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RED WOLF RECOVERY TEAM RECOMMENDATIONS

FACILITATED AND PREPARED BY GROUP SOLUTIONS, INC.

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Contents

PREFACE..4

I. INTRODUCTION & EXECUTIVE SUMMARY..5

II. LESSONS LEARNED...8

III. PROCESS

A. Taxonomy...10

B. Historic Range..11

C. Viability of Captive Population...11

D. Viability of Wild Population...11

E. Human Dimensions..12

F. Resource Commitments..12

IV. GENERAL FINDINGS

A. Conservation Reliance...13

B. Taxonomy...15

C. Historic Range..16

D. The Captive Population..17

E. Human Dimensions..20

V. OPTIONS CONSIDERED

A. Elements Common to All Options Beyond the Status Quo...............................21

1. Population Management..21
2. Administrative Actions..22
3. Public Engagement..22
4. Science...22

B. Status Quo..23

1. Description of the Status Quo Option...23
2. Evaluation of the Status Quo Option..23
3. Summary of the Status Quo Option..25




Contents

C. Suspend or Terminate the NENC NEP..26

1. Description of the Suspend or Terminate the NENC NC Option...................26
2. Evaluation of the Suspend or Terminate the NENC NC Option....................26
3. Summary of the Suspend or Terminate the NENC NC Option.....................28

D. Federal Lands-Focused NEP...28

1. Description of the Federal Lands-Focused NEP Option...............................28
2. Evaluation of the Federal Lands-Focused NEP Option................................29
3. Summary of the Federal Lands-Focused NEP Option.................................30

E. Establishing One or More Large Population to Achieve Full Recovery 31

1. Description of the Full Recovery Option..31
2. Evaluation of the Full Recovery Option...34
3. Summary of the Full Recovery Option..37

VI. LITERATURE CITED...39

APPENDIX A: RECOVERY TEAM ROSTER...41

APPENDIX B: SUMMARY STATEMENTS FROM RECOVERY TEAM MEMBER..............42

APPENDIX C: LESSONS LEARNED & FAQs..52

APPENDIX D: SUMMARY OF USGS TAXONOMY WORKSHOP.................................61

APPENDIX E: WILDLIFE MANAGEMENT INSTITUTE HISTORIC RANGE REPORT.......63

APPENDIX F: POPULATION VIABILITY ANALYSIS REPORT...................................110

APPENDIX G: TEAM COMMENTS..172

ACKNOWLEDGEMENTS...209

PREFACE AND FACILITATOR'S NOTE

This document represents the Final Report of the Red Wolf Recovery Team relative to the U.S. Fish and Wildlife Service's on-going evaluation of the Red Wolf Recovery Program. The Red Wolf Recovery Team is comprised of members with diverse backgrounds, expertise and represents wide-ranging points of view regarding to red wolf conservation.

Group Solutions, Inc. provided neutral third party facilitation for conference calls, meetings, document creation, and team workshops. We have compiled this report summarizing discussions and findings from the process in a good faith effort to accurately include individual and group member input.

Red wolf conservation is a controversial and complex subject. The reader will find that team members remain very far apart on many of the fundamentals in this report. The Executive Summary and main body of the report attempt to accurately reflect the views and opinions of team members, as captured by the facilitator in the minutes of the Team's discussions. Readers of this report are strongly encouraged to review the comments provided by team members to the final draft of this report (see Appendix B) to get a full flavor of each participant's detailed perspective. One area of general agreement among team members is the need be open to new scientific information as it becomes available.

One particular area of disagreement is the taxonomic classification of the red wolf relative to its eligibility for listing under the Endangered Species Act. After the final draft of the report was distributed to team members for review, a new study was published (vonHoldt *et al*. 2016) that challenges the classification of the red wolf as a distinct species. Given the timing of this study's release, the team did not discuss it directly, though it is referenced in the comments of some team members.

