release areas.

METHODS

General

We evaluated release success based on 320 releases of 202 red wolves at the 2 mainland and 3 island sites (1987–97). Human-assisted repatriations and births in the wild were considered to be releases for this analysis. Sixty-two percent of the releases involved wolves born and raised in captivity. We developed 17 classifications of release success (van Manen et al. 1998), which included survival and reproductive criteria, and whether intervention was necessary to prevent or resolve human conflicts (e.g., livestock depredation or movement onto private property). Releases were also classified into survival segments: 6, >6–12, >12–18, and >18–24 months. For instance, 1 classification of release success was survival for 6–12 months without intervention. Releases that did not meet those criteria (i.e., wolves that survived <6 months) were excluded from that analysis. For each of these classifications, we used success or failure as the binomial dependent variable.

Model Development

We evaluated 3 categories of independent variables that were potentially related to red wolf release success (van Manen et al. 1998): (1) biological conditions at the release site, (2) human influences at the release site, and (3) the characteristics of each release. Success of releases may be influenced by prey base, the presence of other wolves, and interactions with coyotes (*C. latrans*). Therefore, variables associated with biological conditions at the release site included wolf population size, coyote density index, large prey density index, and medium prey density index. Conflicts with humans may reduce the success of release efforts. We assessed the potential for conflict with humans by measuring livestock density, human density, improved and unimproved road density, and proportion of developed and agricultural area. Finally, each release is unique because of differences among the characteristics and behaviors of red wolves and because a variety of release procedures were employed. These differences among individual releases may affect release success. For example, long captive periods may result in greater habituation to humans and decrease release success. Therefore, for each release we determined the sex and age of the red wolf and its pre-weaning environment, previous period in the wild, number of previous releases, period in captivity, period of acclimation, translocation, release group size, and release season. Release area characteristics were determined by overlaying habitat features and arithmetic mean activity centers of red wolf home ranges (TELEM88; Coleman and Jones 1988) with a geographic information system (GIS; Arc/Info®, ESRI, Redlands, California, USA). We calculated improved and unimproved road density, percent agricultural area, and percent developed area based on 3 area sizes (50 km^2, 100 km^2, 150 km^2), centered on the activity center, to determine the most effective scaling. Other spatial features were calculated based on county averages.

Although some wolves were released multiple times, univariate logistic regression (PROC LOGISTIC; SAS Institute 1989) indicated that the number of previous releases was not associated with success ($P > 0.20$ for all classifications of success). Therefore, we treated each of the 320 releases as independent observations. We performed univariate logistic regression with all combinations of independent variables and success classifications as the basis for developing multiple-variable models. We used a conservative criterion of $P < 0.5$ to ensure initial inclusion of potentially important variables. When relationships were not detected, those combinations were eliminated from further analysis (Hosmer and Lemeshow 1989). For variables measured at different spatial scales, we selected the scale that demonstrated the most significant relationship.

We calculated the Akaike's information criterion (AIC) and used its lowest value to determine which set of independent variables optimized both simplicity and fit for each success classification (Bozdogan 1987). When lowest AIC values were not statistically different for several subsets, we chose the one with the fewest variables as the operating model. We used the Hosmer-Lemeshow goodness-of-fit statistic to determine how well the data fit the selected model (Hosmer and Lemeshow 1989) and tested the assumption of linearity in the logit with

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the Box-Tidwell transformation (Guerro and Johnson 1982).

Model Testing

Logistic regression models were tested with jackknifing procedures (Verbyla and Litvaitis 1989) using PROC LOGISTIC (SAS Institute 1989). From those tests, we estimated overall correct classification rates, sensitivity (proportion of release successes predicted to be successes), specificity (proportion of release failures predicted to be failures), false positive rate (proportion of predicted successes that were failures), false negative rate (proportion of predicted failures that were successes), and reliability (Marcot et al. 1983). Reliability was defined as the fraction of model predictions that were empirically correct (sensitivity + specificity)/(sensitivity + specificity + false positive rate + false negative rate). We classified observations as successes or failures by selecting a cut-off point for the predicted probability that resulted in the highest overall classification rate (Hosmer and Lemeshow 1989), while keeping the false positive rate <20%. We considered this false positive rate to be reasonable because it is important for wildlife managers to minimize release failures.

Model Application

The U.S. Fish and Wildlife Service asked us to apply the models to evaluate 31 prospective release areas for red wolves. These areas were within the historic range of the red wolf and generally centered on large tracts of public lands with potentially favorable habitat conditions. We used the logistic regression equations to calculate the predicted probability of release success based on habitat conditions of each area, coupled with the characteristics of the wolves available for release. ArcView® GIS (ESRI, Redlands, California, USA) was used to calculate the predicted probabilities of release success at the county level. We used counties as the base unit for model application because we were interested in the general characteristics of habitat conditions in and adjacent to potential release areas and because many variables used in the models were available only by county (e.g., livestock density). Because the logistic regression models we developed included nonspatial variables, they had to be set to constant values. Red Wolf Project personnel projected that future repatriations would be similar to the most recent ones and use wild-reared wolves from other repatriation sites, use wolves with 18 months experience in the wild, include a 6-month acclimation period, and release wolves in spring.

After we calculated the predicted probability of release success for individual counties in and adjacent to the potential release areas, we calculated a composite index of success for each site. We first classified each county as a success (index value = 1) or failure (index value = 0) based on the probability cut-off points we identified during model testing. We used this approach instead of using the actual probability values because the cut-off values differed among models and thus were not directly comparable. The composite index was based on the average of these binomial values for all models and all counties, for each release area. A composite index of 1 could only be achieved if releases were predicted to be successful for all models and all counties in a prospective release area.

RESULTS

Model Development

We considered up to 15 independent variables for best model selection using the AIC criterion. We could not fit multiple-variable models for 10 of the 17 success classifications because of small sample sizes. Of the remaining models, 2 fit the data poorly ($P < 0.10$ for Hosmer-Lemeshow goodness-of-fit test) so they were excluded from further analysis. Thus, our modeling was limited to 5 classifications of success (Table 1).

The model based on survival for >6 months after release (model 1; Table 2) explained 20% of the variation (R^2 value), with human density showing the strongest negative association. This classification of release success was positively associated with livestock density and a wild pre-weaning environment. Survival for 6–12 months after release (model 2; Table 2) showed a significant negative relationship with percent developed area and explained 11% of the variation. The model based on the need for management actions within the first 6 months after release (model 3; Table 2) explained 44% of the variation. Predictions of this model were negatively influenced by human density and percent developed area, a captive pre-weaning environment, and length of acclimation period. Red

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Table 1. Classification used in multiple-variable models to characterize red wolf release success in the southeastern United States, 1987–97.

Classification	Explanation or decision rule[a]	No. of observations	
		Success	Failure
1	Survival for >6 months after release	228	44
2	Survival for 6–12 months after release	117	22
3	Survival without management action for >6 months after release	225	33
4	Survival without management action for 1–2 years after release	71	25
5	Survival on federal property without management action for >6 months after release	149	68

[a] Decision rules based on occurrence of management actions include recaptures to prevent or resolve conflicts due to behavioral problems of released wolves (interactions with coyotes, potential for livestock depredation, and use of developed areas) or wolf movements onto property for which no formal cooperative agreements existed.

wolf survival for 1–2 years after release without the need for management actions (model 4; Table 2) decreased with increasing coyote density and was related to release season; this model explained 27% of the variation. Wolf survival on federal property without management action for >6 months (model 5; Table 2) explained 32% of the variation and was negatively associated with the use of captive-reared wolves, longer acclimation periods, translocations from other release sites, human density, and density of improved roads; positive factors were the use of wild wolves and a high density index for large prey. Variables in all models met the assumption of linearity.

Model Testing

The probability cut-off points we selected to classify an observation as a success or failure ranged from 0.62 to 0.86 (Table 3). The resulting rates of overall correct prediction for the 5 models ranged from 54.7% to 80.2%. Sensitivity generally was greater than specificity, which was likely due to the proportionally greater number of successes than failures for the release observations. Reliability of the models ranged from 0.59 to 0.72. Correct predictions of release success for model 2 was markedly lower than for the other models (Table 3), so it was eliminated from further consideration.

Model Application

Although the model based on survival for 1–2 years without the need for management actions (model 4) showed good performance (Table 3), we excluded this model to rank the potential release areas. Coyote density was the only spatial variable in this model but the regional data showed little spatial variation. Moreover, we were not able to measure this particular variable for the 31 potential release sites with the same accuracy as the data we used to develop the model. This does not mean that the presence of coyotes is not an important consideration, but rather that the complications of future releases due to coyote presence would be similar among the sites we evaluated. We chose the 3 remaining models for application to prospective red wolf release sites: survival for >6 months, survival without the need for management actions for >6 months, and survival on federal property without management actions for >6 months (models 1, 3, and 5, respectively).

We applied the 3 models to 31 areas encompassing 311 counties in 19 states. The composite index of release success ranged from 0 (low) in the western Florida Panhandle to >0.9 (high) in eastern West Virginia, northwestern Alabama, and southwestern Mississippi (Table 4).

DISCUSSION

Mladenoff et al. (1995) used radiotelemetry data and logistic regression to evaluate colonizing gray wolf (*C. lupus*) packs in Wisconsin; road density was used as the predictor variable to delineate favorable habitat across the Great Lakes Region. Natural recolonization into relatively remote areas by gray wolves, as modeled by Mladenoff et al. (1995), is much different from our evaluation of human-assisted releases of red wolves into the developed landscape of the Southeast. Consequently, we considered different habitat variables and included variables to reflect release procedures and the characteristics of red wolves. As such, our emphasis was on interpreting the relationships for the independent variables that routinely showed significance in the analyses and for those variable subsets that were unique among the models.

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Table 2. Parameter estimates of logistic regression models for 5 classifications used to determine correlates of release success of red wolves in the southeastern United States, 1987–97[a].

Variable	Model 1[a]		Model 2		Model 3		Model 4		Model 5	
	Parameter estimate	SE	Parameter estimate	SE	Parameter estimate	SE	Parameter estimate	SE	Parameter estimate	SE
Intercept	1.783*	0.356	2.538*	0.700	3.696*	0.714	−0.461	0.881	1.734*	0.513
Pre-weaning environment (reference group = captive)										
wild	1.383*	0.446	−0.001	0.537	2.417*	1.006			0.952*	0.460
Release season (reference group = fall)										
(1) winter							2.457*	1.270		
(2) spring							2.483*	0.921		
(3) summer							1.730*	1.014		
Acclimation period					−0.071*	0.028			−0.063*	0.028
Previous period in wild					0.065*	0.036				
Translocation (reference group = no) yes	−1.266*	0.462	−1.177	0.7340					−0.816*	0.448
Coyote density index							−0.923*	0.337		
Large prey density index									0.429*	0.194
Livestock density index	0.751*	0.298	0.313	0.472						
Human density index	−0.635*	0.186	−0.442*	0.255	−0.725*	0.194			−0.280*	0.153
Improved road density (150-km^2 area)									−3.0E-5*	1.2E-5
Unimproved road density (50-km^2 area)									−8.8E-6	6.1E-6
Developed area (50-km^2 area)			−135.1*	59.9	−159.1*	56.2				

[a] Model numbers correspond to classification numbers in Table 1.
* Indicates parameter estimates that were significant at $P < 0.10$ based on the Wald χ^2 statistic.

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Table 3. Jackknife testing of logistic regression models to predict release success of red wolves in the southeastern United States, 1987–97.

Model[a]	*P* cut-off	Correct rate (%)	Sensitivity rate (%)[b]	Specificity rate (%)[c]	False positive rate (%)[d]	False negative rate (%)[e]	Reliability[f]
1	0.68	78.7	82.9	56.8	9.1	60.9	0.67
2	0.86	54.7	51.3	72.7	9.2	77.8	0.59
3	0.80	80.2	80.9	75.8	4.2	63.2	0.70
4	0.64	79.4	90.8	46.2	16.9	36.8	0.72
5	0.62	71.9	75.2	64.7	17.6	45.7	0.69

[a] Model numbers correspond to classification numbers in Table 1.
[b] Correct prediction of release success (A).
[c] Correct prediction of release failure (B).
[d] Release success predicted for actual release failure (C).
[e] Release failure predicted for actual release success (D).
[f] (A + B) / (A + B + C + D).

Our results were consistent with field observations on red wolves (Phillips et al. 1995) and the factors influencing the natural recolonization of gray wolf populations in the northern Great Lakes region (Mladenoff et al. 1995). For example, high human population densities increase the probability of conflict. The negative effects of increasing road density and developed areas on release success likely reflected vulnerability of wolves to vehicle mortality and a greater probability of conflict with humans. The positive relationship with livestock density in model 1 was contrary to the results of the univariate analyses. Further analysis of this model, however, indicated a negative correlation (r = -0.76) between human and livestock density, which suggests that increasing human densities masked the effects of livestock density sufficiently to change the sign of the parameter estimate in that analysis.

The multiple-variable models indicated that longer captive and acclimation periods may decrease release success due to habituation to people and the subsequent need for recapture. Likewise, the negative effect of translocation probably was correlated with both of these factors, because translocations generally result in longer captive and acclimation periods. Our results also supported the finding of Phillips et al. (1995) that survival of pups raised in the wild was greater than those raised in captivity.

Factors influencing proximate release success may change over time. During the initial phase of a release (<1 yr; models 1, 3, and 5), management actions to prevent conflict may be reduced and survival increased by releasing wolves in areas where conflicts with humans are less likely to occur (i.e., areas with a low density of human populations and roads, and limited development), by using wild-reared wolves (Phillips et al. 1995), and by using a relatively short acclimation period. However, if wolves survive this initial phase, additional factors such as establishing a home range, habitat use, and reproduction become important. Model 4 (survival for 1–2 yr without the need for management actions) suggests that establishment of social structure may be linked to longer-term success. Coyote density and release season were the important variables in this model. Although we did not apply this model to prospective release sites because of low spatial variation in coyote density, the implications from this model are significant. Greater densities of coyotes may be a significant obstacle to success; anecdotal observations suggest that red wolves may establish home ranges more quickly when coyotes are absent or at low densities (Lucash et al. 1998). The greater success of releases in spring is likely unrelated to the season itself. Spring releases typically included a wolf pair with a pregnant female or a pair with young pups. Adults accompanied by young pups tended to form cohesive groups and were less likely to exhibit wide-ranging movements and experience conflicts with humans or highways (Lucash et al. 1998).

We evaluated proximate release success rather than ultimate translocation success, the latter defined by Griffith et al. (1989) as the establishment of a self-sustaining population. This ultimate success of red wolf repatriations will likely depend on factors we could not evaluate. For example, the potential for hybridization with coyotes, an important factor in the original decline of the species, will affect any future repatriation efforts. These effects are relatively

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Table 4. Composite index of release success of red wolves for selected regions within the historic range of the species. The index is based on success or failure predicted from logistic regression models describing 3 different classifications of release success (e.g., index of 1.0 = releases predicted to be successful for all 3 models and all counties in region).

Region	No. of counties	Composite index
Western Florida panhandle	2	0.000
Southeastern North Carolina	7	0.333
Great Dismal Swamp ecosystem	5	0.333
Western North Carolina	11	0.364
Coastal South Carolina	7	0.429
Eastern Tennessee	10	0.500
Southern Ohio	12	0.500
North Georgia	17	0.510
Great Smoky Mountains	5	0.533
Eastern Kentucky–North central Tennessee	16	0.667
Central Louisiana	5	0.667
Southeastern Mississippi	14	0.667
Central Alabama	11	0.727
North-central South Carolina	10	0.733
Southwestern Kentucky–North-western Tennessee	4	0.750
Central coastal North Carolina	4	0.750
Southern Illinois	10	0.767
Southwestern North Carolina	6	0.778
Central Florida panhandle	6	0.778
Southern Indiana	8	0.792
Western Virginia	34	0.794
Southwestern Arkansas	13	0.795
Eastern Texas	12	0.806
Northern Pennsylvania	9	0.815
Northwestern Arkansas	14	0.833
Okefenokee ecosystem	4	0.833
Southern Missouri	28	0.857
Northern Mississippi	8	0.875
Southwestern Mississippi	7	0.905
Eastern West Virginia	9	0.926
Northwestern Alabama	3	1.000

gradual and could not be measured for each release in our study.

MANAGEMENT IMPLICATIONS

Based on the results of our study, we speculate that the influence of biological factors, such as prey availability, is overshadowed by human influences on the landscape and the characteristics of individual wolves. Indeed, many release failures seemed to occur when wolves moved away from federal lands and into developed areas. No properties under single ownership (federal, state, or private) can completely support a viable red wolf population. Therefore, prior cooperative agreements are essential and prospective repatriation sites should be evaluated based on landscape setting and on potential for human influences to reduce success. Successful establishment of individual red wolves also seems to be strongly influenced by the characteristics of the wolves chosen for release. Preferred candidates are red wolves that have experienced a wild environment and were born in the wild. Although repatriation usually entails some captivity before release, reducing this period to <6 months should improve success. A stable social structure may also be crucial for success because coyotes now occupy historic red wolf range. Releasing wolves as a family unit (adults and pups) may help establish and maintain this social structure.

Our models can be used as tools to objectively rank success potential of future red wolf releases: 9 of 31 prospective release sites exhibited high success potential (composite index >0.8; Table 4). Although tests showed good performance of the models, the variables that we evaluated explained a relatively small amount of the variation in release success (≤44%) and most success classifications were not analyzed because of small sample sizes. Our approach should be used as an aid to, rather than a substitute for, biologically based decision-making. Wildlife managers should consider other factors such as public attitudes, agency cooperation, accessibility, and other operational constraints when evaluating potential release sites.

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Evaluating potential effects of widening US 64 on red wolves in Washington, Tyrrell, and Dare Counties, North Carolina



Final Report

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16. Abstract

We used data from 16 red wolves fitted with GPS-collars between January 2009 and April 2011 to evaluate home range size and habitat selection, road permeability, and identify significant red wolf highway crossing locations. Home range size for red wolves averaged 13.7 mi^2 with no significant difference between males and females. Although we found no significant difference in home range size among age classes, dispersers tended to have larger home ranges than adults and juveniles. Red wolf home ranges were larger during winter than during other seasons. Red wolves avoided wetter habitats such as pocosins, wetlands, and lowland forests, leaving agriculture the best predictor of red wolf presence. Red wolves also selected for the presence of agriculture/forest road systems for travel. Road permeability, calculated using GPS-collar data, was 100%, thus the current 2-lane highway does not impose a barrier effect on the red wolf population. This increases the risk of road mortality events. Using a 3281 ft. (1 km) buffer, construction north of the current US 64 in Tyrrell County has the potential to remove up to 0.16 mi^2 of red wolf habitat and 6% of the home range area used by a current red wolf pack while construction to the south will impact only 0.09 mi^2 of red wolf habitat and will not displace any current red wolf packs. East of Alligator River in Dare County, a widening of the current highway to the south has the potential to remove up to of 0.07 mi^2 of red wolf habitat and 20% of the home range used by the only existing red wolf pack in Alligator River National Wildlife Refuge if construction disturbs out to 3281 ft. (1 km) from the current road. Construction to the north of US 64 in Dare County has the potential to remove up to 0.04 mi^2 of red wolf habitat and will not overlap with any current packs, based on 95% home ranges. Through the use of GPS-collars and remote camera traps, we identified 5 important red wolf crossing locations, 4 in Tyrrell County west of Alligator River and 1 in Dare County east of Alligator River. The presence of agricultural fields, successional fields, and/or upland forests 328 to 492 ft. from the road provided the most parsimonious explanation for the location of crossing sites identified using GPS-collar locations; trail/road width provided the best explanation for the location of crossing sites identified by remote camera traps. The presence of agricultural fields, successional fields, and upland forests as well as proximity to maintained agricultural/forest roads at crossing sites corresponds to habitat selection results. Four of the 5 red wolf crossing locations we identified are suitable for crossing structures. The most western crossing site is located within the town of Colombia, NC where retro-fitting a wildlife underpass is not practical. Well maintained trails at least 26.24 ft. (8 m) in width leading to and from underpasses, which connect habitats selected for by red wolves (e.g. agriculture, successional fields, and upland forests), is suggested to optimize efficacy.

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Executive Summary

Information reported here is the result of a 2-year study evaluating red wolf (*Canis rufus*) habitat use and crossing patterns along US 64 from Columbia, NC east to the 64/264 intersection in Manns Harbor, NC. This report includes a problem statement and background information, evaluation of red wolf home range size and habitat selection, an analysis of probable effects to red wolf home range and habitat availability in the event of a highway widening, identification of current red wolf crossing locations, and suggestions for the location and type of crossing structures to mitigate potential adverse effects of a highway widening of US 64.

We used data from 16 red wolves fitted with GPS-collars between January 2009 and April 2011 to evaluate home range size and habitat selection. Home range size for red wolves averaged 13.7 mi^2 with no significant difference between males and females. Although we found no significant difference in home range size among age classes, dispersers tended to have larger home ranges than adults and juveniles. Red wolf home ranges were larger during winter than during other seasons. Red wolves avoided wetter habitats such as pocosins, wetlands, and lowland forests, leaving agriculture the best predictor of red wolf presence. Red wolves also selected for the presence of agriculture/forest road systems for travel.

Road permeability, calculated using GPS-collar data, was 100%, thus the current 2-lane highway does not impose a barrier effect on the red wolf population. This increases the risk of road mortality events. A decrease in the red wolf population to the west of Columbia, NC, prevented collaring of red wolves where widening to a 4-lane highway was completed. Therefore, we were not able to compare highway permeability between 2- and 4-lane highways. Using a 3281 ft. (1 km) buffer, construction north of the current US 64 in Tyrrell County has the potential to remove up to 0.16 mi^2 of red wolf habitat and 6% of the home range area used by a current red wolf pack while construction to the south will impact only 0.09 mi^2 of red wolf habitat and will not displace any current red wolf packs. East of Alligator River in Dare County, a widening of the current highway to the south has the potential to remove up to of 0.07 mi^2 of red wolf habitat and 20% of the home range used by the only existing red wolf pack in Alligator River National Wildlife Refuge if construction disturbs out to 3281 ft. (1 km) from the current road. Construction to the north of US 64 in Dare County has the potential to remove up to 0.04 mi^2 of red wolf habitat and will not overlap with any current packs, based on 95% home ranges.

Through the use of GPS-collars and remote camera traps, we identified 5 important red wolf crossing locations, 4 in Tyrrell County west of Alligator River and 1 in Dare County east of Alligator River. The presence of agricultural fields, successional fields, and/or upland forests 328 to 492 ft. from the road provided the most parsimonious explanation for the location of crossing sites identified using GPS-collar locations; trail/road width provided the best explanation for the location of crossing sites identified by remote camera traps. The presence of agricultural fields, successional fields, and upland forests as well as proximity to maintained agricultural/forest roads at crossing sites corresponds to habitat selection results.

Four of the 5 red wolf crossing locations we identified are suitable for crossing structures. The most western crossing site is located within the town of Colombia, NC where retro-fitting a wildlife underpass is not practical. Well maintained trails at least 26.24 ft. (8 m) in width leading to and from underpasses, which connect habitats selected for by red wolves (e.g. agriculture, successional fields, and upland forests), is suggested to optimize efficacy.
Detailed results and discussion are provided in the report below.

Evaluating potential effects of widening US 64 on red wolves in Washington, Tyrrell, and Dare Counties, North Carolina

Final Report

Principal Investigators:
Michael R Vaughan, PhD and Marcella J Kelly, PhD

Introduction

Roads have profound effects, both direct and indirect, on natural ecosystems (see reviews by Forman et al. 2003 and Coffin, 2007). Forman and Alexander (1998) estimated that the approximately 10.9 million hectares of public roads in the US and their related habitat loss and degradation has affected >20% of land area in the United States. In a 43-year period (1960 – 2003), the number of registered cars increased from 74 to 231 million nation-wide and the annual distance traveled by car in the US grew from approximately 720,000 to 2.8 million miles (Ouren and Watts, 2005). As transportation needs increase, a rise in the amount of habitat lost and degraded due to road construction can be expected. Indeed, the link between economic development and transportation expansion was well documented by the mid 1960's (Kansky, 1963; Taaffe et al., 1963; Haggett 1965). Such large-scale and multifaceted changes to ecosystems have many detrimental impacts on wildlife (Jackson, 1999), including direct mortality (Lalo, 1987; Harris and Scheck, 1991; Schwabe and Schuhmann, 2002), habitat destruction (Theobald et al., 1997; Angelsen and Kaimowitz, 1999), barrier effects (Forman et al, 2003), and increased human land use activities (Bjurlin and Cypher, 2003; Coffin, 2007).

There is perhaps no other human impact as transportation infrastructure whose far-reaching, cumulative effects on wildlife are so devastating and demanding of attention, yet so commonly underestimated. Direct wildlife mortality results from construction injury and vehicular collisions (Trombulak and Frissell, 2000) and has now surpassed hunting as the leading direct human cause of vetebrate mortality on land (Forman and Alexander, 1998), with an estimated 720,000 to 1.5-million deer-vehicle crashes reported annually (Conover et al., 1995; Forman et al., 2003). While the number of common species killed along roads is staggering, in most cases road mortality of wildlife does not translate into population level effect. However, road related impacts to threatened and endangered species are of particular concern. Road kill is the primary cause of mortality in Florida for Florida panthers, black bears, key deer, and crocodiles (Harris and Scheck, 1991) and accounts for a high percentage of deaths in Iberian lynx (Ferreras et al., 1992). In addition, road impacts have been found in gray wolves (Thiel, 1985; Paquet and Callaghan, 1996), desert tortoises (Boarman, 1996), and some populations of San Joaquin kit foxes (Bjurlin and Cypher, 2003). For the declining copperbelly water snake in Indiana, road mortality accounts for approximately 17% of all deaths (Roe et. al, 2006). Road mortality was the second highest cause of death for red wolves in North Carolina within the 5 county recovery zone between 1999 and 2006, accounting for 14% of mortality overall (USFWS, 2007). When broken down by age class, vehicle strikes were the leading cause of death in dispersing red

wolves, accounting for 19% of mortality (USFWS, 2007). The increasing incidence of wildlife-vehicle collisions also presents a real issue for humans, as they claim hundreds of lives, cause tens of thousands of injuries, and inflict an enormous monetary cost for medical treatment and vehicle repair each year nationwide (Forman et al., 2003). For example, in 1993 1.5 million deer-vehicle crashes were reported in the US leading to $1.1 billion in vehicle damages (Durbin, 2004). Deer-vehicle collisions have been reported to cause 29,000 human injuries and claim 211 lives (Conover et al., 1995).

Beyond direct mortality, roads can negatively affect wildlife populations by degrading habitat quality (Theobald et al., 1997; Carr et al., 2002), fragmenting habitat and populations (Oxley et al., 1974; Trombulak and Frissell, 2000; Nellermann et al., 2001), hindering gene flow (Gerlach and Musolf, 2000; Epps et al., 2005; Riley et al., 2006), skewing sex ratios (Gibbs and Steen, 2005), and limiting dispersal (Beier, 1995). Most roads exhibit a distinct trade-off between permeability and road kill (Forman and Alexander, 1998). A highly permeable road might result in a high level of wildlife/vehicular collisions, whereas an impermeable road might have few road kill events. Yet this decrease in road kill comes at the expense of habitat connectivity. As individuals lose their mobility and gene flow is reduced, portions of the population become isolated. In the event of local extinction due to some stochastic event, fragmentation can make recolonization of previously-occupied habitat impossible (Theobald et al., 1997). These affects are of particular concern in small populations. Small populations have an increased risk of extinction due to demographic stochasticity, decreased heterozygosity, genetic drift, inbreeding, and low effective population size (Caughley, 1994), all of which can be exacerbated though road construction and expansion-related barrier effects. Social organization may also be affected by spatial change leading to population instability (Krausman et al., 2004).

Low population densities and large home ranges make carnivores particularly vulnerable to the effects of habitat fragmentation by roads (Whittington et al., 2005). A highway was found to restrict gene flow in a Cleveland, Ohio coyote population and direct the movements of migrants towards urbanizing centers (Rashleigh et al., 2008). Riley et al. (2006) found that coyote and bobcat populations in southern California separated by a major freeway exhibited genetic differentiation, suggesting that the freeway is a barrier to dispersal. Even when they do not constitute an absolute physical barrier, high-use roads can lead to avoidance behavior in canids affecting their ability to move across a landscape (Kaartinen et al., 2005, Paquet and Callaghan, 1996, Whittington et al., 2004). For those that do cross, heightened territorial behavior along roadways can discourage reproductive success, again limiting gene flow (Riley et al., 2006). The degree to which a road affects canid survival is dependent on the specific situation, and sometimes no detrimental effects are observed, as is the case with a California population of San Joaquin kit foxes (Cypher et al., 2009). Some documentation exists regarding wolves in the vicinity of highways. A study tracking gray wolf dispersal in Minnesota found that wolves were willing to cross major highways to colonize areas in Wisconsin and Michigan (Mech et al., 1995). For gray wolves (*Canis lupus*), a 4-lane unfenced highway in Wisconsin seemed to not influence wolf movements (Kohn et al., 1999). In contrast, a 4-lane fenced highway in Banff National Park in Alberta, Canada, appears to hinder wolf movements (Paquet and Callaghan, 1996), although crossing structures mitigated its barrier effect to some degree (Clevenger and Waltho, 2000, 2005). In Spain, wolves whose home ranges were greater than 5 km from the highway crossed a 4-lane, fenced highway via vehicle bridges (Blanco et al., 2005), however

those living in close proximity to the highway (<5 km) crossed the highway only after severe habitat disturbance. Gray wolves in Canada and Spain seem to prefer large, open wildlife overpasses (Forman et al., 2003). In general, a large void exists in addressing factors that affect how large carnivores use passages. Major transportation corridors bisect and potentially fragment most of the major ecosystems that still support wide-ranging carnivores. Increased concerns expressed by transportation and natural resources agencies regarding mitigation planning for large carnivores highlight the need for more information and research in this area (Forman et al., 2003).

The use of wildlife crossing structures can mitigate some of the negative effects associated with highways (Forman and Alexander, 1998). The appropriate type of crossing structure to mitigate road effects varies with species (Mata et al., 2008). A study monitoring the success of multi-species highway underpasses following the highway-widening just west of this current study area found that bobcats, black bears, and foxes utilized underpasses (McCollister and van Manen, 2010), however there were no confirmed detections of coyotes or red wolves using the underpasses. Because the red wolf population of both this study and the one cited above is the only wild red wolf population, there does not exist literature on the preference of red wolves for particular crossing structures. However several studies have found that while gray wolves will use wide tunnels and underpasses (Clevenger and Waltho, 2000, Kusak et al., 2009), they prefer open overpasses (Forman et al., 2003, Kusak et al., 2009). In Banff, wolves select for taller underpasses close to town (Clevenger and Waltho, 2000). Coyotes on the other hand have been found to use underpasses of a wide variety of sizes, from pipe culverts to wide underpasses, as long as they did not connect developed areas (Ng et al., 2004). Likewise, a study in Virginia found that coyotes readily used a variety of underpasses (Donaldson, 2007). The Wildlife Crossing Structure Handbook published in 2011 by the Federal Highway Administration recommends that underpasses geared towards large mammals (deer, bears, and wolves) and high mobility medium sized mammals (coyote, fox, and likely the category red wolves would be placed) should be greater than 32 ft. in width and greater than 13 ft. in height and that overpasses be at least 50 ft. wide (Clevenger and Huijer, 2011). If designing mitigating structures solely for high mobility medium sized mammals, underpasses and culverts with a diameter of 4ft. have been effective (Clevenger and Huijer, 2011). However, it appears that the structural components of crossing structures play a larger role in determining success for ungulates (Clevenger and Waltho, 2005; Gagnon et al., 2011) while habitat connectivity plays a larger role in the successful use of crossing structures for carnivores (White and Ernst, 2004; Singleton et al., 2005; Riley et al, 2006; Kindall and van Manen, 2007).

Underpasses can function as effective crossing structures for wolves, but high variability in use indicates that consideration of social interactions, placement, construction specifications and distance between crossings is essential for success (Paquet and Callaghan, 1996). Animals do not treat all sections of a roadway indiscriminately, so crossing funnel areas and natural habitat linkages at the landscape level must be identified. White and Ernst (2004), Singleton et al. (2005), and Kindall and van Manen (2007) all stress the need to identify habitat linkages across barriers to properly place crossings. In addition, Roger and Ramp (2009) discuss the importance of species-specific habitat use data in determining roadway impacts. Thus, it is imperative not only that wildlife underpasses be constructed in areas identified as high use for crossings (Scheick and Jones, 1999), but habitat variables at crossing locations be collected as well to

model what landscape factors predict crossings. Often times it is also necessary to install exclusionary fencing in addition to a crossing structure to guide animals to the crossing point and discourage crossing at road-level (Baker, 2005).

Indeed, one study in Portugal found that fencing had a funneling effect, directing larger animals towards culverts (Ascensao and Mira, 2006). Similarly, fencing along a highway reduced elk-vehicle collisions by 97% and other wildlife-vehicle collisions by 64% in Arizona (Gagnon et al., 2010) and likely lead to a decease in white-tailed deer-vehicle collisions in North Carolina (Jones et al., 2010). A study in Germany found that fencing successfully reduced wildcat road mortality by 83% (Klar et al., 20009) and fencing along with culverts lowered wildlife-vehicle collisions by 93.5% in Paynes Prairie State Preserve (Dodd et al., 2004). Ungulate-vehicle collisions were reduced by 80% following the installation of roadside fencing in Banff National Park, Canada (Clevenger et al., 2001). Jaeger and Fahrig (2004) developed a model to look at the trade-off between reductions of road kill and increased barrier effect due to fencing installation. They found that below a certain traffic volume, the barrier effect of fencing is harmful to a population and therefore they only recommend the use of roadside fencing when traffic volume is high (e.g. high risk of road mortality) and the target species does not show behavioral avoidance of roads (Jaeger and Fahrig, 2004). Both Clevenger et al. (2001) and McCollister and van Manen (2010) found that while fencing reduced wildlife-vehicle collisions close to underpasses, wildlife-vehicle collisions increase approaching fence ends. McCollister and van Manen (2010) found that road mortality was higher in fenced highway segments as compared to unfenced segments due to the increased mortality where roadside fencing ends. Therefore, if non-continuous fencing is used, it may be necessary to modify fence ends to direct wildlife away from the highway (Clevenger et al., 2001). Ungulates are the focal species for most studies that successfully demonstrate the effectiveness of roadside fencing. Fencing may be less effective for carnivores as they often go over (e.g. black bears) or under (e.g. coyotes) fencing (Clevenger et al., 2001). Indeed, the use of fencing did not increase culvert use by bobcats in Texas (Cain et al., 2003) and actually lead to an increase in wolf road mortality in Spain (Colino-Rabinal et al., 2011). Burying roadside fencing can help to discourage some species from digging under the fence (Clevenger et al., 2001).

Clearly, an understanding of red wolf activity patterns, movements, and habitat use are all needed in the vicinity of US 64 and across the Albemarle Peninsula. This study assessed red wolf home range, habitat selection, and highway crossing patterns along the US 64 corridor with the use of GPS collars and remote cameras to determine important red wolf habitat and to identify significant red wolf highway crossing locations. In addition, this research examined which landscape attributes promote red wolf use of crossing locations to increase the success of mitigating structures.

Background Information

The North Carolina Department of Transportation (NCDOT) is planning a highway improvement project for US 64 in Tyrrell and Dare Counties North Carolina, which will extend across the full length of the Albemarle Peninsula when completed, separating the northern section of the 5 county (Washington, Tyrrell, Dare, Hyde, and Beaufort counties) red wolf recovery zone. The effects of the highway widening on red wolf recovery and conservation could

be substantial, potentially creating a barrier to movement and gene flow of red wolves and other wildlife from one side of the highway to the other. In addition, the habitat loss associated with a highway widening likely will disrupt red wolves living adjacent to the existing highway causing a shift in current home ranges. Any shifts in home ranges have the potential to affect social order. Even in the absence of a barrier effect, the project may lead to an increase in vehicle related deaths as wolves attempt to cross a wider highway with increased speed limits. In addition, there is a potential to concentrate prey and herbaceous food sources at highway edges, attracting wolves, coyotes, black bears, white-tailed deer and other wildlife, increasing the risk of vehicle collisions. Highway barrier effects, habitat loss, social disruptions, and road mortality resulting from the highway widening may culminate in reduced red wolf population viability.

Problem Need/Definition

Viable populations of wildlife depend, in part, on dispersal to maintain genetic diversity. Whether natural or man-made, barriers to dispersal are of concern to wildlife managers. For restored or recovering populations, potential barriers such as highways or large fenced areas magnify in importance because of their potential to restrict or retard growth and genetic diversity in small wildlife populations. Roads, in particular, recently received attention with respect to large carnivore population dynamics related to increased direct (vehicle collisions) and indirect (changes in behavior that affect food acquisition) mortality (Trombulak and Frissell, 2000). Forced spatial change also may affect area-wide social organization and thus population stability, and increased noise or activity levels may initially affect wildlife behavior (Krausman et al., 2004).

For the past several years the North Carolina Department of Transportation (NCDOT) has been planning a proposed project to widen US 64 from 2 to 4 lanes from Raleigh to Manteo, North Carolina. With respect to the segment of US 64 already widened and elevated between Plymouth and Columbia by 2005, preliminary data collected by the U.S. Fish and Wildlife Service indicates red wolf (*Canis rufus*) movements and gene flow, including dispersal and home range size, may already be restricted by that highway segment. Remaining sections of US 64 planned for widening are the approximate 15.5-mile section from Columbia to Alligator River, and 11.8-mile section that runs through Alligator River National Wildlife Refuge.

The nature of the US 64 widening project calls into question important ecological and regulatory considerations that, together, mean data collection is needed to assist with science-based decisions and project design. Red wolves will be involved in two federal regulatory processes pertinent to widening of US 64, namely, project consultation under Section 7 of the U.S. Endangered Species Act of 1973, and assessment of "refuge compatibility" under the National Wildlife Refuge System Improvement Act of 1997 (Public Law 105-57), along with the National Wildlife Refuge System Administration Act of 1966 (16 U.S.C. 668dd-668ee), as amended. These processes allow cooperation toward achieving a project that takes into account human safety, traffic management, and wildlife concerns that include passage, mortality, large-sized animals, and multiple wildlife refuge values. Refuge considerations include endangered species conservation, waterfowl management, wildlife habitat with associated species, hydrology, wetlands, reptiles and amphibians, public use, fire management, exotic species management, etc.

The effects of US 64 widening on red wolf recovery and conservation could be substantial. Widening US 64 may be accompanied by increased speed limits, and likely will create a barrier to movement of red wolves and other wildlife from one side of the highway to the other. Thus, it is imperative that wildlife crossing structures be constructed in areas identified as high use crossings by red wolves, bears, deer, and other species (Scheick and Jones, 1999). Completed and planned phases of the US 64 widening project extend across the full length of the Albemarle Peninsula, separating and otherwise affecting the entire northern quarter of the 5-county red wolf experimental population area.

Construction of the highway itself most likely will directly disrupt the red wolf population, along with other wildlife populations (e.g., black bear, white-tailed deer) living adjacent to the existing highway during the 1-2 year construction period. These disruptions may cause red wolves to shift out of their current home ranges or territories during the construction phase and move into areas already occupied by other red wolves, causing social disruptions and ripple effects across the Albemarle Peninsula. While the disruption due directly to construction will be short-term, effects on the red wolf population may be long lasting and even permanent. Habitat loss, social disruptions, and ripple effects, as a result of direct, indirect, and cumulative effects of a highway widening, may result in a reduction of the red wolf population, its gene flow, and gene diversity, by some unknown quantity.

Vehicle strike mortality significantly impacts the wild red wolf population on the Albemarle Peninsula in North Carolina (USFWS, 2007). Of 166 known adult red wolf loses since 1999, 23 were killed in vehicle strikes. Vehicle strikes are three times higher in non-breeder (19%) vs. breeder (6%) red wolves in the designated experimental population area. This is partly explained by single red wolves dispersing or roaming over large distances.

Studies are needed to assess how the red wolf population has utilized the area since restoration began. An examination of which landscape attributes promote red wolf use would be helpful, along with a thorough assessment of site-specific habitat availability.

More specifically, the potential problems or benefits examined for red wolves in association with US 64 widening should include the following concerns.

1. Vehicle mortality of red wolves and associated human safety.
2. Reproduction and survival.
3. Considerations of placement of underpasses or overpasses.
4. Changes in red wolf habitat, prey, home range size, dynamics, and associated landscape fragmentation.
5. Effects upon red wolf activity, movements, gene flow, dispersal, territory dynamics, social organization, pack integrity, habitat use, and land occupancy.
6. Ripple effects throughout the red wolf population, across the Albemarle Peninsula.
7. Changes in red wolf numbers pre-project, during project, and post-project.
8. Influences on eastern coyotes, a competitor and threat to red wolves.
9. Effects upon monitoring of red wolves and eastern coyotes.

It is important to understand the effect of canid activity and movements out of or into the experimental area along the expanded highway in western portions of the Albemarle Peninsula. Possible study topics include coyote/red wolf interactions and retrospective examination of adaptability of coyote/hybrids vs. red wolves in the face of significant habitat change and/or significant project construction.

Research Objectives

The objectives of this research project are to:

1. Evaluate wolf habitat use along the entire US 64 corridor from Plymouth to the US 64/264 intersection

2. Evaluate the significance of red wolf habitat changes anticipated from the proposed highway project from Columbia to the US 64/264 intersection in terms of movements, survival, reproduction, home range shifts, and social organization.

3. Identify significant red wolf crossing areas to determine where wildlife crossing structures or other design features could be placed to minimize adverse project effects on red wolves.

Study Area

The only wild population of red wolves occurs on more than 2,567 mi^2 of federal, state, and private lands in 5 counties (Beaufort, Dare, Hyde, Tyrrell, and Washington) in northeastern North Carolina (Figure 1), known as the Red Wolf Recovery Zone (RWRZ). Two of the northern counties within the RWRZ, Tyrrell and Dare Counties, were the focal point of this study because they contain the remaining 27.34 mi of US 64 to be widened. Federal lands within the study area include Pocosin Lakes National Wildlife Refuge, Alligator River National Wildlife Refuge, and a bombing range shared by the Navy and Air Force. State land consists of numerous game management properties, while private lands are primarily made-up of timber plantations, agricultural fields, and a few developed residential and commercial properties.

The most prevalent land cover types within the study area, as identified by the North Carolina Gap database (2009), are agricultural fields (~30%) planted primarily with wheat, corn, soybean, cotton, and potatoes; commercial pine plantations (~15%); pocosin (~15%); non-riverine swamp forests (~10%); and saltwater marsh or open water (~10%). Climate within the study area is characterized by 4 full seasons of nearly equal length with annual precipitation averaging 50 in. Temperatures range from a mean of 41°F in winter to 80.6°F in summer. Elevation ranges from sea level to 164 ft. (Beck et al., 2009). Carnivores that co-occur with red wolves within the study area include gray foxes (*Urocyon cineroargenteus*), red foxes (*Vulpes vulpes*), coyotes (*Canis latrans*), feral dogs (*Canis lupus familiaris*), bobcats (*Lynx rufus*), black bears (*Ursus americanus*), and various mustelids.

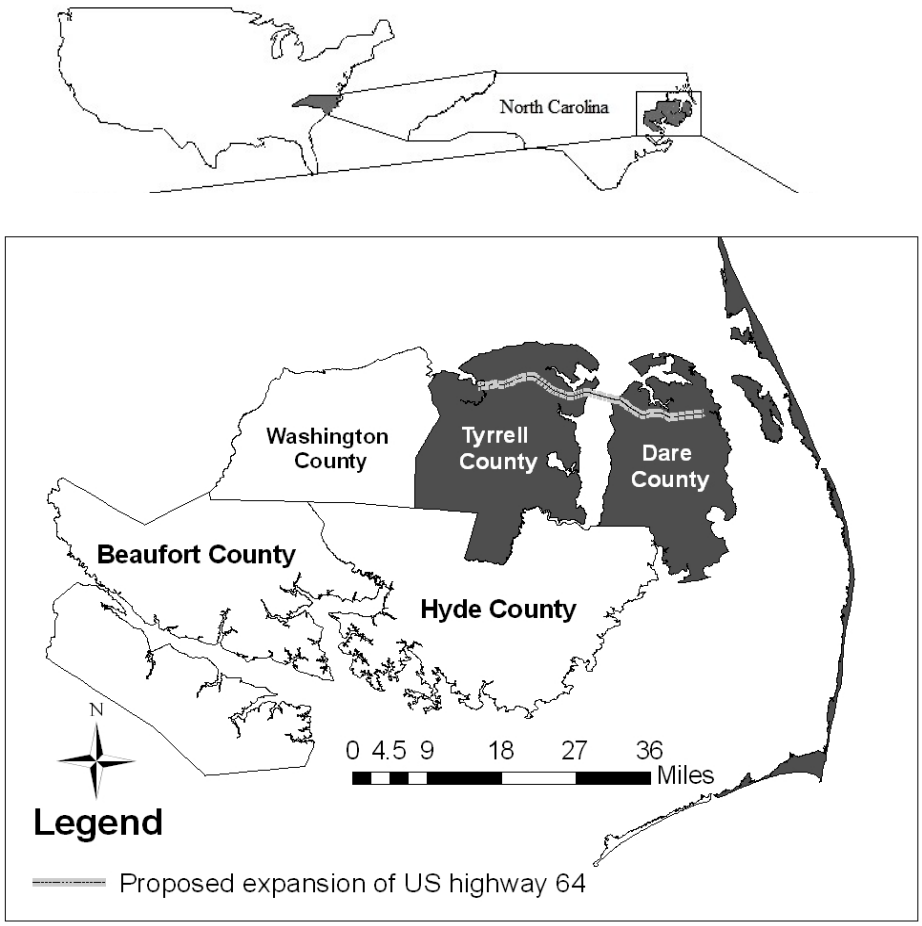


Figure 1. The study area (highlighted in gray) is located within 2 of the northern counties, Tyrrell and Dare, of the 5 county red wolf recovery zone in northeastern North Carolina. The study area focuses on the remaining 27.3 mi section of US 64, between Columbia, NC and the US 64/264 intersection, to be expanded from a 2- to 4-lane highway.

Methods

Capturing and collaring of animals*:* From January 2009 to April 2011, adult and juvenile red wolves were captured by USFWS biologists and fitted with mortality-sensitive Lotek GPS 4400S collars (Lotek Wireless, Inc., Ontario, Canada). Red wolves > 2 years old were classified as adults, < 2 years old as juveniles, and < 9 months old as pups. Pups were not fitted with GPS collars because typically they were too small to safely wear collars. Prior to deployment, GPS collars were remotely programmed to record locations every 5 hours with a nested program to collect a position every 30-minutes for a 5 hour period daily. The nested 30-minute program was scheduled to rotate around the 24-hour clock to capture detailed movements. Each collar emitted a VHF locator beacon each day from 0900 – 1200, allowing us to locate collared animals every 12 weeks on the ground and remotely download stored data.

Objective 1: Evaluate wolf habitat use along the entire US 64 corridor from Plymouth NC to the US 64/264 intersection

***Independence of animal movements*:** To address the issue of correlation of GPS location data between pack mates, we calculated home ranges (Getz et al., 2007) for all collared wolves in a single pack then associated locations for each animal with the corresponding isopleth. Next, Spearman correlation matrices were used to determine the similarity of home ranges and habitat use among all collared animals within the pack. This determined if animals within a pack should be treated separately or if habitat use, selection, and home range of one collared animal was representative of the entire pack.

***Home range analyses*:** Following the conclusion of field work, rarefaction curves of cumulative weekly home ranges were calculated on all complete data sets for each collared animal to determine the relationship between length of time collar was deployed and when size of home range stabilized (Bekoff and Mech, 1984). Starting by calculating size of home range of an animal during the first week of collar deployment, we calculated size of home range of the animal during the second week of collar deployment and so on until the complete data set for that animal was included in calculating size of home range. Ninety-five percent home range isopleths were constructed using adaptive nearest neighbor convex hull methods (Getz et al., 2007). Animals whose home ranges did not stabilize in size were excluded from subsequent analyses. Given the varying age, dominance, and sex of the animals that were collared, and that home range composition between packs with collared animals may vary; we assumed that all factors influencing stabilization of size of home range were captured sufficiently. For individuals whose home range stabilized, monthly home ranges were constructed according to Getz et al. (2007) to examine short-term and seasonal variations in home range composition and size.

Overall and monthly home ranges were overlaid onto habitat maps developed by NC GAP to determine percent composition of home ranges. Habitat types included agricultural fields, wetlands, upland forests, lowland forests, successional fields, and pocosin (areas covered with evergreen vegetation and inundated with water). We used one-way ANOVA to test for differences in overall home range size among age classes and Student's *t*-tests to test for a difference in home range size between sexes. Student's *t*-tests were also used to determine if seasonal variation in monthly home range size and composition for each habitat type were

significantly different. Following previous studies (Phillips et al., 2003; Chadwick et al., 2010; Hinton et al., 2010), we recognized a summer (April – September) and winter (October – March) season. Significance was set at $\alpha \leq 0.05$.

***Habitat use and selection analyses*:** Resource selection functions (RSFs; Manly et al., 2002) were used to examine 2nd order (home range) and 3rd order (within home range) habitat use by red wolves (Johnson, 1980). Resource selection functions were developed using use/availability data with a binomial distribution (Manly et al., 2002).

For 2nd order habitat use, we considered the entire 5 county red wolf recovery area as available habitat and all locations of each GPS-collared animal occurring within its respective 95% home range (Getz et al., 2007) as used habitat. For 3rd order habitat use, the entire 95% home range (Getz et al., 2007) was considered to be available. All locations of each animal contained within its respective 95% home range were combined to examine 2nd and 3rd order habitat use for the entire population. An equal number of random points, compared to locations, were generated within the available areas for 2nd and 3rd order habitat use, respectively. Distance to road and water, human density (people per square mile), and habitat type were determined for all used and random locations. Habitat types were the same as those for determining home range composition. After combining used and random locations for each order of habitat use, RSFs were developed for each order of habitat use which contained habitat type, distance to roads and water, human density, and all biologically meaningful interactions (habitat type by distance to roads, habitat type by human density, and distance to roads by human density). Animals were monitored for varying lengths of time, had different numbers of locations, were of different age classes, and different sexes. Therefore each animal could have potentially influenced the RSFs more or less than another animal. Thus to make sure that no animal biased the RSFs, preliminary 2nd and 3rd order RSFs were developed using a sampling with replacement method in which each animal was excluded once from calculation of a RSF while all other animals were included. For the 3rd order RSF, a random effect for animal was included in the RSFs to account for differences in habitats available to each animal. Akaike's information criterion corrected for small sample sizes (AICc) was used to choose the most parsimonious RSF from the global (all possible variables included) RSF and all possible subsets for each order of habitat use (Burnham and Anderson, 2002). Twenty-five percent of used and random locations for each order of habitat use were not used in developing all RSFs to evaluate fit of most parsimonious RSFs using cross-validation (Johnson et al., 2006). The most parsimonious RSFs that were shown to have a good fit to the data were projected in a GIS to create habitat suitability maps depicting areas of high, medium, and low quality habitat and probability of occurrence of red wolves.

AICc weights of most parsimonious 2nd and 3rd order RSFs were compared to determine whether habitat type, distance to roads and water, and density of humans were scale dependent for red wolves. The RSF with the greatest AICc weight demonstrated the scale at which the variables of interest and associated interactions influenced habitat use the most. Statistical analyses were conducted in R 2.11.1 (R Development Core Team 2010) and spatial analyses using ArcGIS 10 (ESRI® ArcMap™ 10, Copyright © 1999-2010 ESRI Inc.) and Geospatial Modeling Environment 0.5.3 (Beyer, H. L., Copyright © 2001-2010 Spatial Ecology LLC).

Objective 2: Evaluate the significance of red wolf habitat changes anticipated from the proposed highway project from Columbia NC to the US 64/264 intersection.