Some team members now view the vonHoldt *et al*. study as conclusive evidence that the red wolf is not eligible for protection under the Endangered Species Act, while others, mainly the scientists on the team, view it as the latest contribution to a large body of scientific information related to canid taxonomy. The study's release - after our final team meeting and agreed to team recommendations - created some new perspectives.

Specifically, the landowner representatives on the team, including private landowners that have had firsthand experience dealing with the recovery efforts for many years, and the NC Farm Bureau, are emphatic that:

- The NC NENC program should be wound down and terminated;
- The latest released, peer reviewed DNA genome study by vonHoldt, *et al* 2016 http://advances.sciencemag.org/content/2/7/e1501714.full, which questions the distinct species theory of the red wolf, should be given equal and full consideration in the taxonomy of red wolves as any other previously reported findings, including the USGS group findings prior to the study being made public, and at a minimum should confirm there is not consistent agreement among scientists as to the taxonomy of the animal, and;
- Any decisions regarding the future of the wild and captive program should be viewed entirely based on and consistent with the ESA requirement of supporting a distinct species, and not hybrids."

Facilitating the Red Wolf Recovery Team has been a very rewarding experience. The team included individuals steeped in first-hand knowledge of the issues. Most members of the team had deep scientific knowledge of all aspects of the issue. Most met in the spirit of healthy disagreement, seeking a consensus recommendation where one was possible. Most of the members were civil in their discourse and listened to opposing opinions and new information with respect.

We believe the reader will perceive the overall tone of the report, and the appended comments of most team members, projects a collegial tone and recommendations for how to wisely move forward on this complex issue.

It was a privilege to work with such a dedicated group of professionals.

I. INTRODUCTION & EXECUTIVE SUMMARY

In June 2015 the U.S. Fish and Wildlife Service (The Service) announced that it would undertake an evaluation of the Red Wolf Recovery Program to determine the actions needed to achieve recovery of the red wolf (Canis rufus) and assess the extent to which those actions could be implemented on the landscape. This evaluation was initiated after a comprehensive review of the red wolf recovery effort was conducted by the Wildlife Management Institute (WMI; Wildlife Management Institute 2014). The WMI review identified a number of areas where the Service had been successful, a number of areas that need improvement, and highlighted a number of uncertainties and serious challenges for the ultimate recovery of the red wolf.

To build on the WMI findings and help chart a path forward for red wolf recovery, the Service convened a new Red Wolf Recovery Team (Appendix A). The primary task of this team has been to assist the Service and other scientific experts in completing an evaluation of the feasibility of red wolf recovery. As stated in the letters of appointment to Recovery Team members this evaluation report will be used to advise the Service on future recovery actions. The charge to the Recovery Team was to assess four major factors:

1. Addressing questions related to the taxonomic status of the red wolf;
2. Accurately representing the historic range of the species and supporting justification;
3. Determining population viability (both captive and wild populations considering the effects of coyotes, management, and climate change); and
4. Assessing human dimensions.

The Recovery Team represents a diverse group of stakeholders representing local, state and federal government, agricultural interests, academia, non-governmental conservation interests and private landowners that were selected to represent the range of views, expertise and attitudes that exist regarding red wolf conservation.

This report presents the work of the Recovery Team. It identifies areas of agreement and disagreement among team members, and identifies options for the Service regarding the future direction of red wolf recovery in consideration of the four factors identified above and other relevant factors identified by the Recovery Team.

One area of strong agreement among team members was support for continued genetic investigation and willingness to incorporate new findings in management recommendations. A new peer-reviewed report presenting whole-genome sequenced data was unavailable prior to the final team meeting, but deserves special mention. This study questions the assumption that red wolves and eastern wolves are distinct species. For some, this is proof-positive that the red wolf is a hybrid and not listable under ESA. For others, this study is not, in and of itself, conclusive. Researchers and managers must pursue continued research and remain open to the possibility new insight may confirm or overturn past beliefs.