***Quantifying barrier effects using passage rates*:** Following Dodd et al. (2007), we quantified the barrier effects of US 64 by calculating a permeability index. A permeability index is a passage rate measuring an individuals willingness to attempt a road crossing and is calculated by using the following equation: #crossings/(#crossings + #approaches), where an approach is defined as a red wolf entering into a 164 ft. buffer zone around the highway without crossing (see Figure 2). The 164 ft. (50 m) buffer zone was determined by measuring the distance between US 64 and the boundary of the closest red wolf home range (95% MCP) to the highway. This was done to exclude movements within a home range from being counted as an approach. The permeability index ranges from 0 to 1, with 0 indicating an impermeable road and 1 indicating 100% permeability. Permeability indices were calculated for the 30-minute and 5-hour data sets separately. An overall permeability index (using total number of crosses and approaches from all study animals) for the duration of the study was calculated as well as monthly permeability indices. We used a paired t-test to compare monthly permeability indices calculated using the 30-minute and 5-hour data sets.

Using 30-minute monthly permeability indices, regression analysis was then used to determine if a relationship existed between monthly permeability indices and monthly traffic flow along the existing US 64.

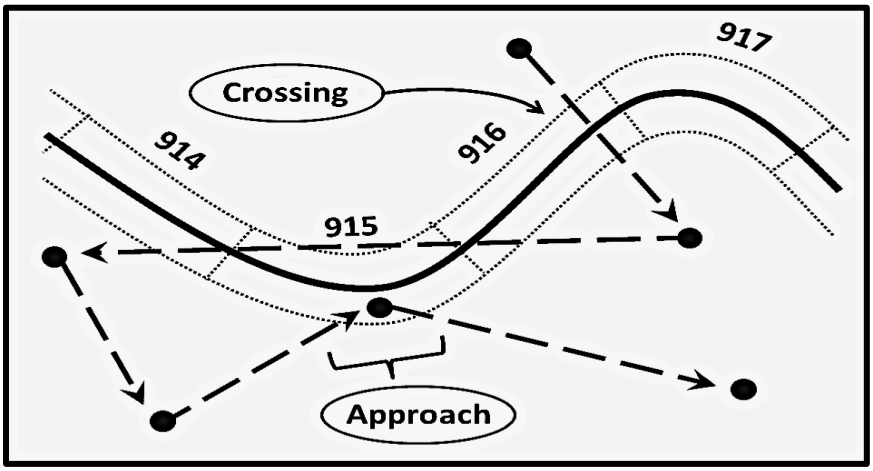


Figure 2. A **crossing** was defined as a line connecting two points on opposite sides of a road that intersects the roadway. An **approach** was defined as any excursion from a point further than 164 ft. from the road to a point within 164 ft., and then back, *without* crossing.

Assessing the effect of the highway widening on current red wolf territories: To determine the potential for the highway widening to displace current red wolf packs, buffers at ~ 164 ft. (50 m) intervals were constructed around the current US 64. The buffers were then overlaid on current red wolf home range locations and the number of home ranges intersected by each buffer was counted. Where the buffers intersected home ranges, the percent of total home range intersected was calculated. As with the home range analysis above, only one home range per pack was used when the movements among individuals of a pack were correlated.

Assessing the effect of the highway widening on important red wolf habitat: To determine the potential for the highway widening to affect important red wolf habitat, buffers around the current US 64 at ~164 ft. (50 m) intervals were overlaid on a habitat map. The area of available red wolf habitat was then calculated within each buffer zone.

Objective 3: Identify significant red wolf crossing areas to determine where wildlife crossing structures or other design features could be placed to minimize adverse project effects on wolves.

***Determining crossing locations and rates using GPS collars*:** Because of the occurrence of different collar schedules, wolf locations were sub-sampled into both 5-hour and 30-minute intervals. The following methods were used to analyze data collected for each frequency, 5-hour and 30-minute, respectively. Using ArcGIS v9.3 (ESRI® ArcMap™ 9.3, Copyright © 1999-2010 ESRI Inc.), we divided the 27.3 mi-section of US 64 into 273 segments, each 0.10 miles long. To determine road crossings, we used the Home Range Tools v9 extension for ArcGIS to calculate the travel path of each individual by connecting consecutive GPS fixes. We then overlaid the travel paths on the segmented highway layer and counted the number of crossings per highway segment for each individual. A crossing was defined as two consecutive fixes on opposite sides of the highway (see Figure 2). Crossing rates for each individual were determined by dividing the number of crossings by the number of days the collar was actively collecting data for each collection frequency sub-sample. Total crossing frequencies per segment were plotted in a histogram to identify the location of key red wolf crossing areas.

***Statistical Analysis*:** To test the hypothesis that the crossing distribution calculated using GPS collar locations was different from a random crossing distribution, an equivalent number of random line segments were drawn between the GPS locations for each red wolf. To approximate actual red wolf movement, random segment lengths were constrained to less than or equal to the maximum distance moved by a red wolf for the 30-minute and 5-hour data sets, respectively. Crossing frequencies for the random segments were calculated for each highway segment following the methods above. The distributions for the GPS crossing frequencies and the random crossing frequencies were compared using a Kolmogorov-Smirnov test (Clevenger et al., 2001). We used a t-test to test for differences in crossing rates between male and female wolves and a one –way ANOVA to test for differences in crossing rates among age classes.

Determining crossing locations using Camera Traps: Even with 30-minute locations, the GPS collars likely did not catch all red wolf crossing events. To capture additional crossing events, remote cameras were placed at canal crossings along the 27.3 mi stretch of US 64 within 328 ft. (100 m) of the roadside. Because drainage canals exist along the entire length of US 64, canal crossings serve as an access point for animals to reach the highway. We used both film and digital remote cameras triggered by laser or heat disturbance. All cameras were active 24-hours per day to maximize the number of crossings captured. Cameras were active from July 2009 to March 2011. However, the number of trap nights varied for each camera station so captures were reported per 100 trap nights. To avoid pseudoreplication, consecutive photos of an individual animal were considered a single event.

Using GPS locations, camera stations were associated with one of the 273 segments along US 64. Not all segments had camera stations. Total crossing frequencies per segment were plotted in a histogram to identify the location of key red wolf crossing areas as identified by cameras.

Evaluating habitat characteristics at crossing sites identified by GPS collar locations: Using the NC GAP habitat map, we extracted the habitat type for each of the 273 highway segments at 164 ft. (50 m) intervals starting at the road to a distance of 656 ft. (200 m) perpendicular to the segment (ArcGIS v9.3). Segments that had at least one crossing were coded with a 1 and segments without crossings were coded with a 0. Logistic regression was used to evaluate 5 *a priori* models developed using site-specific habitat type at different distance intervals and the occurrence of a red wolf crossing. The most parsimonious model was chosen using AIC corrected for small sample size (AICc) (Burnham and Anderson, 2002), with models ranked using ΔAICc.

Evaluating habitat characteristics at crossing sites identified by camera traps:
Using the NC GAP habitat map, we extracted the habitat type for each of the camera stations at 164 ft. (50 m) intervals starting at the camera sites to a distance of 656 ft. (200 m) perpendicular to US 64 (ArcGIS v9.3). In addition, the width of the access road/trail was measured at each camera station. Camera sites that captured red wolves were coded with a 1 and camera sites that did not capture red wolves were coded with a 0. Logistic regression was used to evaluate 5 *a priori* models developed using habitat variables and trail width at camera placement. The most parsimonious model was chosen using AIC corrected for small sample size (AICc) (Burnham and Anderson, 2002), with models ranked using ΔAICc.

Results

Capturing and collaring of animals: Between January 2009 and April 2011, the USFWS Red Wolf Team deployed 32 of 40 collars. Due to a decrease in red wolf population in Washington County, North Carolina, the 8 collars reserved for red wolves living in the vicinity of the previously expanded portion of US 64 could not be deployed. Thirteen of the 32 collars deployed were placed on females (8 adults, 5 juveniles) and 19 on males (8 adults, 11 juveniles). The average collar deployment was 14.8 months (range: 4 to 30 months) and average collar success in obtaining GPS locations was 86.0% (range: 63.6% to 97.5%). In total, 39, 573 successful red wolf locations were collected. We used 6 different collar schedules: 30-minute locations for 5 hours per day, 5-hour locations, 5-hour locations with the nested 30-minute schedule for 5-hours per day, 11-hour locations, 12-hour locations, and 23-hour locations (Table 1).

Table 1. Summary of collar statistics for collared red wolves in Dare, Tyrrell, Washington, Beaufort, and Hyde Counties, NC.

Pack/Area	Collar ID	Sex	Birth Year	Length of Collar Deployment (months)	Reason for Removal	Collar Schedule	Collar Success (%)
Milltail	974	M	2005	30	Found Dead	5hr RO*	96.20
Milltail	1779/1883	M	2006	28	Died	30 min w/5hr RO	90.80
Milltail	1912/1896	F	2004	28	On recovery	30 min w/5hr RO	
Bombming range	1910	F	2007?	6	Found Dead	5hr RO	79.80
Milltail	1777/1893	F	2008	21	Shot	30 min w/5hr RO	91.10
Milltail	1913/1905	M	2008	22	Collar Broken	30 min	
Milltail	1911/1889	F	2008	21	Breeding Female	30 min	82.60
Tyson	1778	M	2008	21	Going to be paired w/F	5hr RO	80.20
F2	1916	F	2007	22	Breeding Female/ paired w/M	5hr RO\23hr RO\30 min w/5hr RO	85.50
Sunnyside	1915	M	2007	23	Collar in Recovery	30 min w/5hr RO	85.40
Timberlake	1901	F	2004	18	Breeding Female	5hr RO\30 min w/5hr RO	86.50
Waupaupin	1894	M	2007	17	On recovery	11hr RO\30 min w/5hr RO	
Gator	1895	F	2000		Still Deployed	12hr	
Davis Fields	1880	F	2001	7	Shot	5hr RO	69.00
Mannings	1881	M	2006	7	Not near any roads	5hr RO	63.60
L-Block	1892	F	2006	5	Breeding Female	30 min w/5hr RO	80.60
Columbia	1906	M	2005	12	On recovery	5hr RO\30 min w/5hr RO	
Bishops	1902	F	2008	9	Breeding Female/ paired w/M	30 min w/5hr RO	94.00
Columbia	1900	F	2007	12	Breeding Female/ paired w/M	30 min w/5hr RO	72.20
Lil' Alligator	1882	M	2008	10	Going to be paired w/F	30 min w/5hr RO	91.50
Frying Pan	1909	F	2008	16	Breeding Female/ paired w/M	30 min	94.50
Tyson	1884	M	2006		Still Deployed	30 min	
Milltail	1891	M	2009	4	Hit by Car	30 min	97.50
Swindell	1887	M	2009		Still Deployed	30 min w/5hr RO	
Milltail	1904	M	2008	11	Died	30 min	84.40
Beech Ridge	1897	M	2008		Still Deployed	30 min w/5hr RO	
Swindell	1908	M	2009		Still Deployed	30 min w/5hr RO	
Beech Ridge	1903	F	2008	14	Breeding Female	30 min w/5hr RO	84.40
East Lake	1777	M	?	9	On recovery	30 min w/5hr RO	
Camerons	1898	M	2008	1	Shot	30 min	95.60
Killkenny	1907	M	2009	13	Management Purposes	30 min	94.30
Killkenny	1888	M	2009	12	Management Purposes	30 min	92.80

* RO = Rollover. A rollover schedule collects locations continuously at a set time interval without resetting at the start of each day.

Objective 1: Evaluate wolf habitat use along the entire US 64 corridor from Plymouth NC to the US 64/264 intersection

***Home range analyses*:** Movements of individuals within the same pack were highly correlated (r_s = 0.87–0.91); therefore only 1 animal per pack (chosen randomly) was used in the following analyses. After removing those individuals where multiple animals in a pack were collared, we calculated cumulative weekly home ranges for 21 of 32 animals (Figure 3). Following analysis, we removed 5 (1 juvenile, 2 dispersers, 2 adults) additional individuals from our sample due to an inadequate number of locations to capture a complete home range. Overall home range varied between 2.61 mi^2 and 38.19 mi^2 with a mean of 12.93 ± 9.50 mi^2

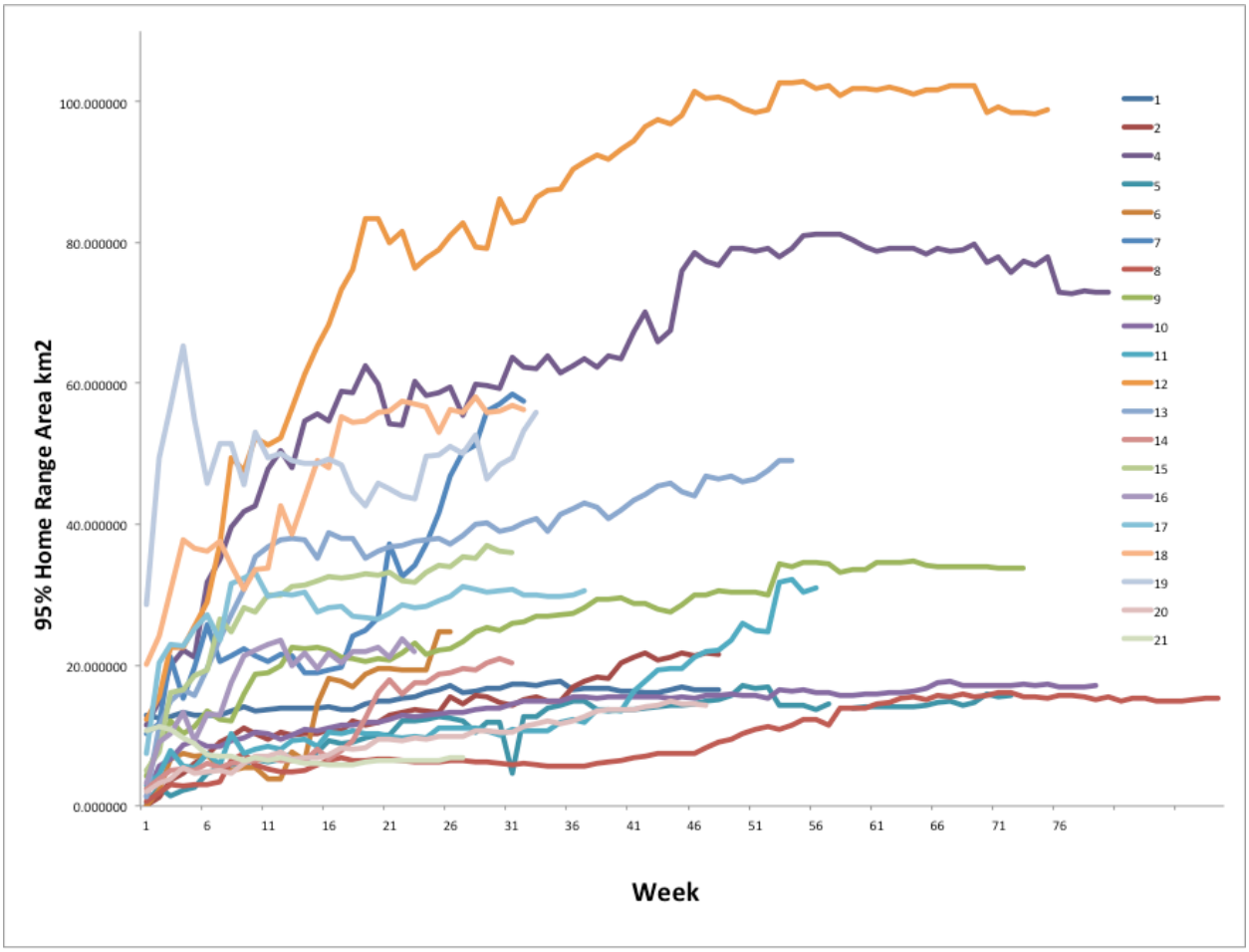


Figure 3. To determine if an adequate number of locations were obtained from each wolf to capture home range area, rarefaction curves of cumulative weekly home ranges were calculated for 21 red wolves of different age groups and sexes collared from January 2009 to April 2011. A home range is considered to be at equilibrium at the point that the home range area no longer increases and reaches a plateau (Bekoff and Mech, 1984). Home range did not reach equilibrium for 5 of the 21 wolves in our sample (6, 7, 11, 13, 14), thus they were excluded from further home range analyses. Collared red wolves were located in Tyrell, Dare, Washington, and Hyde Counties, NC.

Although home range size among age classes (F =2.71, P =0.14) and between sexes (t_{10} = 2.10, P = 0.57) did not differ significantly (Tables 2 and 3), the home range size of dispersers tended to be larger than those of juveniles or adults. Five of 8 animals that died while collared were dispersing and 2 additional dispersers were removed from further home range analyses due to inadequate data.

Table 2. Average and range of 95% home range areas for three age classes of red wolves. A local convex hull method was used to calculate home range from GPS collar locations. The home range analysis was generated from 16 red wolves collared in Washington, Tyrell, Dare, Hyde, and Beaufort Counties, NC from January 2009 to April 2011.

	Juvenile	Disperser	Adult
n	3	3	10
Average (mi^2)	9.15	21.86	15.29
Min (mi^2)	5.93	21.61	2.61
Max (mi^2)	11.95	22.21	38.19

Table 3. Average and range of 95% home range areas for male and female red wolves. A local convex hull method was used to calculate home range from GPS collar locations. The home range analysis was generated from 16 red wolves collared in Washington, Tyrell, Dare, Hyde, and Beaufort Counties, NC from January 2009 to April 2011.

	Male	Female
n	9	7
Average (mi^2)	14.54	12.11
Min (mi^2)	2.61	5.52
Max (mi^2)	38.19	22.21

Home ranges were composed primarily of agricultural fields with 95% home range isopleths on average containing 55% agricultural fields (Table 4). Summer home ranges were between 0.77 and 3.09 mi^2 smaller (t_{10} = -4.84, P < 0.01) than winter home ranges (Table 5). Average monthly home range percent composition was different between summer and winter. Red wolves increased their use of pocosin (t_{10} = -2.65, P =0.03), wetlands (t_{10} = -4.29, P < 0.01), and upland forests (t_{10} = -4.17, P < 0.01) in late winter and increased use of agricultural fields (t_{10} = 3.44, P < 0.01) in summer months (Table 6). Agricultural fields and successional fields account for over 65% of habitat composition regardless of season.

Table 4. Average composition of 95% home ranges for 16 red wolves collared in Washington, Tyrell, Dare, Hyde, and Beaufort Counties, NC from January 2009 to April 2011.

Habitat Type	Average %
Pocosin	6
Lowland Forests	6
Successional Fields	13
Upland Forests	12
Wetlands	8
Agricultural Fields	55

Table 5. Average monthly 95% home range areas for 16 red wolves collared in Washington, Tyrell, Dare, Hyde, and Beaufort Counties, NC from January 2009 to April 2011.

Month	95% isopleth (mi^2)
January	7.56
February	5.97
March	5.71
April	4.31
May	4.54
June	4.98
July	4.84
August	4.84
September	5.73
October	6.60
November	6.54
December	6.36

Table 6. Average monthly percent habitat composition calculated using a 95% home range for 16 red wolves collared in Washington, Tyrell, Dare, Hyde, and Beaufort Counties, NC from January 2009 to April 2011.

Month	95% range isopleth percent habitat composition					
	Pocosin	Lowland Forests	Successional Fields	Upland Forests	Wetlands	Agricultural Fields
January	10	4	16	5	6	59
February	5	4	15	16	8	51
March	6	7	13	12	8	54
April	3	4	13	11	5	64
May	2	3	14	9	4	67
June	2	3	16	7	3	69
July	1	2	13	5	2	76
August	1	3	14	7	3	71
September	3	5	13	7	5	66
October	3	4	15	8	6	64
November	2	3	17	7	5	66
December	5	4	16	7	7	59

***Habitat use and selection analyses*:** We used 29,680 locations of red wolves to construct the 2nd and 3rd order resource selection functions (RSFs), respectively (Johnson, 1980). Second order RSF predicted a patchy distribution of red wolves across the 5-county red wolf recovery area (Figure 4). Third order RSF predicted a relatively equal probability of habitat use by red wolves across a given home range (Figure 5). RSFs calculated for each individual wolf included the same variables as the most parsimonious 2nd and 3rd order RSFs. Thus, despite the fact that collars were deployed on wolves of all ages and both sexes over a range of collar deployment periods (2009, 2010, and 2011) and deployment lengths (4 to 30 months), no one animal was considered to bias the RSFs in a unique way different from other animals. The most parsimonious 2nd order RSF contained: habitat type, distance to roads and water, human density, an interaction between distance to road and habitat type, and an interaction between human density and habitat type (Table 7). The AICc weight of the most parsimonious 2nd order RSF was 0.98. The next most parsimonious RSF included an interaction between human density and distance to road, and had a ΔAICc of 8 and an AICc weight of 0.02. Agricultural fields were more likely to be used than all other habitat types. Likelihood of habitat use by red wolves decreased as human density increased, distance to road increased, and distance to water sources (e.g. steams and ponds) decreased. As distance to road increased, lowland forest, pocosin, and wetland habitats were disproportionately less likely to be used by red wolves than other habitat

types. As human density increased, upland forests and wetlands were more likely to be used by red wolves than other habitat types.

The most parsimonious 3rd order RSF contained: 5 habitat types, distance to roads, and distance to water sources (e.g. steams and ponds) (Table 8). The AICc weight of the most parsimonious 3rd order RSF was 0.75. The next most parsimonious RSF included habitat type, distance to water, and human density, and had a ΔAICc of 2 and an AICc weight of 0.25. Again, agricultural fields were more likely to be used than all other habitat types. Likelihood of habitat use by red wolves decreased as distance to roads and water increased.

To test the validity of our selected 2nd and 3rd order RSF models, we overlaid 9,893 red wolf locations withheld from the initial analysis on the resulting probability maps (Figures 4 and 5). The GPS-collar locations (observed) overlapped areas identified as high probability of red wolf occurrence (expected) for both 2nd ($t_1 = 0.79$, $P > 0.05$) and 3rd order ($t_1 = 1.06$, $P > 0.05$) RSFs.

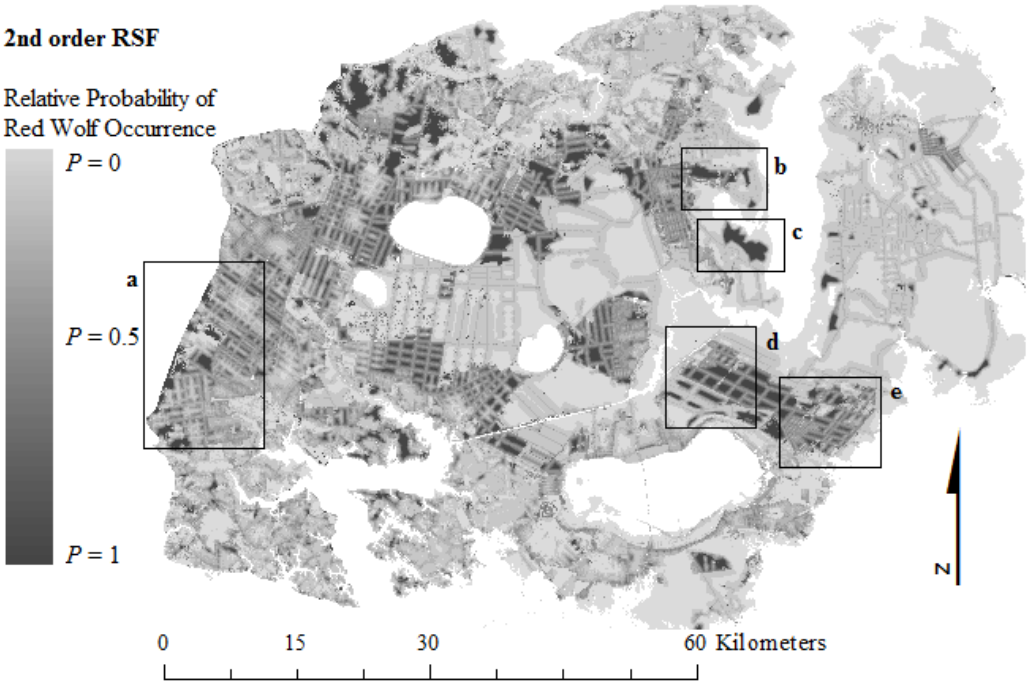


Figure 4. Relative probability of occurrence of red wolves (*Canis rufus*) across Washington, Tyrrell, Dare, Hyde, and Beaufort Counties, North Carolina with respect to 2nd order habitat use, 2009-2011. a) Relative location of packs no longer in existence but identified as habitat with high relative probability of occurrence of red wolves; b-e) Relative location of packs not represented in our dataset but in existence at the time of this study.

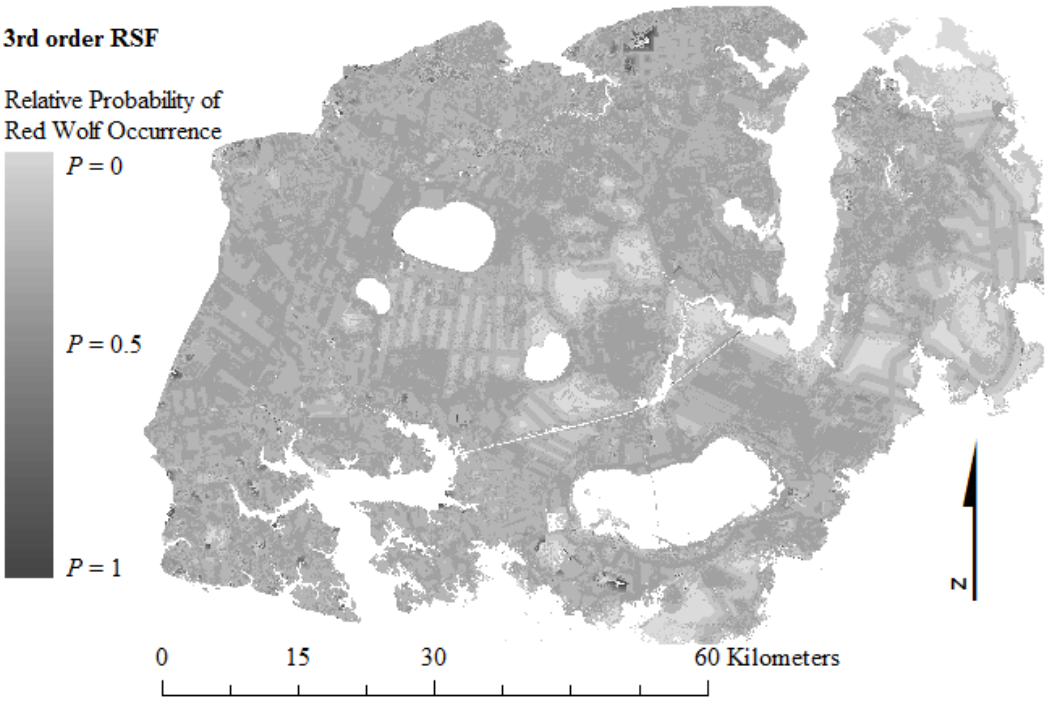


Figure 5. Relative probability of occurrence of red wolves (*Canis rufus*) across Washington, Tyrrell, Dare, Hyde, and Beaufort Counties, North Carolina with respect to 3rd order habitat use, 2009-2011.

Table 7. Most parsimonious 2nd order RSF, according to AICc, for habitat use of red wolves in Washington, Tyrrell, Dare, Hyde, and Beaufort Counties, North Carolina from 2009-2011.

2nd order RSF (AICc weight = 0.98)				
Coefficient	Estimate*	SE	Lower CI	Upper CI
Intercept	0.62	0.04	0.54	0.7
Successional Field	-0.21	0.09	2.68E-03	3.02E-03
Lowland Forests	-0.82	0.11	-1.04	-0.59
Pocosin	-0.67	0.09	-0.84	-0.5
Upland Forests	-0.95	0.08	-1.11	-0.79
Wetlands	-0.81	0.08	-0.96	-0.66
Dist. to Road	-1.29E-03	1.10E-04	-1.50E-03	-1.10E-03
Dist. to H20	2.85E-03	0.04	2.70E-03	3.00E-03
Human Density	-0.08	5.00E-03	-0.09	-0.07
Dist. To Road x Lowland Forests	-2.70E-03	3.40E-04	-3.37E-03	-2.04E-03
Dist. To Road x Pocosin	-2.79E-03	2.16E-04	-3.21E-03	-2.37E-03
Dist. To Road x Wetlands	-2.48E-03	2.08E-04	-2.88E-03	-2.07E-03
Human Density x Upland Forests	0.09	0.01	0.08	0.1
Human Density x Wetlands	0.08	0.01	0.07	0.1

*The estimate is the logistic regression coefficient which describes the size and direction of the influence of each variable

Table 8. Most parsimonious 3rd order RSF, according to AICc, for habitat use of red wolves in Washington, Tyrrell, Dare, Hyde, and Beaufort Counties, North Carolina from 2009-2011.

3rd order RSF (AICc weight = 0.75)				
Coefficient	Estimate*	SE	Lower CI	Upper CI
Intercept	0.58	0.01	0.56	0.6
Successional Fields	-0.07	0.01	-0.09	-0.05
Lowland Forests	-0.1	0.01	-0.13	-0.08
Pocosin	-0.11	0.01	-0.13	-0.08
Upland Forests	-0.1	0.01	-0.12	-0.08
Wetlands	-0.12	0.01	-0.14	-0.1
Dist. To Road	-4.49E-05	2.56E-05	-9.50E-04	-1.80E-05
Dist. To Water	-1.28E-04	2.25E-05	-1.72E-04	-8.37E-06

*The estimate is the logistic regression coefficient which describes the size and direction of the influence of each variable

Objective 2: Evaluate the significance of red wolf habitat changes anticipated from the proposed highway project from Columbia to the US 64/264 intersection.

***Quantifying barrier effects using passage rates*:** Though 3 times as many crossings were recorded using the 30-minute collar schedule compared to the 5-hour schedule, the overall permeability for US 64 calculated from both collar schedules was approximately 100% (Table 9). No difference in monthly permeability index was found between the 30-minute and 5-hour collar scheduled ($t_{10} = 0.045$, $P = 0.48$). No relationship ($F=0.021$, $P=0.89$, $r^2=1.0$) was found between monthly permeability and monthly traffic flow (Figure 6).

Table 9. Permeability index for US 64 between Columbia, NC and the US 64/264 intersection in Manns Harbor, NC. The permeability index was calculated by dividing the number of highway crossings by (the number of highway crossings + the number of approaches). Road crossings were determined using red wolf GPS-collar locations collected between January 2009 and April 2011. A permeability index of 1 represents a highly permeable road while an index of zero indicates impermeability.

Collar Schedule	No. of Wolves	No. of Crossings	No. of Approaches	Permeability Index
5-hour	6	25	0	1.00
30-minute	8	76	1	0.99

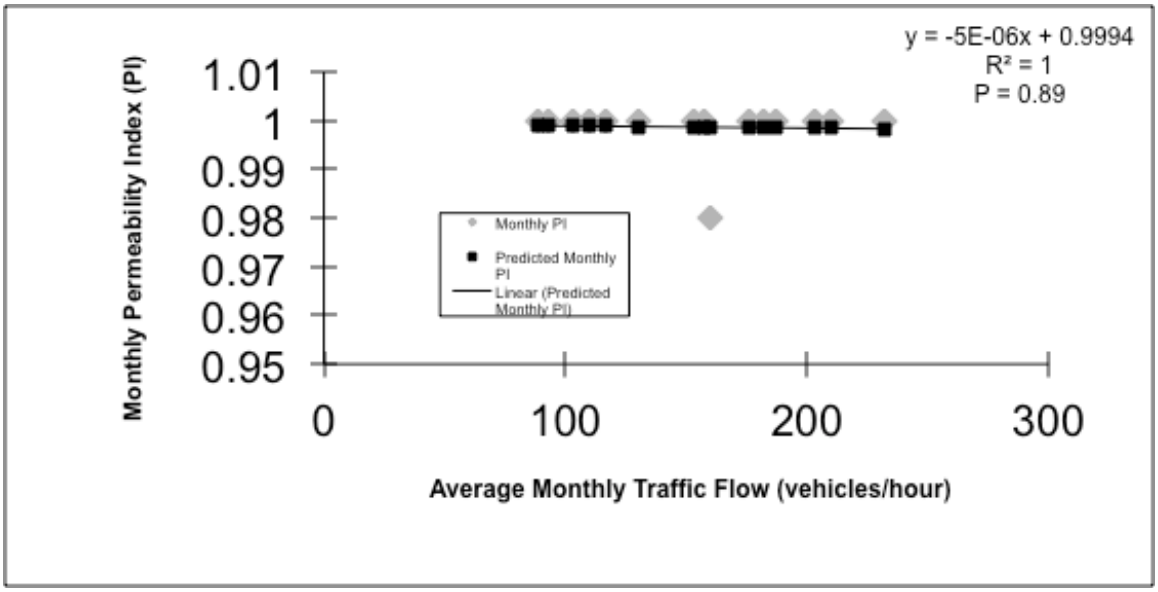


Figure 6. Regression analyzing the relationship between monthly permeability index and average monthly traffic flow rates (vehicles/hour). The monthly permeability index was calculated using GPS-collar data on the 5-hour schedule from 6 red wolves between March 2009 and May 2010 in Tyrrell and Dare Counties, NC.

Assessing the effect of the highway widening on current red wolf territories: Buffers around US 64 to a distance of 3281 ft. (1000 m) in 164 ft. (50 m) increments overlaid on a map displaying current red wolf home ranges showed that 2 red wolf packs would be directly affected by a highway widening. One pack is located north of the current 2-lane highway in Tyrrell County and the second is south of the highway in Dare County, the only existing pack in Alligator River National Wildlife Refuge. The proportion of home range to be affected in Tyrell County ranges between 0.11% and 6.63% (Table 10) and is located between 820 ft. (250 m) and 3218 ft. (1000 m) from the existing highway just east of Columbia, NC where the previously widened portion of US 64 narrows to a 2-lane highway (Figure 7). In Dare County, the proportion of home range that would be affected ranges between 0.01% and 20.31% (Table 11) and is located south of US 64 between River Rd. and Bear Rd. on Alligator River National Wildlife Refuge (Figure 8).

Assessing the effect of the highway widening on important red wolf habitat: Important red wolf habitat is defined as, following the results of the resource selection function analysis in objective 1, agricultural fields, successional fields, and upland forests. Buffers at 164 ft. (50 m) increments extending out to a distance of 3281 ft. (1 km) from US 64 overlaid on the NC GAP habitat map revealed that construction to the north of the current US 64 in Tyrrell County would remove more red wolf habitat than construction to the south. The opposite was found in Dare County, with more red wolf habitat at risk south of the current US 64 than north (Figures 9 and 10). If highway construction were to disturb the entire area between the existing US 64 and the 3281 ft. (1 km) buffer, a total of 0.16 mi^2 of red wolf habitat will be removed north of the highway vs. 0.09 mi^2 south of the highway in Tyrrell County. For Dare County, 0.04 mi^2 would be removed north of the highway vs. 0.07 mi^2 south of the highway if construction were disturb the whole area between the existing US 64 and the 3281 ft. (1 km) buffer.

Table 10. The proportion of a red wolf pack home range that will be directly affected by highway construction in Tyrell County between 820 ft. and 3218 ft. from the existing highway. The red wolf pack is located north of US 64 east of Columbia, NC where the previously widened portion of US 64 narrows to a 2-lane highway.

Distance from US 64 (ft)	Area of Home Range Intersected (ft^2)	Percent of Total Home Range Intersected
820	195312.38	0.11
984	603486.60	0.35
1148	1090902.45	0.64
1312	1643090.94	0.96
1476	2267019.48	1.33
1640	3024945.23	1.77
1804	3804239.09	2.22
1969	4595883.17	2.69
2133	5399701.05	3.16
2297	6215641.60	3.63
2461	7043620.94	4.12
2625	7883536.99	4.61
2789	8735389.60	5.11
2953	9599174.70	5.61
3117	10474842.94	6.12
3281	11335796.06	6.63

Table 11. The proportion of a red wolf pack home range that will be directly affected by highway construction in Dare County between 264 ft. and 3218 ft. from the existing highway. The home range is located south of US 64 in Alligator River National Wildlife Refuge between River Road and Bear Road.

Distance from US 64 (ft)	Area of Home Range Intersected (ft^2)	Percent of Total Home Range Intersected
246	13042.46	0.01
328	83853.62	0.04
410	216085.24	0.11
492	437479.56	0.23
574	748402.64	0.40
656	1263772.11	0.67
820	2790219.95	1.48
984	4548208.33	2.41
1148	6384017.38	3.39
1312	8293445.22	4.40
1476	10394240.80	5.51
1640	12531442.45	6.64
1804	14691958.47	7.79
1969	16867816.15	8.94
2133	19053292.57	10.10
2297	21293992.59	11.29
2461	23677537.88	12.55
2625	26280933.95	13.94
2789	28997590.89	15.38
2953	31868217.99	16.90
3117	34957184.80	18.54
3281	38297623.09	20.31

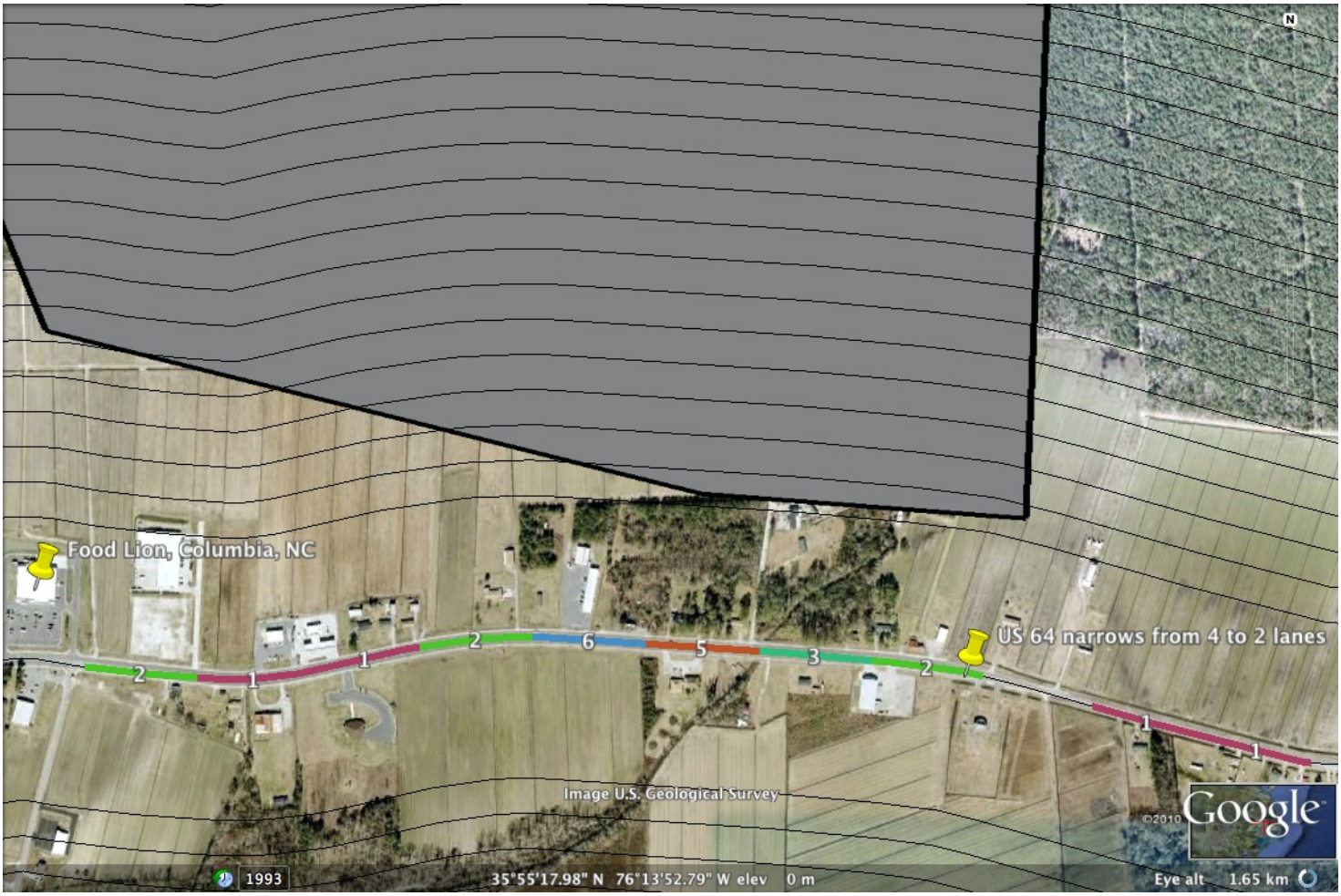


Figure 7. Location of the Tyrrell County red wolf pack home range with potential to be directly affected by highway construction. The home range extends to within 820 ft. from the existing highway where 4-lanes merge into 2-lanes just east of Columbia, NC. The highway buffer lines above (black lines) start at 820 ft. from US 64 and end at 3281 ft. in 164 ft. increments. If highway construction were to disturb the area between 820 ft. to 3281 ft. from the existing highway, 6.63% of this pack's home range would be removed. The numbers along US 64 indicate the number of red wolf highway crossings per 0.10 mi. segment captured using GPS-collar data collected between January 2009 and April 2011.

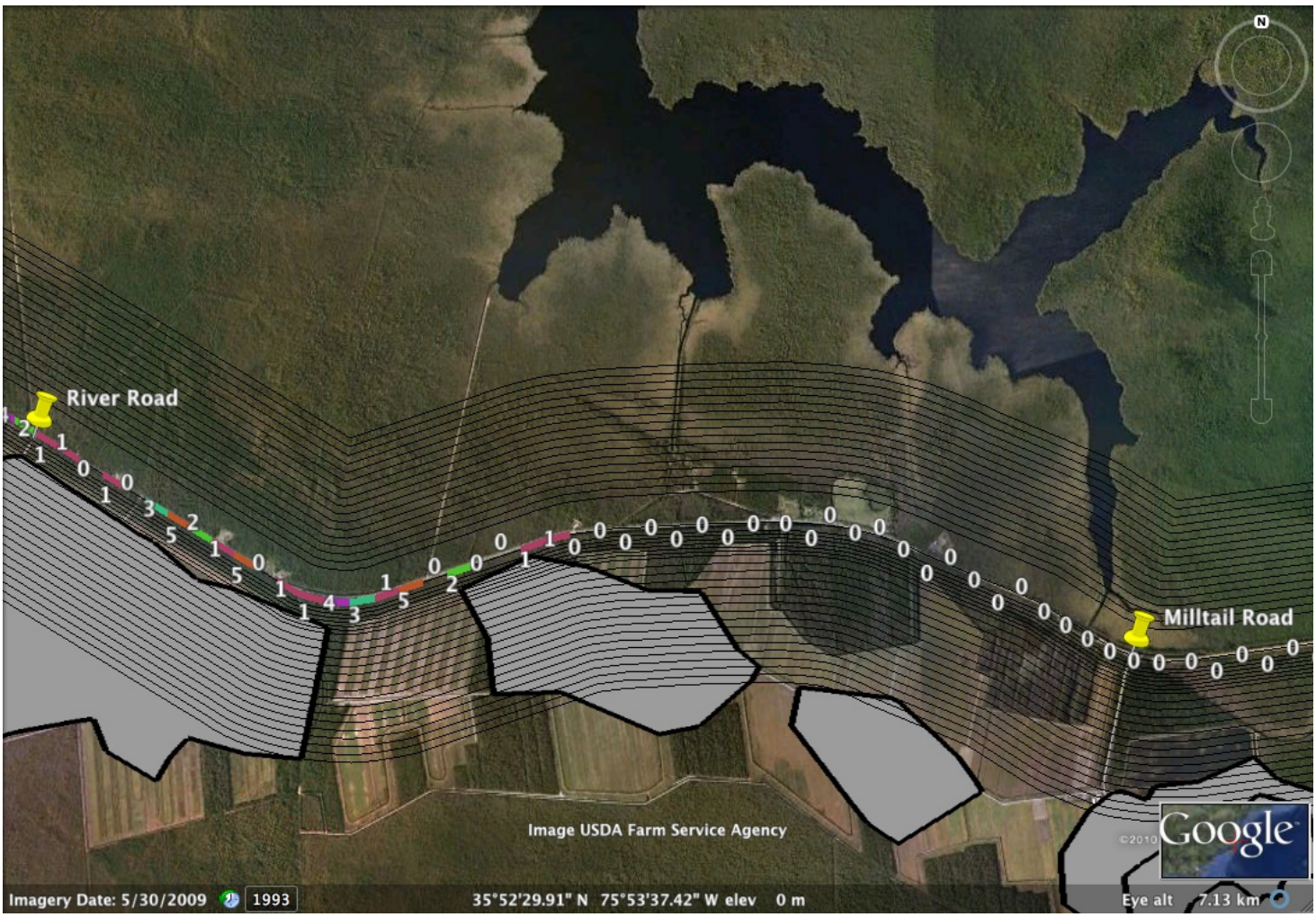


Figure 8. Location of the Dare County red wolf pack home range with potential to be directly affected by highway construction. The home range extends to within 264 ft. just south of the existing highway between River Rd. and Bear Rd. (east of Milltail Rd – not pictured) on Alligator River National Wildlife Refuge. This is the only red wolf pack on the refuge. The highway buffer lines above (black lines) start at 264 ft. from US 64 and end at 3281 ft. in 164 ft. increments. If highway construction were to disturb the area between 264 ft. to 3281 ft. from the existing highway, 20.31% of this pack's home range would be removed. The numbers along US 64 indicate the number of red wolf highway crossings per 0.10 mi. segment captured using GPS-collar data collected between January 2009 and April 2011.

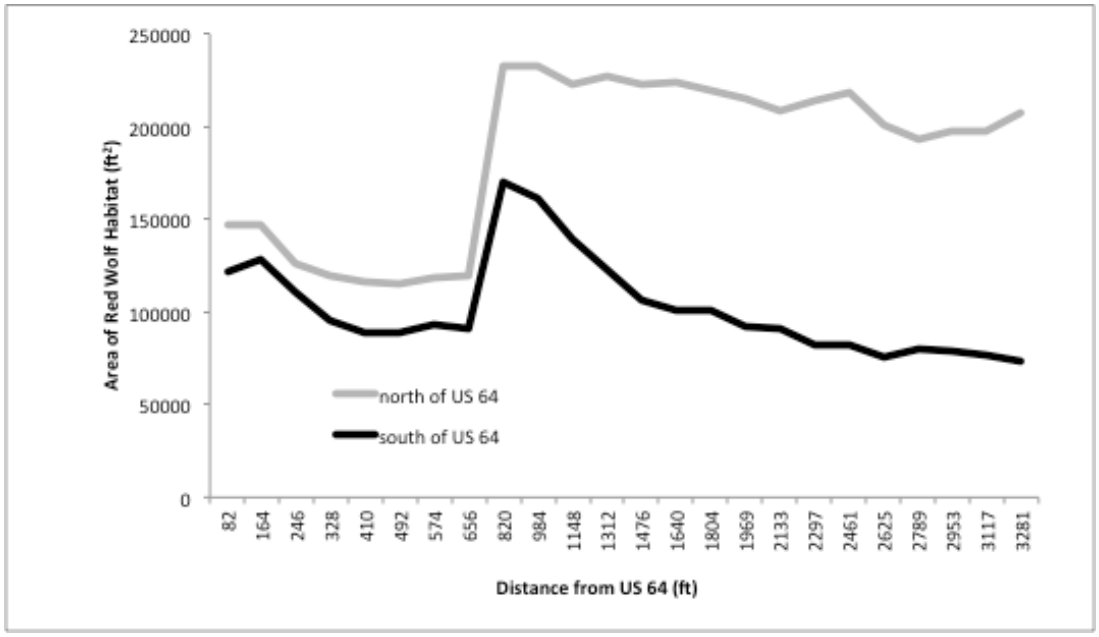


Figure 9. The area of important red wolf habitat per 164 ft. buffer for Tyrrell County, NC. Important red wolf habitat for eastern North Carolina includes agricultural land, upland forests, and early successional fields.

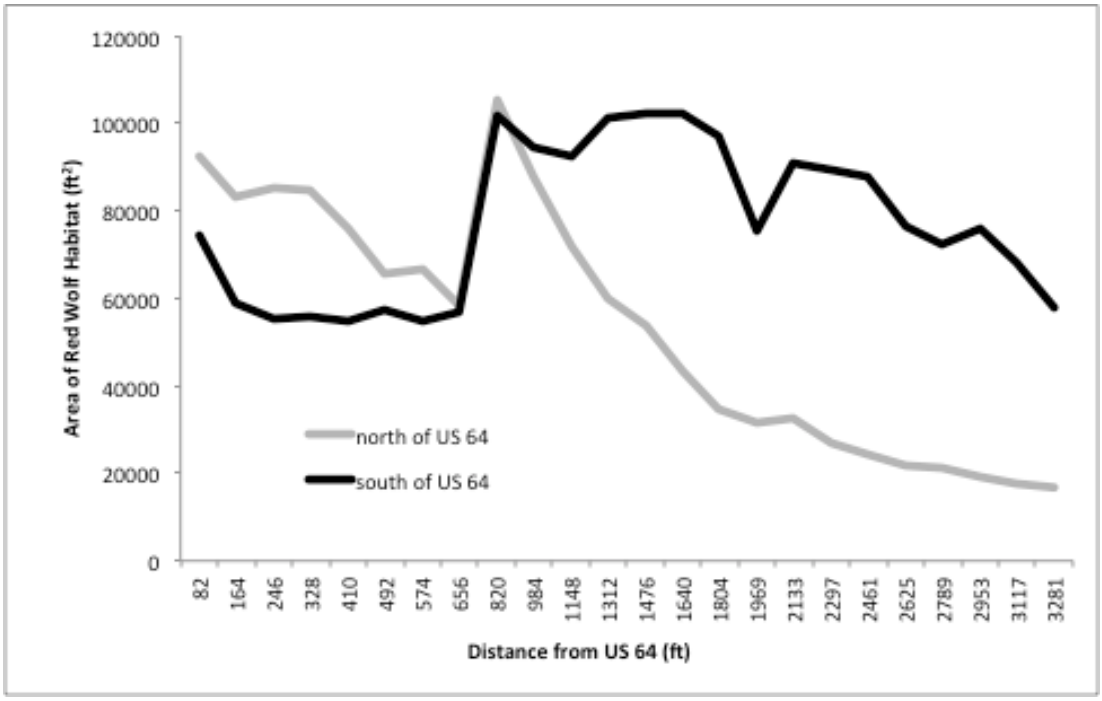


Figure 10. The area of important red wolf habitat per 164 ft. buffer for Dare County, NC. Important red wolf habitat for eastern North Carolina includes agricultural land, upland forests, and early successional fields.

Objective 3: Identify significant red wolf crossing areas to determine where wildlife crossing structures or other design features could be placed to minimize adverse project effects on wolves.

***Determining crossing locations and rates using GPS collars*:** Six wolves on the 5-hour schedule (3 M: 3 F) and 8 on the 30-minute schedule (4 M: 4 F), with 3 wolves that started on the 5-hour and were switched to the 30-minute schedule, displayed crossing activity around US 64 out of a total of 32 collars. Only wolves with home ranges along US 64 crossed the highway. Wolves on the 5-hour schedule crossed between 2 and 9 times while wolves on the 30-minute crossed between 2 and 20 times. Five wolves (1 M: 4 F) on the 30-minute schedule, subsampled every 5-hours for a paired t-test, crossed 53 (30-minute) and 19 times (5-hour), respectively (*P=0.030),* showing that the 30-minute schedule captured nearly 3 times the road crossings as compared to the 5-hour rollover.

An additional 5-hour wolf, (8-year-old female #1880; Figure 11), crossed the highway 266 times. On reviewing the distribution of her points, which extended about 11 miles along the highway, it was determined that US 64 bisected the core of her home range (Figure 12). Additionally, her movements in a narrow band surrounding the road increased the likelihood of "false crossings," where the line connecting consecutive points on either side of the highway did not necessarily represent the true crossing location. For these reasons, and because 1880 represented an unusual circumstance that heavily skewed the rest of the data, this wolf was considered an outlier and removed from all further analysis of US 64 GPS-collar data.



Figure 11. Photo of wolf #1880 (adult female) obtained by camera trap along US 64 in Tyrrell County, North Carolina in July 2009.

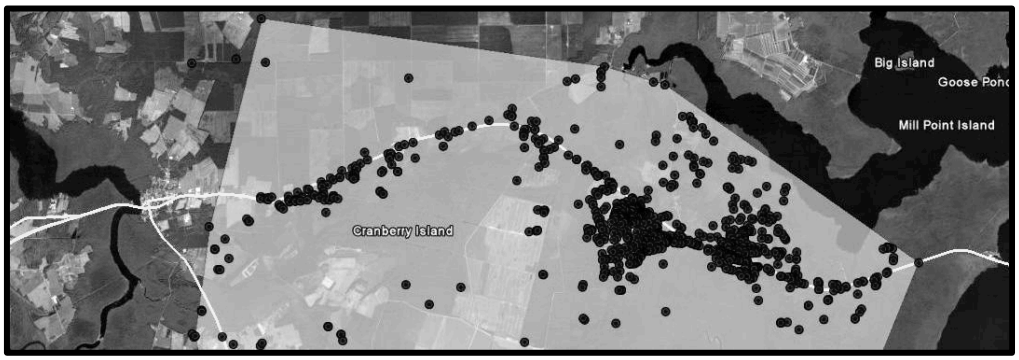


Figure 12. GPS-collar locations collected between April 2009 and November 2009 of wolf #1880 along US 64, Tyrrell County, North Carolina within its 95% MCP home range.

Although observed red wolf crossings and randomly generated crossings were both normally distributed, observed red wolf crossings occurred at a significantly lower frequency (*t=1.196, P=0.03*) and were bimodal as compared to the random crossings (Figure 13). Data from both the 5-hour and 30-minute schedules pointed to 2-crossing locations (Figures 14 and 15, respectively), 1 east of Alligator River in Dare County between miles 8 and 10 and 1 to the west in Tyrrell County centered on mile 28. However, the 30-minute data were more tightly concentrated and obvious. The two clusters of crossings identified by the GPS-collar data (Figure 16) coincided with where home ranges approached US 64.

Using the 30-minute collar data, red wolf highway crossing rates did not differ by wolf age (*F=5.14*, *P* = 0.13, *n = 13*; 3 juveniles, 3 dispersers, 7 adults) or sex (*t=0.32, P* = 0.76; *n = 13*; 7 males, 6 females).

Determining crossing locations using Camera Traps: Crossing data were collected at 39 camera stations along US 64 accumulated over 8,154 trap nights. The average and median number of trap nights per station was 204 and 160, respectively. The number of trap nights per station ranged from 35 to 617 nights. Four red wolf crossing sites were identified from camera data, 3 west of Alligator River in Tyrrell County at miles 19, 20.5 and 23 - 24 and 1 east of Alligator River in Dare County between miles 9 and 10 (Figure 17). The crossing site in Tyrrell County between miles 23 – 24 and the crossing site in Dare County between miles 9 – 10 were considered one location each due to proximity and habitat continuity.

The combined GPS and camera crossing data indicated 5 important crossing sections along US 64 between Columbia, NC and the US 64/264 intersection, 4 west of Alligator River in Tyrrell County and 1 east of Alligator River in Dare County (see Figures 17 - 19). The crossing site in Dare County identified by the cameras overlaps with the crossing site identified using GPS-collar locations, however that was not the case in Tyrrell County. The 3 crossing sites identified in Tyrrell County using cameras are from crossings made by wolf #1880, the wolf excluded from collar analyses. The crossing site in Tyrrell County identified with the GPS-collar data occurred in an area where no cameras were placed, within the town limits of Columbia, North Carolina.

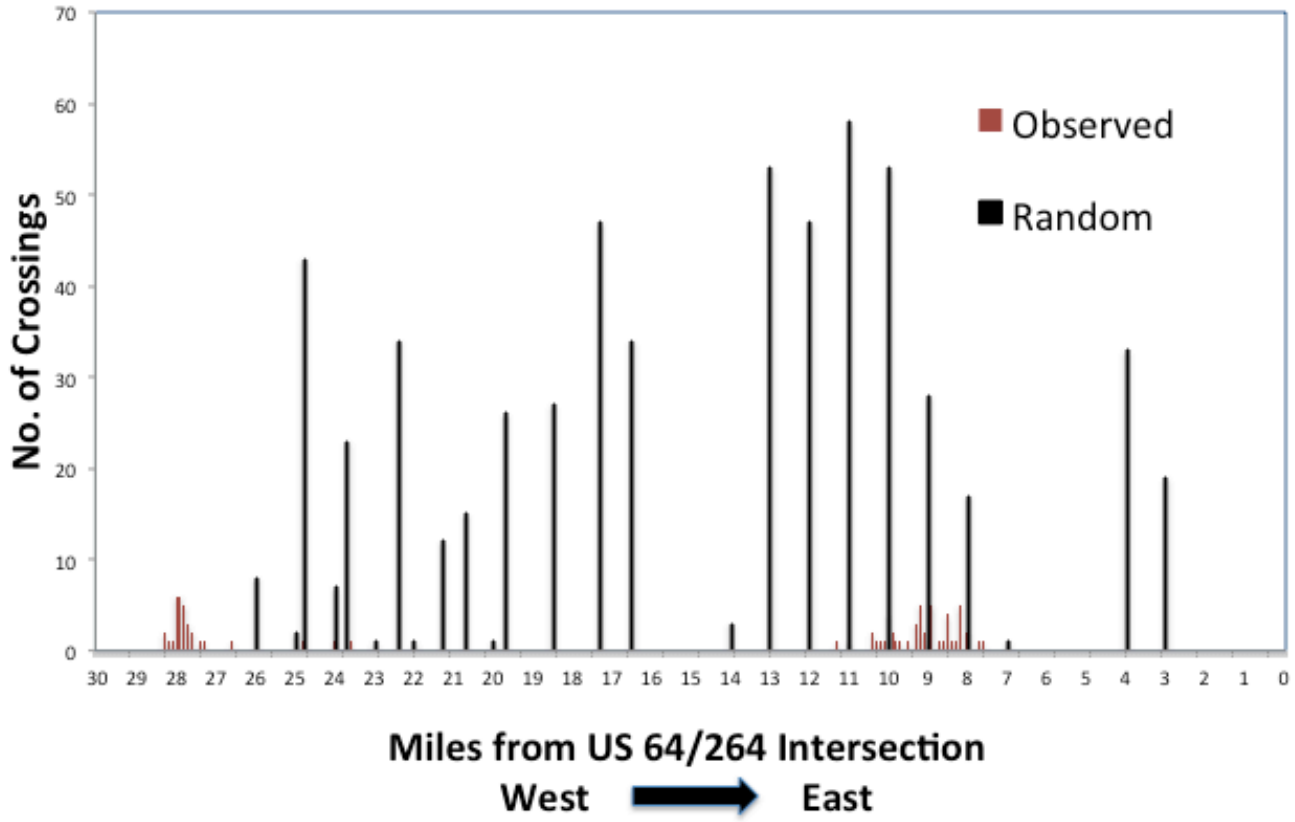


Figure 13. Observed red wolf crossings (red bars) occurred at a significantly lower frequency (*t=1.196, P=0.03*) and were bimodal as compared to the random crossings (black bars). Observed crossings are based on GPS locations taken at 30- minute intervals from red wolves in Washington, Tyrrell, Dare, Hyde, and Beaufort Counties, North Carolina collared between October 2009 and March 2011. An equivalent number of random line segments were drawn between the GPS locations for each red wolf. To approximate actual red wolf movement, random segment lengths were constrained to less than or equal to the maximum distance moved by a red wolf for the 30-minute data sets.

Determining crossing locations using historical road kill data: From May 1988 to February 2009, 58 wolves (31 M, 27 F) died as a result of vehicle collisions in the recovery zone, with an average of nearly 3 wolves per year. Twelve of these occurred on US 64. While not significant, the locations of current known road-kills appear to be generally clustered around crossing sites identified in this analysis, particularly on US 64 (Figures 18 – 19). However many of the historic road kill events highlight the location of packs no longer present.

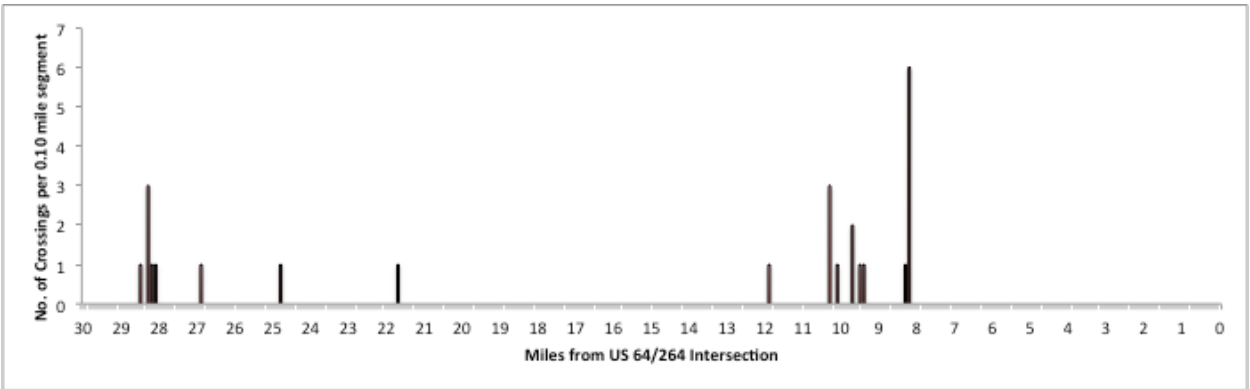


Figure 14. The number of red wolf crossings identified by GPS locations per 0.10 mile segments along US64 between Columbia, NC and the US64/US264 intersection. Crossings are based on GPS locations taken at 5- hour intervals between January 2009 and March 2011.

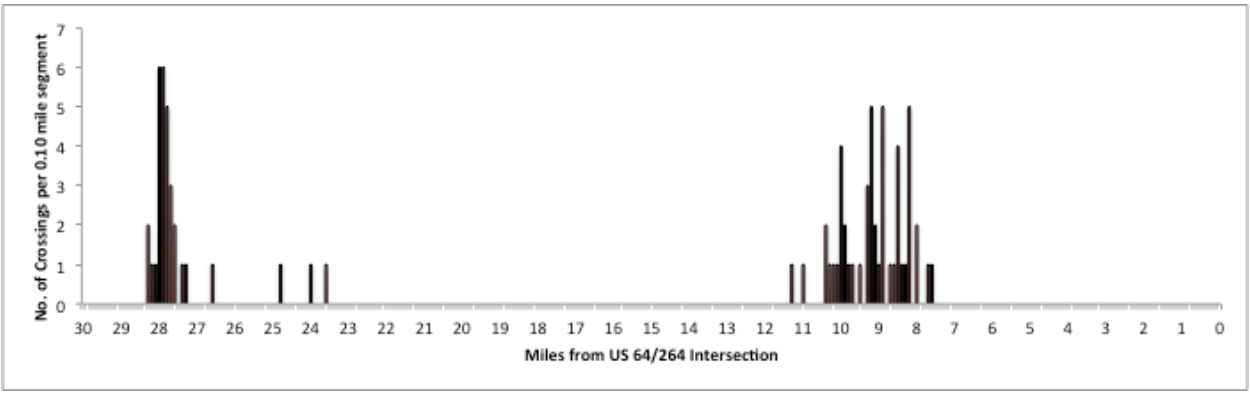


Figure 15. The number of red wolf crossings identified by GPS locations per 1 mile segments along US64 between Columbia, NC and the US64/US264 intersection. Crossings are based on GPS locations taken at 30- minute intervals between October 2009 and March 2011.

a)

b)

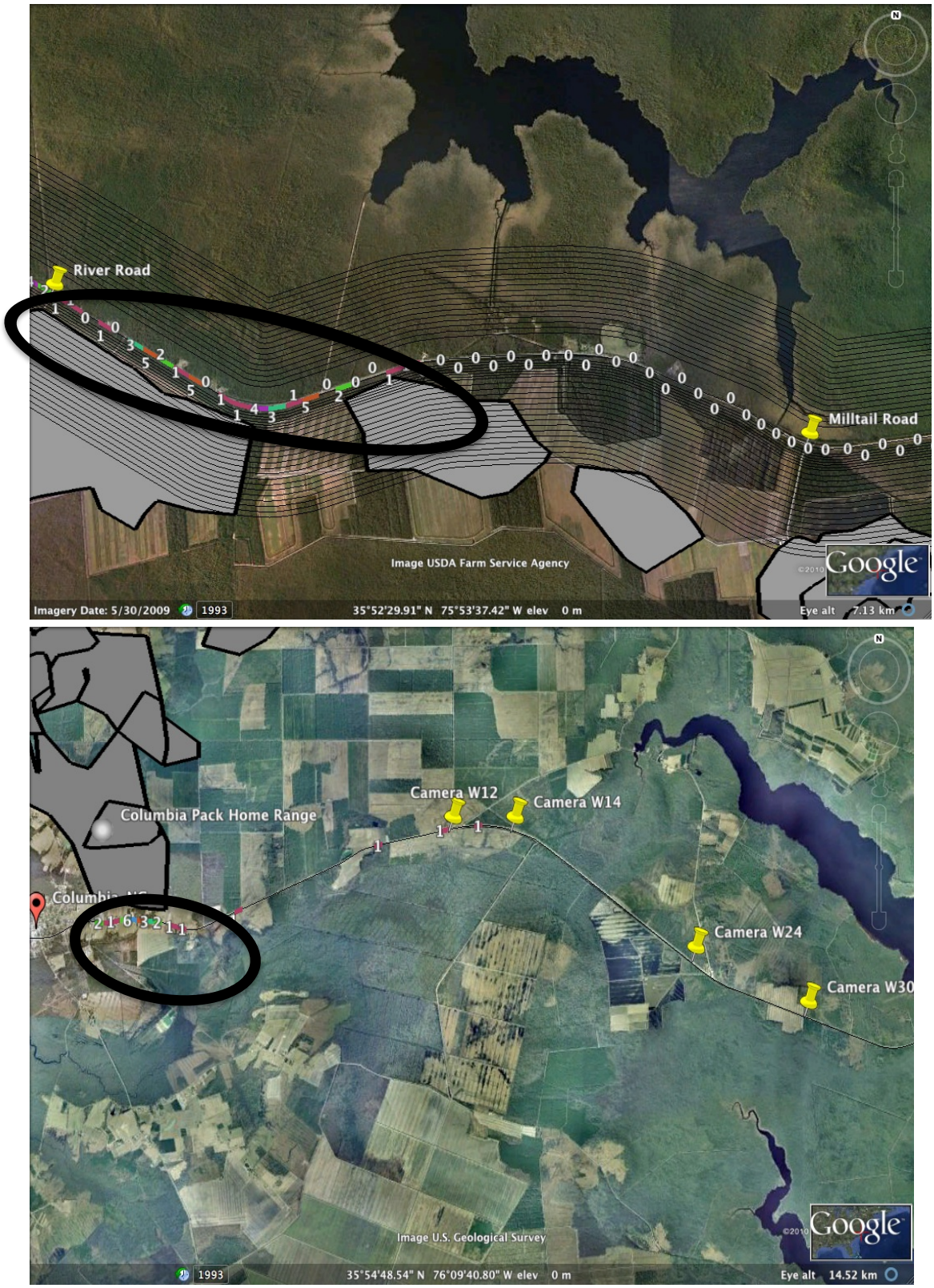


Figure 16. The two clusters of crossings identified by the GPS-collar data in both a) Dare and b) Tyrrell Counties, North Carolina coincided with the location where home ranges approached US 64. Crossings are based on GPS locations taken at 30- minute intervals between October 2009 and March 2011.

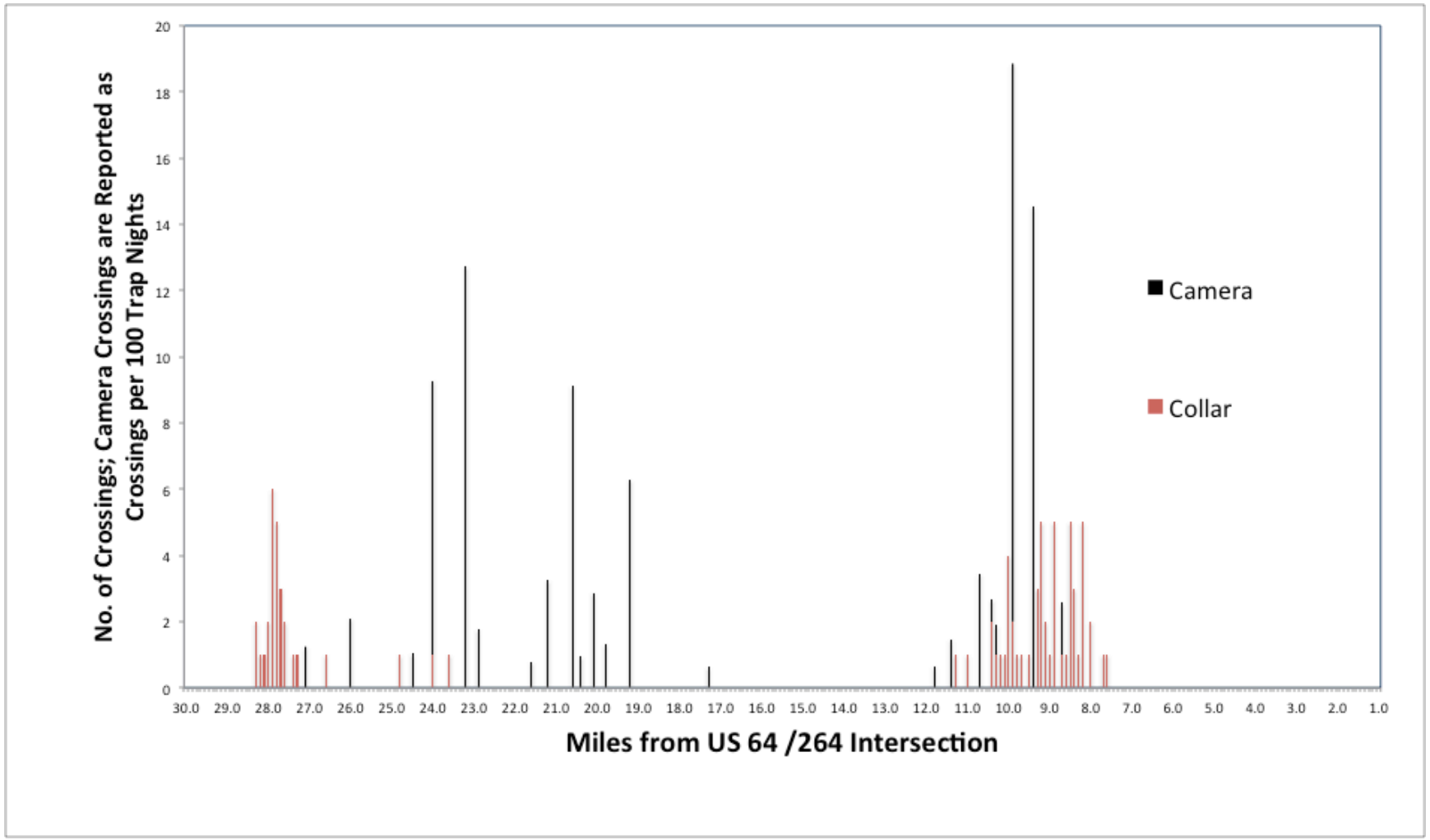


Figure 17. Combined GPS- collar (red bars) and camera (black bars) data, collected from 2009 – 2011, revealed 5 areas along US 64 currently used by red wolves as crossing sites, 4 in Tyrrell County west of Alligator River and 1 in Dare County east of Alligator River, North Carolina. Camera data are presented as number of captures per 100 trap nights. The red wolf crossing site identified by camera data in Dare County (miles 9 – 10) overlaps with the crossing identified by GPS-collar data (miles 8 – 10). However, crossing sites identified by camera data in Tyrrell County (miles 19, 20.5 and 23 – 24) do not overlap with the crossing site identified using GPS-collar data (mile 28). The crossing site in Dare County between miles 9 – 10 and the crossing site in Tyrrell County between miles 23 – 24 were considered one location each due to proximity and habitat continuity.

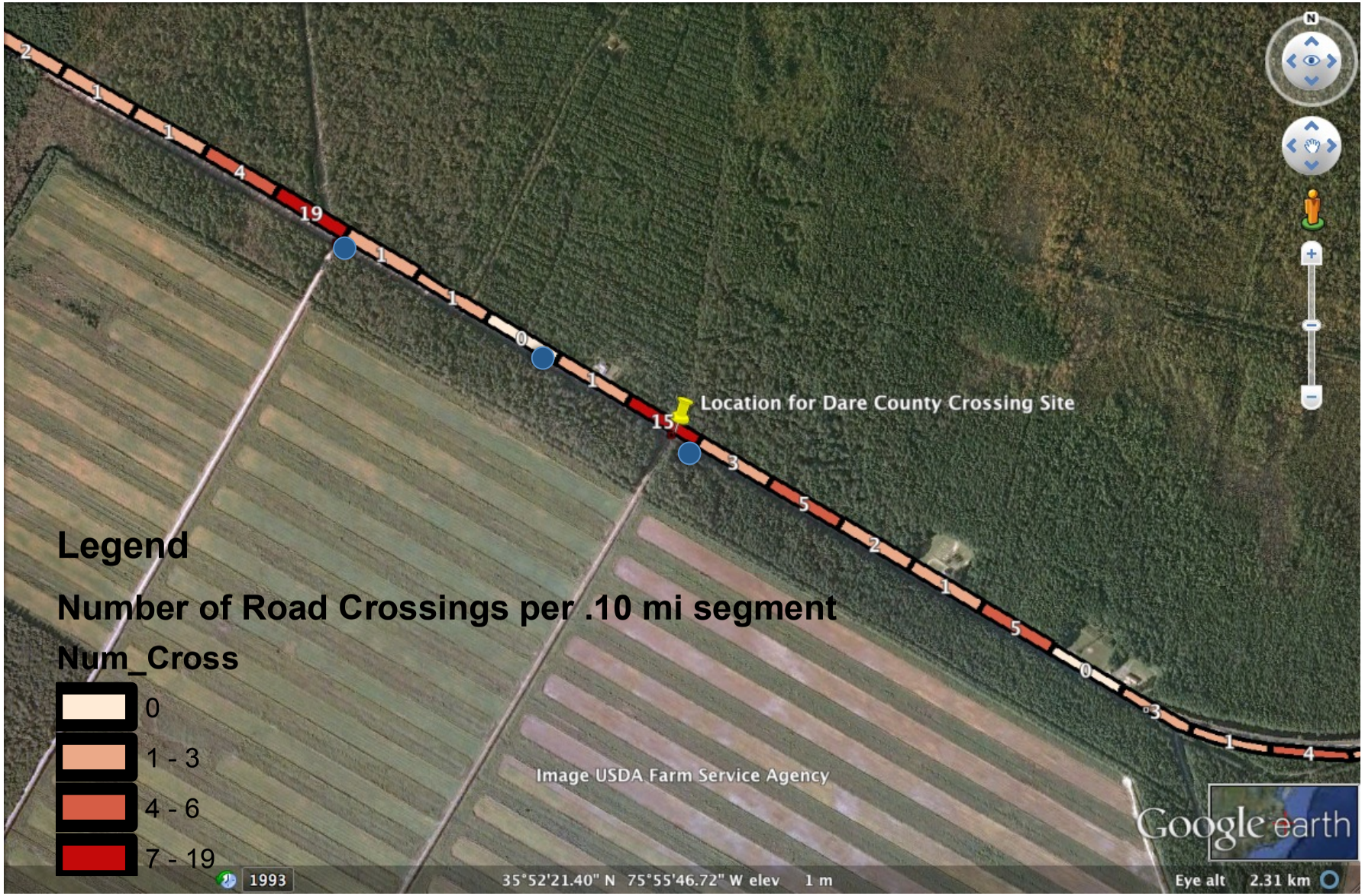


Figure 18. Map of red wolf highway crossing locations along US 64 in Dare County, NC. Crossing locations were calculated from GPS collar and remote camera data. The numbers indicate how many crossings per 0.10 mi. segment were recorded. The yellow marker shows the suggested location for a red wolf crossing structure in Dare County. The blue points indicate the location of a red wolf road mortality event.

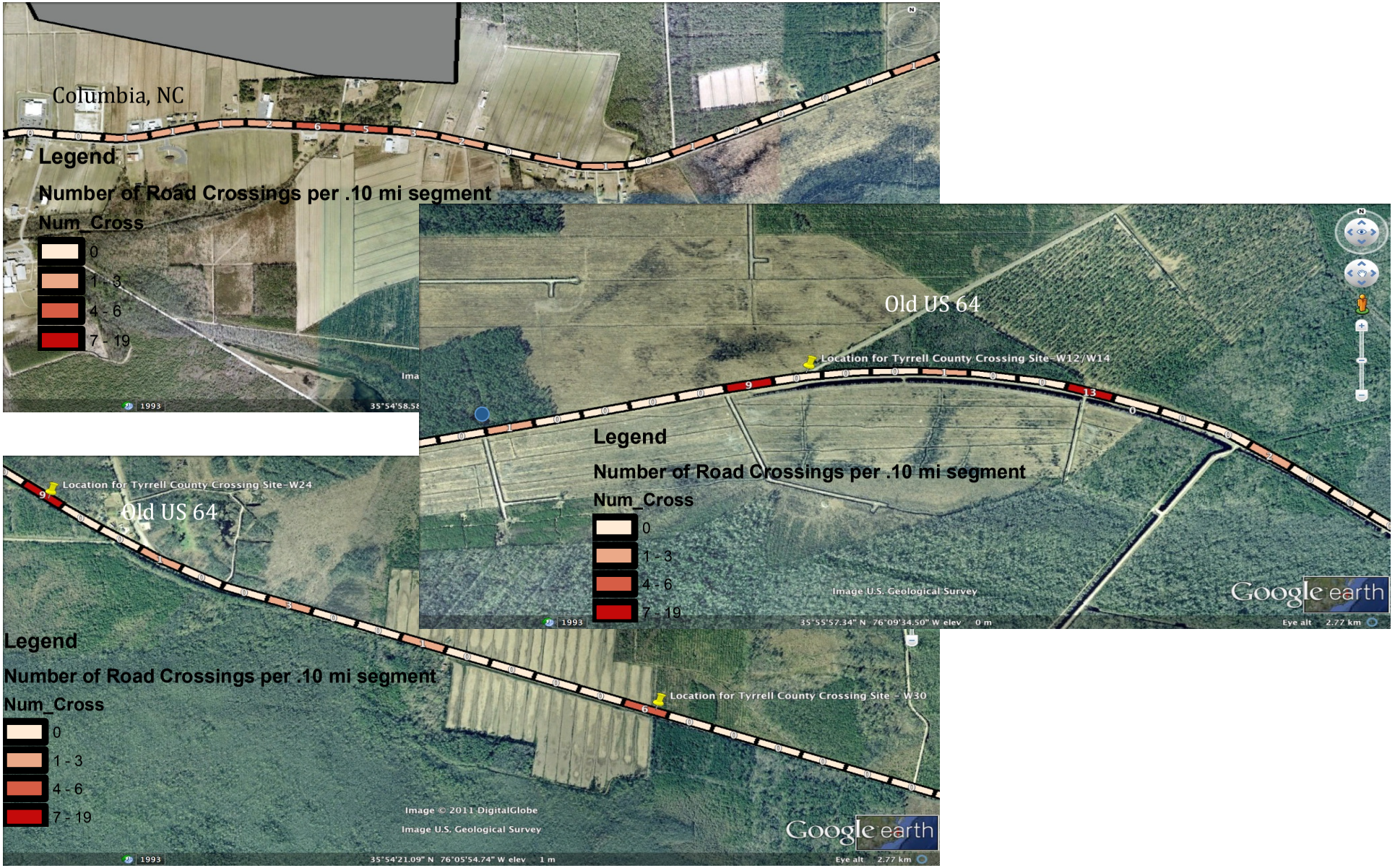


Figure 19. Map of red wolf highway crossing locations along US 64 in Tyrrell County, NC. Crossing locations were calculated from GPS collar and remote camera data. The numbers indicate how many crossings per 0.10 mi. segment were recorded. The yellow markers show the location of the 3 suggested locations for red wolf crossing structures in Tyrrell County. The blue point indicates the location of a red wolf road mortality event.

Evaluating habitat characteristics at crossing sites identified by GPS collar locations: The most parsimonious habitat model at crossing locations determined using GPS-collar data included habitat type at distances of 328 ft. and 492 ft. from the crossing site (Table 12). The AICc weight of the most parsimonious habitat model was 0.69. The second most parsimonious model included habitat type at 656 ft. from the crossing site and had a ΔAICc of 3.19 and an AICc weight of 0.07. The habitat types at distances of 328 ft. and 492 ft. from crossing locations correspond to those identified by resource selection functions for red wolves: agriculture, upland forests, and early successional fields.

Evaluating habitat characteristics at crossing sites identified by camera traps: The most parsimonious habitat model at crossing locations determined using camera trap data included width of the road/trail at the camera location (Table 13). The AICc weight of the most parsimonious habitat model was 0.89. The second most parsimonious model included road/trail width and habitat type at 164 ft. from the camera site and had a ΔAICc of 6 and an AICc weight of 0.03. The trail widths (which ranged from 1.64 ft. to 65.6 ft.) at camera trap locations with recorded red wolf crossings were 26.24 ft. or wider.

Table 12. Most parsimonious habitat model for red wolf crossing sites in Tyrrell and Dare Counties, NC identified using GPS-collar data collected between January 2009 and April 2011.

Model	AICc	ΔAICc
Habitat 329 ft from US 64 + Habitat 492 ft from US 64	42.99	0.00
Habitat 656 ft from US 64	46.18	3.19
Habitat 164 ft from US 64 + Habitat 328 ft from US 64 +Habitat 492 ft from US 64 + Habitat 656 ft from US 64	46.84	3.85
Habitat 164 ft from US 64 + Habitat 328 ft from US 64	55.19	12.20
Habitat 164 ft from US 64	55.42	12.43

Table 13. Most parsimonious habitat model for red wolf crossing sites in Tyrrell and Dare Counties, NC identified using camera trap data collected between March 2009 and April 2011.

Model	AICc	ΔAICc
Trail/Access Road Width	40.08	0.00
Trail/Access Road Width + Habitat 164 ft from US 64	46.03	5.95
Habitat 656 ft from US 64	52.95	12.87
Trail/Access Road Width + Habitat 328 ft from US 64 + Habitat 492 ft from US 64	73.48	33.40
Habitat 164 ft from US 64 + Habitat 328 ft from US 64 + Habitat 492 ft from US 64	74.32	34.24

Discussion

Objective 1: Evaluate wolf habitat use along the entire US 64 corridor from Plymouth NC to the US 64/264 intersection

Understanding of basic species survival needs is required before completing any wildlife management plan. This study used data from 16 wolves from 16 different packs to estimate home range size and habitat selection of red wolves (*Canis rufus*) in eastern North Carolina. The home range sizes we calculated (2.61 mi^2 – 38.19 mi^2) were smaller than those reported in 2 earlier studies that followed 3-red wolf packs each (Phillips et al., 2003: 13.40 mi^2 - 78.10 mi^2; Chadwick et al., 2010: 31.51 mi^2 - 57.72 mi^2). However, if the red wolf pack with the largest home range size in the Phillips et al. (2003) study is excluded, the home ranges for the remaining 2 packs fall within the range of our findings (13.40 mi^2 - 30.00 mi^2). In addition, Phillips et al. (2003) used minimum convex polygons to determine home range size where as we used α-NNCH, a more conservative method of home range estimation (Getz et al., 2007), which could account for the discrepancy in home range sizes between the two studies. Chadwick et al. (2010) tracked males 2 – 3-years in age, two of which were brothers, and therefore may have been dispersing individuals. Though not significantly different, our study showed that dispersing animals tended to have larger home ranges than adults or juveniles, which could account for the differences in home range size between our study and the one completed by Chadwick et al. (2010). Small sample size likely accounts for no significant difference in home range size among age classes. Seven dispersers were eliminated from this study, 5 due to death and 2 because of inadequate data. Summer (June – September) home range size (4.84 mi^2 – 5.73 mi^2) averaged for all 16 packs over 2-years (2009 and 2010) corresponded to summer home ranges reported (1.34 mi^2 – 4.72 mi^2) for one red wolf pack monitored during the summer of 2005 (Hinton et al., 2010). We did not look at the influence of pack size on home range size, as previous research suggests that a relationship does not exist between pack size and home range size in gray wolves (Jedrzejewski et al., 2007).

Similar to Phillips et al. (2003) and Chadwick et al. (2010), our study revealed that home range size varied with season, being smaller during summer months and larger in winter with monthly home range size peaking in January. Smaller home ranges in summer are likely due to the presence of pups (Phillips et al. 2003; Chadwick et al., 2010). Mating, den preparation and whelping for red wolves typically occurs between February and April (C. Lucash, per. comm.), which coincides with the reduction of monthly home range sizes. This study found that monthly home range continually reduced in size starting in February and continued until reaching the smallest size in April. Monthly home ranges remained small until September when they started a steady increase that peaked in January. Jedrzejewski et al. (2001) showed home range size and movement patterns of gray wolf (*Canis lupus*) packs were also influenced by reproductive cycles.

Habitat and prey availability also may influence seasonal fluctuations in home range size. We found that habitat in the home ranges was primarily composed of agricultural fields

year round. However, the percentage of agriculture within home ranges was highest in summer and lowest in winter. Increased use of agricultural fields in summer could be due to increased food resources available to prey species of red wolves such as white-tailed deer. A recent study found that red wolves readily prey on adult white-tailed deer (*Odocoileus virginianus*) and fawns during summer months (Dellinger et al., *In Press*). Growth of crops in agricultural fields in summer could help concentrate prey (Vercauteren and Hygnstrom, 1998). Additionally, the birth of fawns in early summer could provide a source of prey that is easier to catch, thus allowing red wolf packs to gather adequate food in a smaller area. Variation in home range size due to prey availability also has been shown in gray wolves (Ballard et al., 1987).

A decrease in percentage of agricultural fields making up home ranges in winter may be related to the harvesting of crops. Harvesting eliminates food resources available to prey and eliminates potential cover for red wolves. This study found an increase in non-agricultural habitats, such as upland forests, pocosins, and wetlands, during the fall and winter months (Table 6). Chadwick et al. (2010) noted that increased use of non-agricultural habitats corresponded to the harvesting of row crops between September and November and with the onset of the hunting season. Although this study showed that red wolves typically selected against non-agricultural habitats, cover types such as early successional fields, upland forests, and pocosins could be providing essential cover for red wolves after crop harvesting. Also, red wolves tend to prefer cover types with denser ground vegetation for den sites (Phillips et al., 2003), thus leading to a switch in habitat use during late winter and spring months.

Another important habitat finding is the selection for areas closer to roads. Most roads in the red wolf recovery zone are unpaved gravel or dirt roads used for agricultural purposes (C. Lucash pers. comm.). Red wolves likely used the road network as travel corridors, which could allow for packs to persist in areas where habitats are highly interspersed and large parcels of quality habitats are few.

Conclusion: White and Ernst (2004), Singleton et al. (2005), and Kindall and van Manen (2007) all stress the need to identify habitat linkages across barriers to properly place crossings. Thus, it is imperative not only that wildlife underpasses are constructed in areas identified as high use for crossings (Scheick and Jones, 1999), but also that crossings are placed in a manner that connects habitat being selected by the species of concern. This study suggests that red wolf crossing structures should connect agricultural landscapes that are interspersed with upland forests, successional fields and pocosins. In addition, avoiding the aforementioned cover types during construction will minimize direct impacts to the red wolf population.

Objective 2: Evaluate the significance of red wolf habitat changes anticipated from the proposed highway project from Columbia NC to the US 64/264 intersection.

This was the first study to employ the use of a permeability index to a non-seasonal migrating species. This provided a challenge in determining what could be considered a

road “approach”, as we had to be careful not to include normal movements within a home range as an approach. The resulting buffer width of 164 ft., which is similar to the buffer width suggested for gray wolves (Paquet and Callaghan, 1996), illustrates the willingness of red wolves to establish home ranges in close proximity to the current 2-lane highway. The resulting permeability indices calculated for the 2-lane section of US 64 using both 5-hour and 30-minute data were 1.0 and 0.99, respectively. This suggests that the current 2-lane highway is not discouraging the red wolf population from attempting to cross US 64. However, it is important to note that only 14 of the 32 collared red wolves crossed a highway within the 5-county recovery zone, and 8 of those only crossed either once or during dispersal. Just 6 wolves from 3 packs crossed a highway regularly, and all 3 packs had home ranges that were adjacent to or straddled US 64.

The original goal was to compare permeability indices between the previously widened 4-lane section of US 64 in Washington County to the permeability index for the 2–lane section. However, a decrease in and near disappearance of the red wolf population to the west of Columbia, NC, prevented the collaring of red wolves where the widening to a 4-lane highway already was completed.

Although the current 2-lane highway is not discouraging wolves from attempting to cross, it is important to note that most roads exhibit a distinct trade-off between permeability and road kill (Forman and Alexander, 1998). A highly permeable road might result in a high level of wildlife/vehicular collisions, whereas an impermeable road might have few road kill events. Yet this decrease in road kill comes at the expense of habitat connectivity. This trade-off indeed holds true for US 64. Though the 2-lane portion of US 64 may not be hindering attempts to cross, road mortality is the second leading cause of death among red wolves accounting for 14% of mortalities (USFWS, 2007).

Permeability was expected to behave inversely to traffic flow, decreasing during the busy summer months and increasing during the winter. However, due to the high permeability of the highway, no such relationship existed. In addition, time of day may play an instrumental role in the event that crossing times (typically at night) do not coincide with peak traffic hours (midday). Such a pattern could be determined by separating traffic flow and permeability data by time. It should also be noted that while traffic fluctuates heavily on US 64 between summer and winter, the highway experiences relatively low traffic volume (maximum 250 vehicles per hour during the peak season) in comparison to other highways in the vicinity of the Outer Banks outside of the study area (~791 vehicles per hour; Currituck Development Group, 2011). The Federal Highway Administration reports that relatively few animals avoid crossing the road at traffic volumes below 2,500 cars per day and, that while road avoidance increases at moderate volumes (2,500 – 10,000 cars per day), it is not until traffic volume surpasses 10,000 cars per day that a large portion of animals will avoid highway crossing attempts (Clevenger and Huijer et al., 2011). The average daily traffic volume for the study site is 1,995 cars per day with a peak of 6,500 cars per day in July, placing the focal section of US 64 in the low to moderate traffic flow category as defined by the Federal Highway Administration.

Construction north of the current US 64 in Tyrrell County has the potential to remove a maximum of 0.16 mi^2 of red wolf habitat and 6% of the home range area used by a current red wolf pack while construction to the south will directly impact only 0.09 mi^2 of red wolf habitat and will not displace any current red wolf packs. East of Alligator River in Dare County, a widening of the current highway to the south has the potential to lead to a loss of 0.07 mi^2 of red wolf habitat and 20% the home range used by the only existing red wolf pack in Alligator River National Wildlife Refuge. Construction to the north of US 64 in Dare County will only remove up to 0.04 mi^2 of red wolf habitat and will not overlap with any current packs. Therefore, limiting construction to the south of the existing US 64 in Tyrrell County and north of the highway in Dare County will avoid direct effects to the current red wolf population.

We highlight that these results quantify only direct effects on current wolf home ranges. Road construction can have many indirect effects through changing hydrology; air, water, noise, and light pollution levels; wind flow; humidity; temperature; vulnerability to invasive species; and habitat continuity (Forman et al., 2003; Coffin, 2007). These indirect effects of the construction can disrupt red wolves living adjacent to the existing highway causing a shift in current home ranges. Any shift in home ranges has the potential to affect social order, mating, and ability to locate prey. At this time we are not able to quantify these effects, but these potential indirect effects may be measured in the "during-" and "post-" construction phases of the project.

Conclusion: Road permeability, calculated using GPS-collar data, was 100%, thus the current 2-lane highway does not discourage the red wolf population from attempting to cross US 64. This does, however, increase the risk of road mortality events. A decrease in the red wolf population to the west of Columbia, NC, prevented collaring of red wolves where widening to a 4-lane highway was completed. Therefore, we were not able to compare highway permeability between 2- and 4-lane highways. To avoid any direct effects to the current red wolf population, highway construction should be limited to the south of the existing US 64 in Tyrrell County and north of the highway in Dare County. Potential indirect effects of highway widening activities were not quantified, as they could not be quantified using GPS or camera data. It is important to note that indirect effects can negatively effect the red wolf population.

Objective 3: Identify significant red wolf crossing areas to determine where wildlife crossing structures or other design features could be placed to minimize adverse project effects on wolves.

Movement patterns obtained through tracking of GPS locations and remote camera traps clearly demonstrate that red wolves crossed US 64 and two other highways in the red wolf recovery zone, with some frequency. This implies there is potential for one of two outcomes of widening the road from 2 to 4 lanes: (1) either increased traffic or the increased width itself may increase road mortality, or (2) these factors may decrease road permeability. The degree to which these threats are deemed relevant and serious will have a significant bearing on NC DOT's planning and execution of the construction project.

The distribution of GPS-collar locations and camera trap photos along US 64 revealed 5 distinct red wolf crossing sites, 4 west of Alligator River in Tyrrell County and 1 east of the river in Dare County. Though they do not overlap completely, GPS-collar data and camera trap data are in accordance for the location of the crossing site in Dare County. However, that is not the case in Tyrrell County. GPS-collar data revealed 1 crossing site in Tyrrell County, while camera trap data identified the 3 additional crossing sites. Two factors contributed to the 2-methods not overlapping in Tyrrell County. First, due to the number of false crossings, GPS-collar data from wolf #1880 was eliminated from our analysis, thus eliminating GPS-collar data along the section of US 64 coinciding with the cameras. False crossings were obtained from this wolf because US 64 bisected her home range (Figure 12). Secondly, cameras were not set up where GPS-collar data identified a crossing location in Tyrrell County due to increased risk of camera theft within the town limits of Columbia, NC.

The potential for "false crossings," which may suggest that a crossing took place in a different location from where it actually occurred, exists in the remainder of the GPS-collar data as well. However, the presence of such distinct activity clusters, particularly under the 30-minute schedule, suggests that our results captured real movement trends. Although we captured nearly 3 times as many crossing events and the data displayed tighter clustering with better defined locations using the 30-minute collar schedules, the location of crossing sites identified using GPS-collar data was generally consistent between the 2 schedules (5-hour and 30-minute).

The red wolf crossing site identified in Dare County is within the Alligator River Wildlife National Wildlife Refuge and is centered on Hickory Road. This matches the location of an important black bear crossing site (Vaughan et al., 2011), and therefore is a candidate site for the placement of a multi-species crossing structure for large wildlife. Likewise, the 3 red wolf crossing sites in Tyrrell County located via camera trap data overlap with candidate areas for large wildlife crossing structures identified in an earlier study by University of Central Florida (UCF) (Smith, 2011). The red wolf crossing site between miles 23 and 24 (cameras W12 and W14) overlaps with "Area 1" of the UCF study (Smith, 2011), which is centered on the western intersection of Old US 64 and US 64. The red wolf crossing sites at mile 20.5 (camera W24) and mile 19 (camera W30S) overlap with "Area 3"and "Area 5" of the UCF study, respectively (Smith, 2011) and are located near the eastern intersection of Old US 64 and US 64. Using the eastern intersection of Old US 64 and US 64 as a reference point, "Area 3" is 0.31 miles west of the intersection and "Area 5" is 1.16 miles east of the intersection.

The red wolf crossing site in Tyrrell County identified using GPS-collar locations is located within the town limits of Columbia, NC where US 64 narrows from 4 to 2 lanes. Placement of a crossing structure here may not be practical because of proximity to residential areas.

Crossing rates suggest that there is no difference in highway crossing behavior between sexes or among ages. As with the home range analysis, the lack of any significant difference in either sex or age class might simply be a function of low sample size, and it

is possible that a real relationship could be hidden by an interaction between the two variables, which we were unable to test for the same reason. This possibility is supported by data on road mortality, which has impacted dispersers hardest among the age classes. Although road mortality accounts for 14% of deaths for the red wolf population over all, when broken down by age class, road mortality accounts for 19% of dispersers but only 6% of breeding adults (USFWS, 2007). Low sample size and high expense per individual is a common hurdle in research involving large carnivores, as was true for this study. In addition, the status of the red wolf as critically endangered puts a major constraint on population size from which to draw a sample.

In addition to identifying the location of important red wolf crossing sites, we also investigated which habitat variables were correlated with those locations. The presence of agricultural fields, successional fields, and/or upland forests 328 ft. to 492 ft. (100 to 150 m) from the road best predicted where a red wolf chose to cross when using GPS-collar data while trail/road greater than 26.24 ft. (8 m) provided the best explanation for the location of crossing sites identified by remote camera traps. The presence of agricultural fields, successional fields, and upland forests as well as proximity to maintained agricultural/forest roads at crossing sites corresponds to habitat selection results.

Conclusion: The distribution of GPS-collar locations and camera trap photos along US 64 revealed 5 distinct red wolf crossing sites, 4 west of Alligator River in Tyrrell County and 1 east of the river in Dare County. Four of the 5 red wolf crossing locations we identified are suitable for crossing structures. The most western crossing site is located within the town of Columbia, NC where retro fitting a wildlife underpass may be impractical. All 4 crossing sites suitable for placement of a crossing structure overlap with large wildlife crossing locations identified in previous studies. The 1 red wolf crossing site located in Dare County is centered on Hickory Road and the 3 crossing sites in Tyrrell County are approximately where US Old 64 intersects with US 64. Although no significant difference in crossing behavior was found during this study, high road mortality among dispersers suggests they may cross the highway more frequently than adults or juveniles. The most parsimonious models looking at the relationship between habitat variables at 164 ft. increments from US 64 and road/trail widths measured at road access points where cameras were placed (e.g. dikes, logging roads, public property access roads) indicates that well maintained trails at least 26.24 ft. (8 m) in width leading to and from underpasses and connect habitats selected for by red wolves (e.g. agriculture, successional fields, and upland forests), will optimize efficacy.

The data presented here are reflective of the current population's behavior. In the event that wildlife crossing structures are deemed necessary, our results identify locations where crossing structures would have the greatest effect on the red wolf population. This project is only one of several examining the use of US 64 by numerous wildlife species. The results of those studies, in addition to this one, should be taken into account in determining the need for mitigation, the type of mitigation to use, and the layout that would be most compatible with all target species. The direct and indirect effects of the road widening project remain difficult to predict, yet the potential for a negative effect on the red wolf must be considered. Careful monitoring of the red wolf population

throughout and following the construction process will be crucial to ensuring red wolf survival and will aid management decisions in future road issues.

Literature Review

Red Wolves: Past, Present, and Future

Red wolves (*Canis rufus*) were originally described in 1851 by Audubon and Bachman and considered a subspecies of the gray wolf. However, red wolf heritage came under debate in the mid-1900's when Goldman suggested that all of the southeastern wolf subspecies should be combined into the distinct species of *Canis rufus*, separate from gray wolves. Many supported this decision until the advent of genetic methodologies in the 1990's. Genetic studies in the 1990's provided support for the hypothesis that red wolves evolved from a natural hybridization between gray wolves and coyotes (Wayne and Jenks 1991; Wayne 1992; Roy et al. 1994, 1996; Wayne and Gittleman 1995; Wayne et al. 1998; Reich et al. 1999). However, Wilson et al. (2000) suggested that red wolves and Algonquin wolves (*Canis lupus lycaon*) diverged from gray wolves 1.2 million years ago and then diverged from coyotes 150,000 to 300,000 years ago. Work by Hendrick et al. (2000) investigating major histocompatibility complex genetics data indicates that red wolves are more closely related to coyotes than to gray wolves, adding support to the claims made by Wilson et al. (2000).

The current stance that the red wolf is a species in its own right, separate from gray wolves, coyotes, and domestic dogs is based on mtDNA sequencing of 340 base pairs showing a unique sequence for red wolves (Adams, 2002; Adams et al., 2003). However, the debate over red wolf taxonomy is far from over. Both Wilson et al. (2000, 2003) and Kyle et al. (2006, 2007) now suggest that red wolves and Algonquin wolves are genetically similar enough to be combined into one species, the eastern wolf (*Canis lycaon*). In 2007 Murray and Waits, while acknowledging the genetic similarity between red wolves and Algonquin wolves and the plausibility that they are conspecifics, argue that combining the two species would hinder red wolf conservation efforts and the ability to secure conservation funds because red wolf extinction would become an issue of population extinction rather than species extinction. In 2008, Kyle et al. rebutted the article by Murray and Waits stating that taxonomy embracing conservation agendas rather than scientific scrutiny should be avoided. Kyle et al. (2008) go on to say that while they agree with Murray and Waits (2007) that there are instances in which genetically unique populations warrant protection, that the genetic uniqueness of the red wolf population is not supported scientifically. Red wolves and Algonquin wolves are only separated genetically by one mtDNA haplotype differing by one base pair (Wilson et al. (2000, 2003). Kyle et al. (2008) suggest that any difference between red wolves and Algonquin wolves may be an artifact of a low effective population size, a founder effect, a by-product of artificial selection, and/or because of current management strategies that remove individuals that are <80% red wolf from the breeding population (potentially removing important red wolf genes from the population). For now, the taxonomy of red wolves remains under debate.

The historical range of red wolves was originally described as occurring from south central Texas east to Florida and then north to the Ohio River (Nowak, 1979). The historical range was then extended north to Pennsylvania in 1995 (Nowak) and then north again to south central Maine in 2002 (Nowak) in support of the theory that there is one eastern wolf species. Red wolves declined initially with European colonization (USFWS, 2007). Predator control programs and habitat fragmentation in the 1960's dramatically reduced red wolf populations. By the 1970's, red wolves were reduced to remnant populations along the Texas and Louisiana coast. In 1973, the red wolf achieved endangered status with the passing of the Endangered Species Act of 1973. The United States Fish and Wildlife (USFWS) Service worked to capture the remaining wild red wolves between 1974 and 1980 to establish a captive breeding population as a last ditch effort to save the red wolf (USFWS, 2007). The USFWS successfully captured 17 individuals, 14 of which were used as founders for the captive breeding program (USFWS, 2007). As a result of capturing the remaining wild animals, red wolves were declared extinct in the wild in 1980.

Through the establishment of a captive red wolf breeding program with the Association of Zoos and Aquariums (AZA), enough red wolves were bred in captivity to attempt a reintroduction in 1987. The reintroduction began with the release of 4 breeding pairs on the Alligator River National Wildlife Refuge. By 1988, the first pups (2 litters) were born post reintroduction (USFWS, 2007). The USFWS started two additional red wolf reintroduction programs; in 1991 at the Great Smoky Mountains National Park at the Tennessee/North Carolina border and in 1993 at the Pocosin Lakes National Wildlife Refuge in North Carolina just 27 miles west of the original reintroduction site. The reintroduction in the Great Smoky Mountains did not succeed, but the reintroduced populations at Alligator River National Wildlife Refuge and the Pocosin Lakes National Wildlife Refuge continued to expand and merged to form the current, and only, red wolf population in the wild. The current red wolf recovery zone has expanded to 5 counties in North Carolina's Albemarle Peninsula (Dare, Tyrrell, Washington, Beaufort, and Hyde Counties – see current range in Figure 1) and contains between 100 and 130 red wolves forming 20 packs (USFWS, 2007). Red wolves remain listed under the Endangered Species Act of 1973 (USFWS, 2007) and are recognized by IUCN as one of the most endangered canid species in the world (IUCN, 2006). The re-introduced population is designated as non-essential experimental.

The USFWS has a population goal of 220 individuals, yet the population has fluctuated between 100 and 130 individuals over the past 12 years (USFWS, 2007). USFWS biologists with the Red Wolf Recovery team feel that the population can still expand further west allowing population growth to continue. However, non-USFWS researchers on the Red Wolf Implementation Team believe that the red wolf population may have reached carrying capacity within the recovery zone (USFWS, 2007). Models suggest that carrying capacity for red wolves within the current 5 county recovery zone is approximately 138 individuals (Murray, unpublished data). Starting in 2002, to help bolster the wild population, captive-born pups have been fostered to wild parents with similarly aged pups (USFWS). However, a better understanding of habitat requirements is needed to determine the ability of the peninsula to hold more animals.

Management of the red wolf gene pool and genetic fitness are the primary focus of the red wolf recovery and species survival plan due to a low effective population and potential founder effects. Genetic drift and inbreeding depression are of concern with small populations (Caughley, 1994). A study by Kalinowski et al. (1999) reported to find no evidence of inbreeding depression within the captive red wolf population. Long and Waddell (2006) reported that the captive population retained 89.65% of the genetic diversity of the founding captive population. Despite these results, there have been reports of physical anomalies in the captive red wolf population such as progressive retinal atrophy, malocclusion and undescended testicles (USFWS, 2007). Although a study by Miller et al. (2003) showed that only a few individuals per generation were needed to maintain sufficient genetic diversity in a grizzly bear population, further studies are needed to determine if genetic drift and inbreeding depression are impacting the wild red wolf populations.

For now, management of the reintroduced red wolf population focuses on a different genetic problem, the introgression of coyote genetics. Kelly et al. (1999) reported interbreeding between coyotes and red wolves resulting in coyote gene introgression into the wild red wolf population. As a result, an adaptive management plan was developed (Fazio et al., 2005). The plan calls for either the complete removal of coyotes and hybrids or the sterilization of hormonally intact coyotes and hybrids via vasectomy and tubal ligation, depending on the location within the recovery zone. In Zone 1 of the plan, all coyotes and hybrids are removed. In zones 2 and 3, coyotes and hybrids are sterilized and then used as territorial "place-holders" until replaced by wild red wolves. The sterilized coyotes and hybrids cannot interbreed with wild red wolves and they exclude intact coyotes or hybrids from the territory they hold. The idea is that these sterilized animals act as "place-holders" until red wolves replace them either naturally via displacement or through management actions to make room for translocation of a red wolf pair. The effectiveness of the management plan is evaluated via non-invasive genetic monitoring of canid scats (Waits 2004; Waits and Paetkau, 2005; Adams, 2006; Adams and Waits 2007). Through continued genetic monitoring, Adams noted strong evidence that a single hybridization event in 1993 resulted in most introgression of coyote genes into the red wolf population observed to date. From this evidence, Adams (2006) infers that hybridization with coyotes has had less genetic impact on the restored red wolf population than originally thought by Kelly et al. (1999), largely because backcrossing has been rare in the population.

Due to the immediate attention required to address the hybridization of red wolves and coyotes, less is known about red wolf home range, habitat, and diet requirements. Two recent studies examined red wolf home range and habitat use. The first study (Hinton and Chamberlain, 2010) used VHF collars to follow two red wolf packs during summer 2005 (July to September), one with pups and one without pups. This study found that the pack with pups had a smaller average home range size than the pack without pups, 5.74 km^2 vs. 9.55 km^2 for diurnal home range and 8.24 km^2 vs. 9.40 km^2 for nocturnal home ranges, respectively (Hinton and Chamberlain, 2010). Although it is important to note that the larger averaged home range calculated for the non-breeding pack is likely driven

by one male whose home range was 2-3 times larger than any other wolf in the study. Adults in both packs increased home range size nocturnally (1800-0559 hours) and both packs spent approximately 98% of their time in agricultural fields, defined as corn, soybean, and cotton (Hinton and Chamberlain, 2010).

The second study investigating red wolf home range and habitat use employed GPS collars to monitor 4 male wolves from 3 packs over a period ranging from 11 to 18 months (Chadwick et al., 2010). Chadwick et al. (2010) corroborated the finding that red wolf packs primarily utilize agricultural fields during summer and early fall months, with highest use of agricultural fields occurring July through September. However, they noted a seasonal switch to grass/brush and forested habitats during winter and early spring months, November to May (Chadwick et al., 2010). Though results of both studies showed similar summer habitat preferences, the home range size estimates calculated by Chadwick et al. (2010) were several magnitudes larger than those calculated by Hinton and Chamberlain (2010). Home ranges reported in Hinton et al. (2010) ranged from 3.48 km^2 to 12.24 km^2 while those calculated by Chadwick et al. (2010) ranged from 81.6 km^2 to 148.1 km^2. Both studies employed kernel density estimators to estimate home range size. Chadwick et al. (2010) did mention that they found a 40 to 63% reduction in home range size during summer months, but that places their summer home range estimates between 51.4 km^2 and 59.24 km^2, still considerably larger than those estimated by Hinton and Chamberlain (2010).

Though Hinton and Chamberlain (2010) did calculate home range size for both sexes and all age classes, they only collected point locations for a period of 3 months and the number of daily locations varied. Chadwick et al. (2010), while focusing only on nocturnal movements of males, collected point locations over a period of 11 to 18 months and were able to consistently collect 4 locations per day with the use of GPS collars. This suggests that the discrepancy in home range estimates between the two publications may be the result of Hinton and Chamberlain (2010) not collecting enough locations to accurately capture the entire home range size. Until data on all sexes and age classes collected covering the entire 24-hour period and across all seasons is made available, conclusions concerning red wolf home range and habitat requirements cannot be made.

Phillips et al. (2003) reports that the primary prey species of red wolves include: white-tailed deer, raccoon, rabbits, nutria, and other small rodents. A more recent diet assessment via scat analysis lists white-tailed deer as the primary prey item of red wolves (Dellinger et al. in review). However, packs will increase the amount of small rodents and human-sourced foods (e.g. hog pits) in their diet during periods of increased energy demands such as pup rearing (Dellinger et al., in review).

For red wolf management to move forward, the current gaps in knowledge of red wolf natural history need to be filled. Furthermore, before model building to predict the effect of a highway widening through the red wolf recovery zone starts, base knowledge of home range and habitat selection is required.

Road Ecology

Accompanying the rapid expansion of our transportation network was a growing concern over the environmental effects of roadways. The emergence of road ecology, coined by Richard T.T. Forman (1998), as a distinct discipline has brought together scientists from many disciplines (e.g. landscape ecology, wildlife biology, toxicology, hydrology, limnology, etc) and engineers to tackle the ecological challenges posed by transportation systems. For several decades now, researchers have studied the effects of roads on both the abiotic and biotic components of ecosystems. As a result, we now know that roads affect hydrology, air, water, noise, light pollution levels, wind flow, humidity, temperature, vulnerability to invasive species, and habitat continuity (Forman et al., 2003; Coffin, 2007). Such large-scale and multifaceted changes to ecosystems have many detrimental effects on wildlife (Jackson, 1999), including direct mortality (Lalo, 1987; Harris and Scheck, 1991; Schwabe and Schuhmann, 2002), habitat destruction (Theobald et al., 1997; Angelsen and Kaimowitz, 1999), barrier effects (Forman et al, 2003), and increased human land use activities (Bjurlin and Cypher, 2003; Coffin, 2007).

Before road mortality can be effectively mitigated, it is important to understand the factors that influence wildlife-vehicle collisions to occur in the first place. Jaarsma et al. (2006) modeled several road, traffic, vehicle, and species characteristics to find which had the greatest influence on the occurrence of a wildlife vehicle collision event. They found that traffic volume and the animal's traversing speed were the greatest predictors in determining a road mortality event, with higher traffic volumes and slower crossing speeds more likely to lead to a collision (Jaarsma et al., 2006). Two separate studies investigating the relationship among road kill events, body size, and diet found that carnivores were less likely to be hit along a road as compared to herbivores and omnivores (Ford and Fahrig, 2007, Barthelmess and Brooks, 2010). Those same two studies found a peaked relationship between road mortality and body size, with small (<1 kg) and large (>10 kg) body animals less like to be killed by vehicles as compared to medium (1 – 10 kg) sized animals (Ford and Fahrig, 2007, Barthelmess and Brooks, 2010). All three of the above cited articles suggest that direct mortality resulting from roads may not have a significant negative impact on carnivore populations as many carnivores are faster moving and larger bodied.

However, a study in southern Texas that looked at the influence of habitat variables on the location of bobcat road mortality events found that suitable habitat adjacent to the highway best explained the location of mortality events (Cain et al., 2003). These results were corroborated by another bobcat study in southern Illinois (Kolowski and Nielsen, 2008). Likewise, red wolves in northeastern North Carolina cross highways at locations adjacent to preferred habitat and established home ranges (Proctor, unpublished data). These results are similar to studies evaluating the use and success of highway crossing structures. The most successful wildlife crossing structures are the ones that connect preferred habitats of the targeted species (Ng et al. 2003, White and Ernst 2004, Singleton et al., 2005, Kindall and van Manen, 2007).

When vehicle strikes do occur, they account for a low percentage of mortality in

carnivores and do not translate into population level effects. Even for endangered San Joaquin kit foxes, road mortality rarely accounted for over 10% of mortality, with predators accounting for most mortality events (Bjurlin and Cypher, 2003). In a 3-year study that followed 60 radio collared kit foxes that lived in close proximity to a 2-lane paved highway, only one was lost to a vehicle strike (Cypher et al. 2009). However, prior to mitigation efforts, road mortalities did account for 49% of mortality in Florida panthers (Maehr et al., 1991). The carnivore populations with the highest reports of road kill events in the United States are black bears. In Virginia, black bears and white-tailed deer account for the most frequently recorded road kill events (Donaldson, 2007). Two studies in Florida found increased road mortality of black bears in areas of higher road density (Hostetler et al., 2009, McCown et al., 2009). These results differ from studies focusing on other carnivore populations where an increase in road density lead to increased road avoidance rather than increased mortality events (Dickson et al. 2005, Chetkiewicz and Boyce 2009). However, the studies by Ford and Fahrig (2007) and Barthelmess and Brooks (2010) did find that omnivores are more likely to be stuck by vehicles as compared to carnivores. Although black bears are classified as carnivores, their diet is omnivorous.

A barrier effect blocking access to resources, dispersal, and gene flow is the greatest impact of highways and roads on carnivore population in the United State. A study in southern California found that while cougars often made use of dirt roads, they actively avoided paved roads (Dickson et al., 2005). Similar results were found in another study with cougars negatively associated with roads, particularly during winter months (Chetkiewicz and Boyce, 2009). Riley et al. (2006) found that coyote and bobcat populations in southern California separated by a major freeway exhibited genetic differentiation, suggesting that the freeway is a barrier to dispersal. For those that do cross, heightened territorial behavior along roadways can discourage reproductive success, again limiting gene flow (Riley et al., 2006). Likewise, a study found that a highway in southern Canada is acting as a dispersal barrier for grizzly bears at the US-Canada border, as evidenced through genetic differentiation between the two populations (Proctor et al., 2005). The result is the creation of two vulnerably small populations (Proctor et al., 2005). A highway was found to restrict gene flow in a Cleveland, Ohio coyote population and direct the movements of migrants towards urbanizing centers (Rashleigh et al., 2008). Even when they do not constitute an absolute physical barrier, high-use roads can lead to avoidance behavior in canids affecting their ability to move across a landscape (Kaartinen et al., 2005, Whittington et al., 2004). The degree to which a road impacts canid survival is dependent on the specific situation, and sometimes no detrimental effects are observed, as in the case with San Joaquin kit foxes (Cypher et al., 2009).

The amount to which a road constitutes a movement barrier for black bears is dependent of the level of traffic volume (McCown et al., 2009). A study documenting the movements of two black bear populations along the same highway in Florida found that the population living in the area with lower traffic volume crossed the highway more often (McCown et al., 2009). In Maryland, black bears avoided the larger primary highways, but readily crossed all other road classes (Fecske et al., 2002). In the northern

Rockies, just under 50% of collared black bears were willing to cross a highway at least once were (Lewis et al. 2011). A study in North Carolina found that site occupancy of black bears deceased from 0.81 to 0.35 a highway in the study area was widened from 2-lanes to 4-lanes (Nicholson and van Manen 2009). For black bears, roads appear to exhibit the distinct trade-off between permeability and road kill discussed by Forman and Alexander (1998).

Though the last 10 years has documented many adverse effects of highways and roads on carnivore populations, there have been positive developments as well. Highway crossing structures have been successful at mitigating some negative impacts of highways on carnivore populations. In Texas, bobcats did make use of culverts to cross a highway when the culverts were placed adjacent to suitable habitat (Cain et al., 2003). A study in California found that a large variety of species, including reptiles, small mammals, carnivores, and mule deer use highway underpasses, even underpasses not designed specifically for wildlife (Ng et al., 2004). A study investigating wide variety of structures, including culverts, modified box-culverts, underpasses, and overpasses, found that culverts were the least used preferences between underpasses and overpasses varied with species (Mata et al., 2008). A study in Portugal found that red foxes, badgers, genet, and Egyptian mongooses used underpasses and culverts without preference (Grilo et al., 2008). However, a study of wildlife underpasses in Virginia revealed that while they were effective for foxes and coyotes, they did not find evidence of black bears utilizing highway underpasses (Donaldson, 2007). Likewise, a study monitoring the success of multi-species highway underpasses following a highway-widening project found that bobcats, black bears, and foxes utilized underpasses, but not coyotes or red wolves present in the area (McCollister and van Manen, 2010).

In all documented success of highway crossing structures, the authors noted that the successful structures connected areas of suitable habitat for the target species. The non-detection of all area carnivore species in the multi-species crossing structures may be the result of not being located in an area that contains suitable habitat for all species. Though multi-species structures may be may appear to be more cost effective initially, a lower success rate will decrease the cost effectiveness in the long run.

While the subjects above have gotten considerable coverage in the peer-reviewed literature, relatively little research has been directed at determining the placement of highway underpasses. In may be beneficial to focus future research efforts on determining the effective placement of highway crossing

Of the studies that focused on placing mitigating structures, methodologies have varied widely and range from non-invasive to the capture and handling of target species. Non-invasive techniques include the use of track/trail counts (Van Dyke et al., 1986; Rodriguez et al., 1996; Alexander and Waters, 1999; Scheick and Jones, 1999, 2000; Barnum, 2001, 2003), remote cameras (Scheick and Jones, 1999, 2000), barbed wire hair traps (Wills and Vaughan, 2005), road kill surveys (Clevenger et al., 2003b; Mazerolle, 2004; Smith et al., 2009), and GIS based modeling (Smith et al. 1998; Klein, 1999; Kobler and Adamic, 1999; Sheick and Jones, 1999, 2000; Clevenger et al., 2003a; Lloyd

et al., 2005). Non-invasive techniques are relatively inexpensive and can be effective, however all are time intensive. A constraint of track counts is the requirement of an appropriate substrate, the use of sand, or, in some areas, the presence of fresh snow. Remote camera traps provide crossing location, date, time, and work for a wide variety of species. Yet, cameras cannot cover the entire length of the highway simultaneously. Running barbed wire the length of the study area provides crossing location and, with the addition of genetics, crossing frequency on the level of the individual. Drawbacks of using barbed wire include the added cost of genetics and the limited number of mammals this technique is appropriate for. Road-kill surveys to detect crossing hotspots are an excellent method for collecting data on a wide range of species simultaneously. However rate of decay, scavenger activity, and method of survey (driving vs. walking) can affect results and must be considered in planning survey interval times. Road kill surveys may also miss animals that wander away from the collision site before dying. It has also been suggested that while road kill events do represent failed attempts to cross, they do not necessarily indicate important linkage areas. The primary weaknesses of the GIS-based techniques are data availability and data quality. GIS models are most effective when data on habitat use patterns of the subject species are well known and where the habitat is diverse and heterogeneous. A limitation of non-invasive techniques as a whole, with the exception of GIS based models, is inherent bias unless the entire length of the proposed highway construction project is covered. Many of the studies cited here established transects or plots rather than surveying the entire study area, thus missing crossing activity at sites not surveyed.

The more invasive techniques involve capturing and collaring target species in order to track movements. These techniques are especially useful when the study is focused on a particular species as opposed to a generalized group. A few studies employed the use of VHF radio collars to identify road-crossing locations and the influence of highways on animal movements (Beringer et al., 1990; Chruszcz et al., 2003; Riley et al., 2003; Dickson et al., 2005; Wray et al., 2005). Though radio telemetry is a more affordable method of telemetry, it is time intensive and often long time intervals exist between locations. Low-resolution movement data may inaccurately depict crossing sites, or miss crossings altogether. In addition, accessibility to collared animals can be limited due to terrain, road condition, and/or private property. GPS telemetry, though more expensive, allows the tracking of animal movements via satellite and reduces accessibility issues. In addition, GPS collars can be programmed to collect data in short time intervals, improving resolution. High-resolution movement data is essential for pinpointing road-crossing locations. Though GPS collars may cost more up front, they provide more accurate locations, and save money by reducing man and vehicle hours required for data collection (Rodgers et al. 1996, Mech and Barber 2002). GPS collars have successfully been used to identify road-crossings for many large mammals such as grizzly bears (Waller and Servheen, 1999, 2005), black bears (McCoy, 2005), and elk (Dodd et al., 2007).

All of the techniques described above identify cross-locations for the placement of mitigating structures, but do not measure the extent to which a road is acting as a barrier. Most studies use genetic sampling to measure whether or not a road is acting as a barrier

to gene flow in a population (Gerlach and Musolf, 2000; Epps et al., 2005; Riley et al., 2006). However, in 2007, Dodd et al. proposed the use of a permeability index to measure the barrier effect of a highway. A permeability index is a passage rate calculated by using the following equation: #crossings/(#crossings + #approaches, where an approach is defined as a red wolf entering into a 164 ft. buffer zone around the highway without crossing (see Figure 2). So far, this methodology has only been used on ungulates with seasonal migration patterns and not on species that remain in smaller defended territories.

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379.



WHAT IS A SPECIES?

An assessment of the red wolf (*Canis rufus*)

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"SPECIES" UNDER THE ESA

FWS Policy

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WHAT IS A SPECIES?

ESA Definition:

The term "species" includes any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature.

- Term is used in a legal sense to refer to any of those entities (NRC 1995, p. 46)

As such, a "species under the Act may include any:

- Taxonomically defined species of fish, wildlife, or plant;
- Any taxonomically defined subspecies of fish, wildlife, or plant;
- Or any DPS of any vertebrate species as determined by us per our Policy Regarding the Recognition of Distinct Vertebrate Population Segments (61 FR 4721; February 7, 1996). (coastal CA gnatcatcher; 81 FR 59957 (2016))

50 CFR 424.11

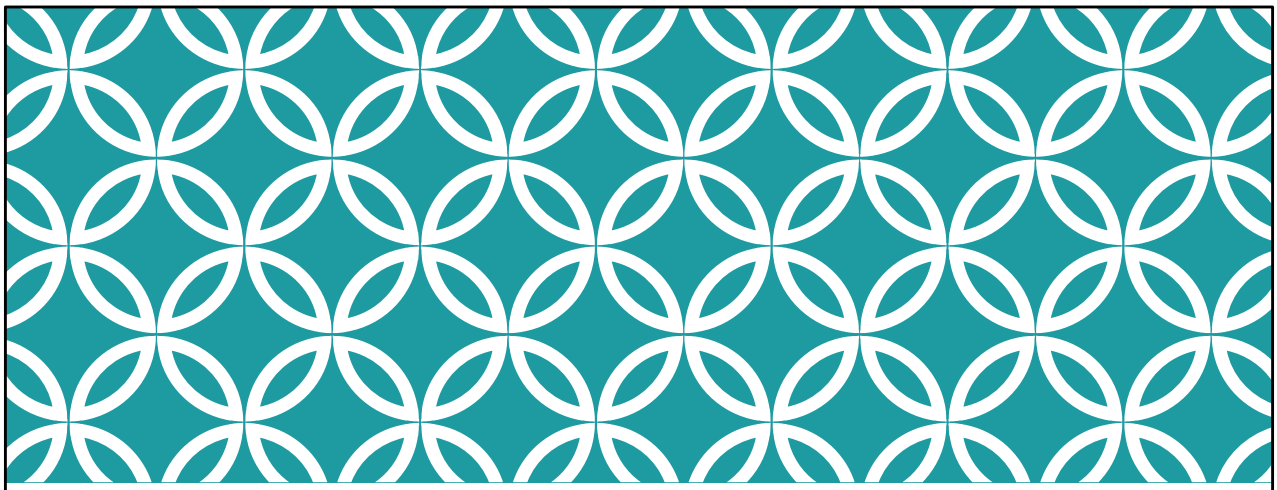
- The Secretary shall rely on standard taxonomic distinctions and the biological expertise of the Department and the scientific community concerning the relevant taxonomic group.

Director's Memo Taxonomy and the Endangered Species Act (Nov. 25, 1992)

- Service is required to exercise a degree of scientific judgement regarding the acceptance of taxonomic interpretations, particularly when more than one possible interpretation is available
- When informed taxonomic opinion is not unanimous, we evaluate available published and unpublished information and come to our own adequately documented conclusion regarding the validity of taxa.

Species is not actually defined under the ESA…except to clarify that the term (a legal term) "species" **includes** a subspecies…and DPS.
In the coastal CA gnatcatcher, the Service goes on to clarify that a species may include any taxonomically defined species or subspecies of fish, wildlife, or plant or DPS.
So, what is a taxonomically defined species? Leaves open for interpretation –
Continues to be an evolving science
Regulations state that we shall rely on … [regulations]. This sounds like we shall, as with other decisions, use and rely on the best information available, experts, etc.

This lead to research on what the scientific community is using to determine a species.



"SPECIES" IN THE LITERATURE

Species Concepts

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"SPECIES" IN THE LITERATURE

At least 22 species concepts – See Handout

- Historically, moderate to strong support for BSC among mammologists (Mayr 1942 in Baker and Bradley 2006, p. 644)
- Before 1985, and the onset of DNA data sets, most descriptions of mammal museum species were based on morphological analyses (Baker and Bradley 2006, p. 644).
  - Morphological characters are the traditional character base for species identifications (Mayden 1999, p. 108).
  - Examination of listing docs…morphological features overwhelmingly used for differentiation of taxa (NRC 1995, p. 48)
- Recent trend in *Journal of Mammology* toward use of PSC (Baker and Bradley 2006, p. 644).
- Most catalogues/checklists (e.g., Wilson and Reeder 1993, 2005) are not constructed under a single concept (Baker and Bradley 2006, p. 644)

Using best available information, relying on the scientific community…History of dominant species concepts
Since Darwin, there have been at least 22 species concepts presented (Mayden 1999, p. 100). Each focuses on a particular trait that is important to a particular taxon or field of study.

Over the years, a particular concept has been favored in identifying species.
May reflect the level of knowledge/growing knowledge on biota. E.g., use of morphological features may have been used because there was no other information available for most animals (NRC 1995, p. 48)

Although listing docs mainly used morphological features, in more conspicuous or commercially valuable species, other factors, like breeding time or genetic analyses were used (NRC 1995, p. 48)

Problems with BSC: First, mating between species (hybridization), as often occurs in the canine family, is quite common in nature. Second, in some instances, the differences between two populations might not prevent them from interbreeding, even though they are rather dissimilar in traits unrelated to reproduction; one might

question whether such disparate groups should be considered a single species. A third problem with the biological species concept is that investigators cannot always determine whether two groups that live in different places are capable of interbreeding (Wayne and Gittleman 1995, p. 3).

If BSC difficult to apply, some investigators use phenotype as a surrogate – two groups that have evolved separately are likely to display measurable differences in their traits (Wayne and Gittleman 1995, p. 3).

THE SPECIES PROBLEM

- Biologists in different fields have different ideas about what a species is (Naomi 2011, p. 177; de Queiroz 2007, p. 56; Mayden 1997, p. 389; NRC 1995, p. 51)
- Concepts are incompatible, at least partially (de Queirzo 2007, pp. 879, 880)
  - Lead to different/inaccurate conclusions on boundaries and numbers of species
    - Biological species concept vs. phylogenetic species
  - Likely lead to extinction of lineage that should have been recognized (Naomi 2011, p. 177).
- A concept that can accommodate the diversity of life is the "Holy Grail" of natural science (Mayden 199, p. 95).
  - So much is dependent on our ability to discover and study naturally occurring entitles
- All seem to have merits as they are all based on important biological properties (de Queirzo 2007, p. 880).
- The "species problem" is not a scientific problem at all, merely one about choosing and consistently applying a convention about how we use a word." (In Baker and Bradly (2006, p. 648) Brookfield 2007, cited in Coyne and Orr 2004).

Why so many concepts?
Emphasis on different properties due to greatest interests to different subgroups; concepts developed by researchers to suit individual needs or peculiarities of the particular organism being studied; concepts dependent on expertise and type of organism.

reproductive incompatibilities are of central importance to biologists who study hybrid zones

niche differences are important for ecologists

monophyly and diagnosability are fundamental for systematists (dQ 207, p. 880).

Morphological differences are central for paleontologists and museum taxonomists

Genetics are key for geneticists (deQ 2007, p. 880)

BSC leads to recognition of fewer species than, for example, the PSC

"The essence of the "species" problem is the fact that, while many different authorities have very different ideas of what species are, there is not set of experiments or observations that can be imagined that can resolve which of these views is the right one.

IS THERE A RESOLUTION?

- 2 integrated frameworks have been proposed
  - Hierarchy of species concepts (Mayden 1997)
  - Unified species concept (de Quierzo 1998, 1999, 2005, 2007)
- Essentially the same - share same major components and important consequences
- Same two major components:
  - 1) a concept for species category: evolutionary (or lineage) concept of species, and
  - 2) multiple operational criteria for species delimitation or the contingent biological properties to serve to diagnose said lineages (Naomi 2011, p. 180).
- Same consequences
  - 1) all evolutionary lineages are species;
  - 2) issue of species delimitation is clearly separable from the issue of species conceptualization;
  - 3) all of the biological contingent properties (secondary concepts) are relevant to the issue of species delimitation (Naomi 2011, p. 180).

Add in Avise and Ball (1990) and Avise (2004) proposed as integration of concepts from the BSC and PSC into "concordance principles". This approach accepts intrinsic reproductive barriers as basic to species recognition, but incorporates "evidence of concordant phylogenetic partitions at multiple independent genetic attributes (Champber et al. 2012, p. 5).

Chamber et al. (2012, p. 5) uses an integrative approach and one that encompasses the concordance principles of Avise and Ball (1990). Id's species as separate lineages supported by concordant data from various classes of genetic markers, morphometric analysis, behavior, and ecology.

IS THERE A RESOLUTION? (CONTINUED)

How are they different?

- De Queiroz's concept considers species can be nested within other species.
  - applied to some particular situations involving incomplete or partial lineage separation
  - cases of introgressive hybridization (Naomi 2011, p. 180).
- Mayden's approach rejects this idea as clear evidence of demonstrated lineage independence (Naomi 2011, p. 180).

Criticisms

- Naomi (2011) provided criticisms of both; however, those criticisms were not fatal flaws.
  - Proposed a revised version of these integrated frameworks

Criticism of Mayden: Only shortcoming is the adoption of the secondary species concepts as operational criteria for species delimitation (Naomi 2011, p. 181). However, this may not be a critical mistake as those secondary concepts include components for species delimitation and thus serve under the primary evolutionary concept as the working operational tools in delimiting species (Naomi 2011, p. 180).

Criticism of de Queiroz: Shortcoming is concerned with his newly proposed terminology for a new species concept (Naomi 2011, p. 181).
De Queiroz claims all modern species concepts share the common idea of a general lineage, but he characterizes the modern species concepts of species as not being different at base.
Modern species concepts make important different ontological (relations) claims. E.g., BSC does not permit asexual organisms as species (Naomi 2011, p. 178).
Therefore, de Queiroz mischaracterize disagreements among proponents of the various modern species concepts (Naomi 2011, p. 178).

REVISED INTEGRATED FRAMEWORK OF SPECIES CONCEPTS

- Concept for species category: Wiley's version (1978) of ESC
- The contingent biological properties of species are adopted as operational criteria in delimiting species.
  - Properties defining various species concepts are no longer defining/necessary
  - Considered contingent properties: properties that species may or may not acquire during the course of their existence (De Queiroz 2007, pp. 882, 883).
  - Important operational lines of evidence relevant to assessing the separation of lineages.
  - Evidence of lineage separation and divergence.

E.g., morphological, phylogenetic, genetic, ecological, etc. differences

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ANOTHER APPROACH…

- Used by Chambers et al. (2012); a paper relied on by Service to make taxonomic call on gray wolves (78 FR 35664 (2013)).

- Uses an integrated approach that also encompasses the concordance principles of Avise and Ball (1990)
  - Identifies species as separate lineages supported by concordant data from various classes of genetic markers, morphometric analysis, behavior, and ecology (Chamber et al. 2012, p. 5).
  - Appropriate for North American *Canis* because populations are and have been in contact with one another and there is considerable genetic information bearing on reproductive relationships
  - At the same time there is extensive data from genetic lineage markers that provide phylogenetic info
    - needed to understand evolutionary history, ancestral condition, and taxonomic relationships

Various classes of relevant data (morphometrics, various genetic marker systems, ecological and behavioral attributes) each have somewhat different applications in assessing lineage separation and species delimitation. The taxonomy of North American Canis up to and including Goldman's 1944 monograph was based on morphological characters based on single specimens or means and ranges of character measurements of series of specimens, most commonly skulls (Chamber et al. 2002, p. 5).

According to Avise and Ball (1990), concordance among genetically independent attributes should be a deciding criterioin upon which to base formal taxonomic recognition of subspecies

TAXONOMICALLY DEFINED SPECIES IN SERVICE DOCS

Species Examples

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2011 DUSKY/RED TREE VOLE (76 FR 63726)

- There is no universally accepted definition of what constitutes a subspecies, and the use of the term may vary among taxonomic groups (Haig et al. 2006).
- To be operationally useful, ssp must be discernable (i.e. diagnosable), not merely exhibit mean differences (Patten and Unit 2002, pp. 28, 34).
  - Diagnosable = ability to consistently distinguish between populations.
- Important to use multiple sources of info
  - The greater the concurrence among multiple characteristics, the higher the level of confidence in classification (Haig et al. 2006, p. 15911).
- Evaluated all available data to determine whether evidence points to consistent separation.
  - If assessment provides clear and consistent separation such that any individual is likely to be correctly assigned based on the suite of characteristics evaluated, that evidence would be considered indicative of a likely valid ssp.
- Found that the dusky tree vole is NOT a valid subspecies
  - Although 3 distinct genetic entities (mtDNA), no other differences in characteristics or differences were too subtle to be of use or differences explained by latitude.

Service evaluated available information under geography, blood proteins, genetics, morphology, and behavior.

Summary of finding
Although one study failed to find genetic differences, a later study found 3 distinct genetic entities in mtDNA. Follow-up with authors led to their statement that the difference was sufficient to potentially support a ssp recognition IF there were congruent differences in other characteristics. No sufficient evidence to indicate dusky tree vole is a distinct ssp. There were some behavioral (diet) differences, but characteristic was only a portion of the range of the putative ssp. Some morphological (coat color and morphometric features) differences, but these could be explained by latitude and they were too subtle to be readily used (statistically significant difference).

2013 PREBLE'S MEADOW JUMPING MOUSE
(78 FR 31680)

- Much like the red wolf, there were conflicting studies on validity of PMJM as a valid ssp.
- Made determination on the basis of the best scientific and commercial info available
  - Available data suggest the PMJM meets or exceeds numerous, widely accepted ssp definitions.
- Considered: morphology, ecological exchangeability, mtDNA, microsatellite DNA
- Found to be a valid ssp based on microsatellite DNA and mtDNA
  - While microsatellite DNA is not a strong case on its own, in concert with mtDNA findings, the 2 datasets corroborated the distinctness of PMJM.

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2016 COASTAL CA GNATCATCHER

(81 FR 59957)

- Given the wide range of taxa and the multitude of situations and types of data that apply to species under review, the application of a single set of criteria that would be applicable to all taxa is not practical or useful
- Because of the wide variation in kinds of available data for a given circumstance, we do not assign a priority or weight to any particular type of data, but must consider it in the context of all the available data for a given species
- For purposes of being able to determine what is a listable entity under the Act, we must necessarily follow a more operational approach and evaluate and consider all available types of data that may inform the taxonomy of the coastal CA gnatcatcher, such as ecology, morphology, genetics, and behavior
- Confirmed that CCG is a valid ssp.
  - Multi-evidence criteria involving multiple lines of genetic, morphological, and ecological scientific data used to support recognition of CCG as distinguishable ssp.

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2017 HUALAPAI MEXICAN VOLE
(82 FR 28582)

- There is no universally agreed-upon approach for delineating, defining, or diagnosing ssp boundaries
  - Each possible subspecies has been subject to unique evolutionary forces, different methods of selection will act on each subspecies, and the potential divergence time will, therefore, lead to different signals, particularly genetically.
  - As such, the methods for detecting each will be different (came from CCG finding)
- Used same approach as coastal CA gnatcatcher (see previous slide)
- Mainly relied on genetics information
  - Best available information presented conflicting information
  - Trapping success in conjunction with genetic studies demonstrated that HMxV populations are widespread and not restricted to a single mountain range, as original listing indicated.

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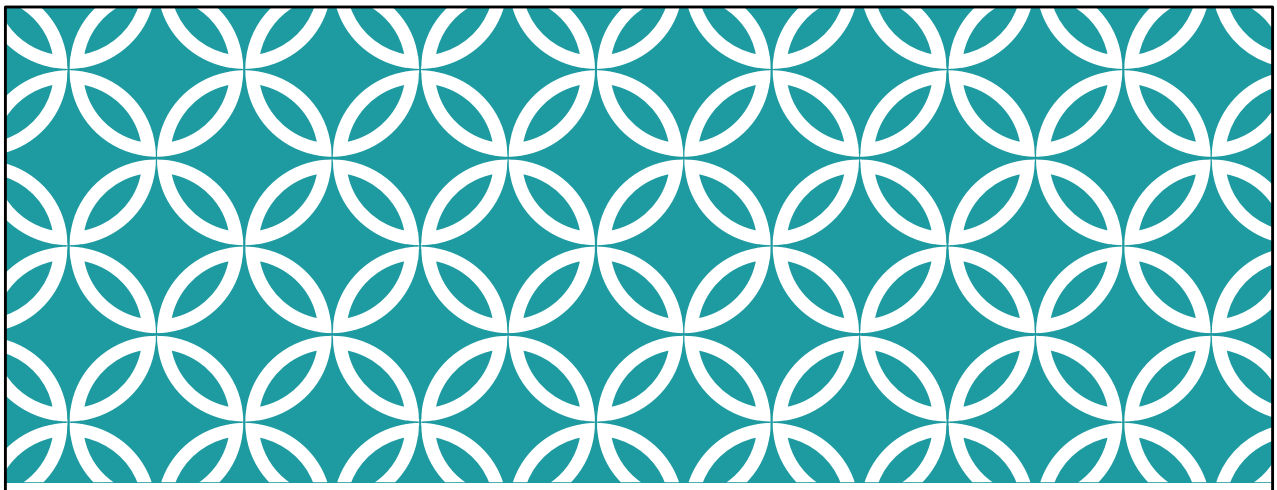
Indicates FWS has a lot of discretion on what to consider

- Various analyses and reviews present multiple interpretations of taxonomy and distribution

- Although reviews of published and unpublished reports have inconsistent conclusions because of differences in data sets and genetic analyses, FWS and each peer reviewer agreed that the currently listed entity is no longer a valid taxonomic ssp.

Interesting in that with this one, FWS did not make a determination on what the HMxV really is…only that the different interpretations didn't match up to the original listing (1 pop).

5/7 reviewers of Busch et al. 2001 found HMxV NOT distinct from other vole ssp.



SUMMARY

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ESA and FWS Regulations and Policy

Definition of a species

- ESA doesn't define "species" in a taxonomic sense – it's a legal term
  - As such, a "species" under the Act may include any:
    - Taxonomically defined species of fish, wildlife, or plant;
    - Any taxonomically defined subspecies of fish, wildlife, or plant;
    - Or any DPS of any vertebrate species
- 50 CFR 424.11
  - Shall rely on standard taxonomic distinctions and the biological expertise of the Department and the scientific community

Determining species status

- Director's Memo
  - Required to exercise a degree of scientific judgement regarding the acceptance of taxonomic interpretations, particularly when more than one possible interpretation is available
  - When taxonomic opinion is not unanimous, we evaluate available published and unpublished information and come to our own adequately documented conclusion

= Use Best Available Information

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"Species" in the Literature

- 22 Species Concepts
  - Each concentrates on a different biological property
  - Leads to conflicting determinations
- The problem is about choosing and consistently applying a convention about how we use a word.

- Integrated frameworks attempt to address the "species problem"
  - 3 versions – essentially the same
    - Mayden 1997
    - De Quierzo (1998, 1999, 2005, 2007)
    - Naomi 2011

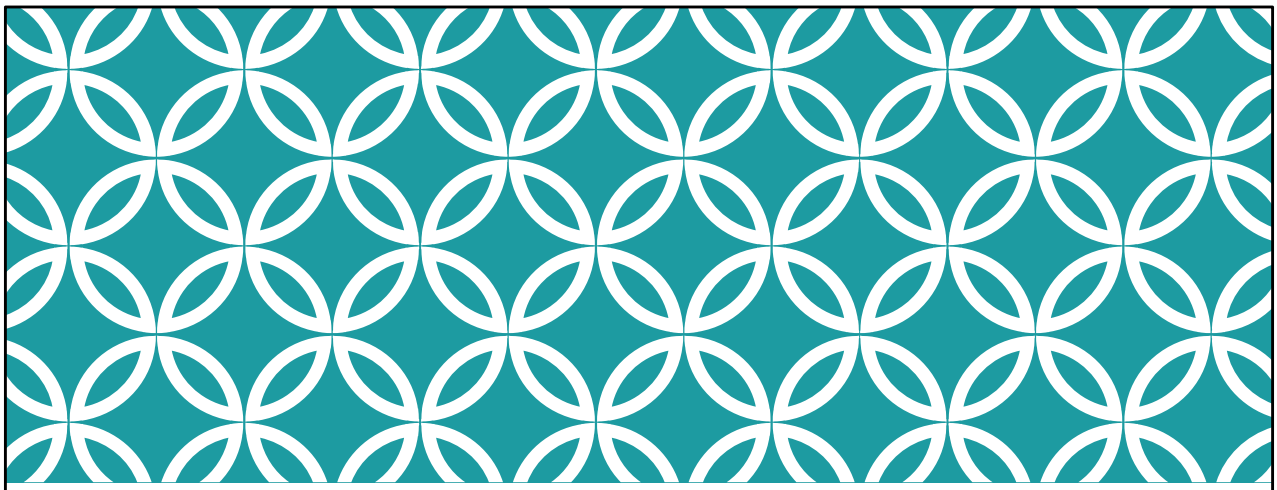
- Revised Integrated Framework (Naomi 2011)
  - Concept for species category: Wiley's version (1978) of ESC
  - The contingent biological properties of species are adopted as operational criteria in delimiting species.
  - Important operational lines of evidence relevant to assessing the separation of lineages and divergence.
  - E.g., morphological, phylogenetic, genetic, ecological, etc. differences

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Examples from Service Docs

- Have followed our Regulations and Director's Memo
  - Best available information
- They do NOT reference Mayden, de Quierzo, or Naomi
  - Nor do they mention any species concepts
  - No universally excepted definition*
  - Examples have been subspecies determinations
- They DO state the importance of using multiple lines of evidence/types of data
  - Determinations are made on the entity being distinct, distinguishable, diagnosable, separate

- In the CCG, the did refer to the ornithological union for criteria on subspecies.
- Note that at least some of these examples used scientific panels to review information.



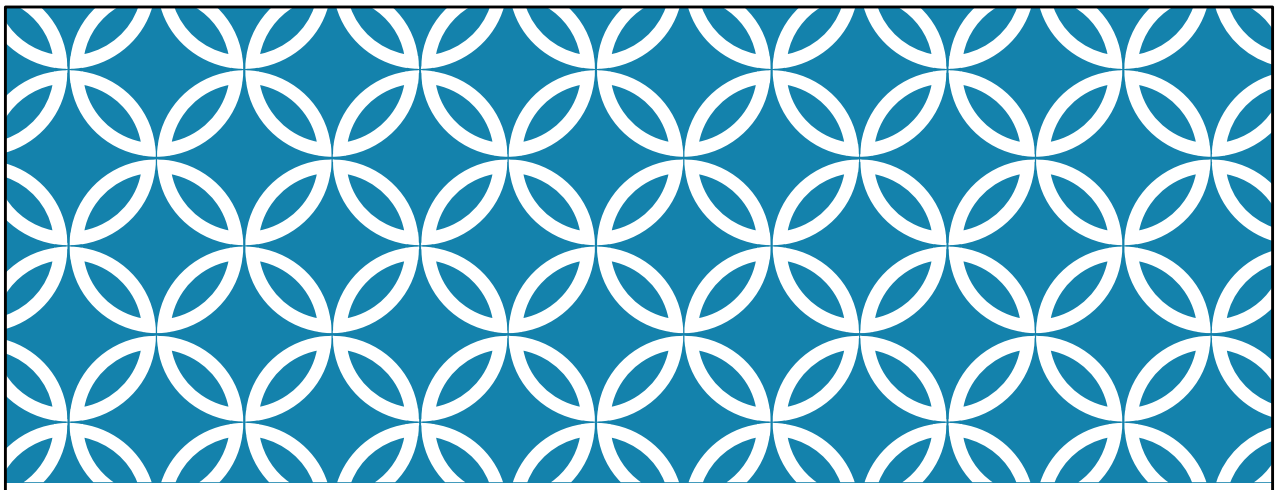
DOES THE RED WOLF FIT UNDER THE ESA DEFINITION OF A "SPECIES"?

Discussion on what criteria to use

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Step-by-step discussion given:

1) The definition of "species" under the ESA
2) Definition of species in the literature
3) Approaches used by the Service in previous findings/rules
4) Referring to the expertise of the Dept. and scientific community
5) Using best available information



TYPES OF EVIDENCE USED TO DIAGNOSE A SPECIES/SUBSPECIES

Summaries of Various Studies

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MORPHOLOGY

Red wolf is a distinct species:

- Red wolf consistently found to be distinct/distinguishable from coyote and gray wolf (an intermediate position) (see notes for citations)
  - Nearer to gray wolf (Paradiso and Nowak 1972, p.2; Nowak 1979, p. 26), but resembles coyote more (Paradiso and Nowak 1971, p. 8).
  - Separation even where ranges overlap (red wolf and coyote; Paradiso and Nowak 1971, p. 10)
- Red wolf hybrids form distinct clusters (Nowak 1995, pp. 3-4).
- Body-size measurements of red wolves and coyotes are distinct – consistent with Nowak (1979, 2002) (Hinton et al. 2014, pp. 857, 858, 859).
  - Able to distinguish red wolves, coyotes, and hybrids (Hinton et al. 2014, p. 859).
- Complete lack of morphological intergradation where two populations approach without physical barriers argues for specific distinction (Nowak 1995b, p. 394 referring to red wolf and gray wolf).
  - Significant morphometric differences most likely a result from true phylogenetic distinction (Nowak 2002, p. 99).
  - In animals as large and as mobile as wolves, it would be rather surprising to have such a substantial shift in characters over so small a distance with no geographic barrier if only 1 species were involved (Paradiso and Nowak 1971, p. 7).
- Red wolf and gray wolf-coyote hybrid may overlap if the sample is large enough, but they do not have identical characteristics (Nowak 1995, pp. 3-4)
  - F1 and F2 hybrids incapable of reaching body sizes of adult red wolves (Hinton et al. 2014, p. 859).

(1) (Atkins and Dillon 1971; Nowak 1979, pp. 26, 28, 31-32; Paradiso and Nowak 1971, pp. 7, 8; Paradiso and Nowak 1972, p. 21972; Gipson, Sealander, and Dunn 1974; Freeman 1976, and Elder and Hayden 1977; Nowak 1992, p. 594; Nowak 1995b, pp. 388, 389; Nowak 2002, p. 118)

MORPHOLOGY

Red wolf is a gray wolf-coyote hybrid:

- Intermediate position used to argue that red wolf is essentially the same as hybrid

(Wayne and Jenks 1992; Nowak 1995, pp. 2-3; Wayne 1995, p. 7; Wayne and Gittleman1995, p 4).

- McCarley (1962, pp. 233, 234) proposed C*anis niger rufus* was not a valid taxon, but represented the result of a natural hybridization between C*anis latrans* and C*anis niger gregoryi*
  - Possibility supported by Young and Goldman (1944) and Young and Jackson (1951) (p. 233).

Red wolf is a gray wolf subspecies:

- If the study of small wolves in southern states had begun with *niger* in FL, and been based on adequate series, it is highly unlikely that *niger* ever would have been separated as a species from *lupus* (Lawrence and Bossert 1967, p. 228).

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MORPHOLOGY

Advantages/Disadvantages/Reliability of Morphology?

- Results seem to be consistent, it's the interpretation of those results that are different
- Efforts to use morphological criteria as a basis to classify red wolf as a distinct species are problematic. (Wayne 1995, p. 7).
  - Quantitative differences alone to define species status is controversial (p. 7 – other citations).
  - Phenotypic argument may be circular because hybrids between gray wolves and coyotes are expected to be intermediate in morphology; thus the phenotype of red wolf may reflect either:
    - Recent hybridization between gray wolf and coyotes in southeast, or
    - Ancient origin and long distinct evolutionary heritage (p. 7)

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PHENOTYPE

- *If BSC difficult to apply, phenotype may be used as a surrogate.*
  - *Two groups that have evolved separately are likely to display measurable differences in their traits* (Wayne and Gittleman 1995, p. 3).
- Most accounts of external characteristics of red wolf give the impression that it closely resembles the coyote except in size and color variations; however there are certain definite characteristics which can be readily distinguished in the field (Riley and McBride 1972, pp. 3, 12, 14; Phillips and Henry 1992, p. 597).
  - Disproportionately long legs
  - large ears
  - Coloration
  - Weight
- Same phenotype not found in other hybrid zones (MN and Canada), indicating unique environmental and genetic conditions required (Wayne and Jenks 1991, p. 568).

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If Biological Species Concept difficult to apply, phenotype may be used as a surrogate. Two groups that have evolved separately are likely to display measurable differences in their traits (Wayne and Gittleman 1995, p. 3).



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GENETICS

Ancient Hybrid Theory (Pre-Columbian Hypothesis)

- Wayne and Jenks (1991, p. 566) proposed the red wolf is a coyote-gray wolf hybrid based on red wolf genotypes falling within both coyote and gray wolf genotypes.
- A component of the phenotypic distinction of red wolves may be attributed to historic hybridization of distinct populations of gray wolves and coyotes (von Holdt 2011, p. 8).
  - Show that red wolves and GL wolves have a DISTINCT but admixed evolutionary history (p. 9).
  - Supports admixed or ancient origin hypothesis (von Holdt et al. 2016, p. 1).
- Hohenlohe et al. (2016, p. 1) agree with von Holdt et al. (2016) that the genetic data support admixture as part of the evolutionary history of NA canids; however, they argue that the data is consistent with multiple evolutionary hypotheses, including ancient hybridization (p. 2), but do not support a recent origin by hybridization.
  - The degree of differentiation calculated by von Holdt et al. (2016) is also consistent with an interpretation of red wolves as a distinct evolutionary lineage (p. 2).
- Convincing demonstration that extensive hybridization occurred among North American Canis in the Pleistocene (Leonard et al 2008, Koblmüller et al 2009, Rutledge et al 2010a, Sefc & Koblmüller 2016) suggests that much of the eastern wolf introgression observed in modern coyotes may be due to natural consequences of range contraction and expansion associated with glacial cycling (Hailer et al 2012) (Fain 201, pers comm).

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Red wolf falls within coyote clade

GENETICS

Recent Hybrid Theory (European Settlement to Present)

- Lack of discernable red wolf genotype may be due to three centuries of human settlement gave rise to gray wolf-coyote zone at least as large as red wolf range (Wayne and Jenks 1991, p. X; Wayne 1995, p. 9).
- Roy et al. (1994, p. 565) hypothesize that the red wolf phenotype may represent a phenotype resulting from several-hundred-year period of hybridization between coyote and gray wolf in south-central U.S., which began with arrival of settlers circa 1700.
- Reich et al. (1999, p. 143), based on microsatellite allele length distributions estimate that hybridization originated less than 12,800 years ago, likely within 2,500 years ago – lends support to the hypothesis of a recent hybridization between coyotes and gray wolves associated with extensive agricultural cultivation by European settlers around 250 years ago.
- Von Holdt et al. (2011, pp. 8, 9) found that red wolves appear to have a distinct admixed ancestry with 75-80% of their genomes attributed to coyotes and the remainder to gray wolves
  - Von Holdt et al. (2011, p. 8) estimate admixture initiated 144 generations (287-430 years ago), placing it approximately in a period when the Southeast U.S. was being converted and predators were intensely hunted.
- The authors also state that even if red wolf is entirely a hybrid, it filled a role as a top predator throughout its geographical range and was an integral part of the ecosystem (Wayne and Jenks 1991, p. 567).

Whelan (2017, pers comm) – von Holdt and Hohenlohe appear to agree red wolves are distinct evolutionary lineages; they just disagree about the time scale.

- It's a distinct question from is the red wolf a valid species.
- Distinct evolutionary lineages can be produced from recent hybrid origins

Von Holdt et al. (2016, p. 1) – intermediate body size of red and eastern wolves is consistent with an admixture scenario.

Red wolf branched from coyote lineage (greater than 55-117,000 years ago) (von holdt 2016, pp. 7, 8).

GENETICS

Distinct Origin Theory

- Ferrell et al. (1980, p. 47) found an allele only known in red wolves
- Caru-3 appears to be potentially unique to red wolves, but may be the result of recent evolutionary divergence from coyote allele Cala-18 (Hedrick et al. 2002, p. 1908)
- Red wolves had an average of 4.4% unique alleles (Hohenlohe et al. 2016, p. 2); although von Holdt et al. (2016) expected proportion of new alleles to be higher than observed, the observed proportion of unique alleles reveal a higher degree of evolutionary distinctiveness in red and eastern wolves relative to other North American canids, a finding inconsistent with recent hybrid origin for the taxa (p. 2).
- Genetic data supports a close relationship between eastern and red wolf, but do not support that they are the same species; more likely that they evolved independently from different lineages of a common ancestor with coyotes (Chambers et al. 2012, p. 1; Abstract).
- Wolves possess wolf-derived nuclear DNA that produces a wolf-like rather that a hybrid-like organism; thus is seems red wolf is a valid taxon or at the very least a subspecies of gray wolf (Phillips and Henry 1992, p. 597).

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GENETICS

Advantages/Disadvantages/ Reliability of Genetics

The cytochrome b gene is not an appropriate marker for testing the hypotheses in Wayne and Jenks 1991, Roy et al. 1996 (Fain 2017, pers comm)

The control region has been the standard, but complete mtDNA genome sequence comparisons are common (Fain 2017, pers comm)

Are genetic studies supported by the fossil record, other evidence? Vice versa?

E.g., Does the fossil record support presence of gray wolf in southeast U.S.?

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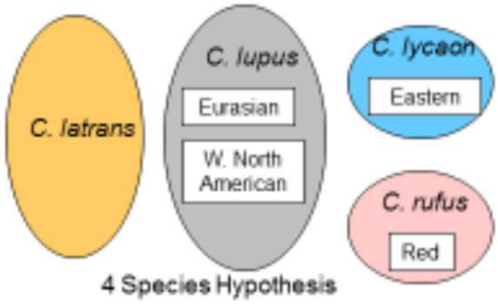
ALTERNATIVES

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ALTERNATIVES

Red wolf is a species (Canis rufus)

4 species Hypothesis

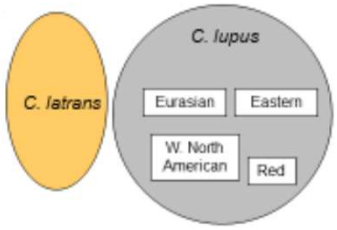


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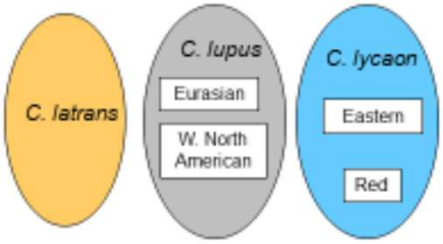
ALTERNATIVES

Not a species:

2 species Hypothesis



3 species Hypothesis



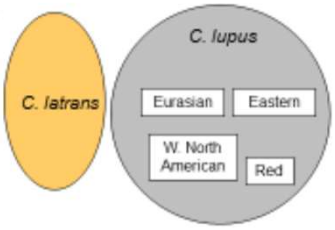
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ALTERNATIVES

Red might be a subspecies or DPS of:

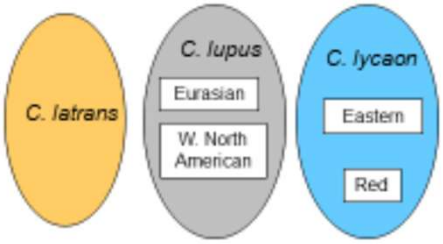
C. lupus

2 species Hypothesis



C. lycaon

3 species Hypothesis



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