There continues to be a wide range of perspectives as to whether or not red wolf is a listable entity under ESA. This has enormous implications for this decision, the future of the captive program and dozens of other trust species.

After careful consideration of all the available information, the Recovery Team was not able to reach consensus that recovery of the red wolf in the wild is “feasible”. Work conducted in association with this evaluation provided new perspectives on the taxonomic status of the red wolf and the probable historic range of the species.

I. INTRODUCTION & EXECUTIVE SUMMARY

Regarding recovery in the wild, it is possible or even likely that the red wolf is a conservation-reliant species (see Carroll *et al*., 2014), meaning the threats to the continued existence of this species are such that they cannot be eliminated or sufficiently controlled to allow red wolves to persist on the landscape without perpetual intensive federal management. The predominant threats are genetic introgression through hybridization with coyotes (Canis latrans) exacerbated by human-induced mortality. Effective techniques have been developed to manage hybridization between coyotes and red wolves (Bohling and Waits 2011, Gese and Terletzky 2015, Gese *et al*. 2015, Bohling *et al*. 2016). These techniques (e.g., augmenting the wild population with releases from the captive population, tracking parentage of individual animals, removal of hybrids, use of sterile placeholder animals) are labor intensive and expensive. Without them, the ability of a red wolf population to persist with more modest management input is uncertain.

It is the view of some members of the Recovery Team that the uncertainty about the ability of the Service to sustainably manage these threats argues against pursuit of efforts to fully restore the red wolf within all or a significant portion of its historic range.

Rather, it may be advisable to pursue a more measured approach to red wolf conservation that focuses on 1) sustaining and expanding the captive population; and 2) fundamentally altering the management of the Northeastern North Carolina Nonessential Experimental Population (NENC NEP) or terminating the effort entirely.

Efforts to restore and manage red wolves in the wild may need to be more specifically designed and narrowly focused to determine whether and to what extent it is possible to develop and implement sustainable measures to manage red wolves and coyotes sympatrically on a private lands-dominated landscape in the southeastern U.S.

There was consensus among the Recovery Team members for sustaining and expanding the captive population to ensure long-term preservation of the red wolf genome depending on further research into red wolf taxonomy under the ESA.

Regarding the NENC NEP, there was consensus that current management practices are not acceptable and fundamental change needs to occur. There was broad agreement that, for a variety of reasons, it is time to for a process to wind down the NENC NEP.

While the Recovery Team did not agree on a specific future course of action, several points of agreement were reached. Chief among these was that any potential for success in future recovery efforts must include a much greater emphasis on community engagement and stakeholder involvement in wild population management.

Additionally, the Recovery Team agreed that several steps were necessary as part of the transition from the current management practices of the NENC NEP to any of the potential options identified. These included updating the Red Wolf Recovery Plan; appropriate care for any wolves removed from the wild; retention of wild-ranging animals for use in future reintroductions; development and testing of a new community engagement and shared governance model; continued research on red wolf-coyote behavior and ecology; and careful coordination of necessary administrative actions.

I. INTRODUCTION & EXECUTIVE SUMMARY

Summary of findings

While there was not consensus on all issues, team members found it useful to express their viewpoints on what they could live with and what they would oppose. Summary themes from this discussion fell into the following groups:

Things We Can Live With	Things We Oppose
Continued genetic investigation and willingness to incorporate new findings.	Considering NENC a failure; much has been learned.
The historic range of red wolf is at least a large as originally believed.	Additional releases of wolves from SSP to wild under current conditions and without sufficient research to address biological and social uncertainty.
Continued support to sustain and expand the SSP	De-coupling SSP from wild introductions.
Significant retooling or termination of NENC project is warranted.	Continued failure to enforce and comply with existing rules.
Using retooling/termination process as an opportunity to learn and increase credibility between the Service and private landowners.	Removing wolves from the wild without a clear plan to humanely handle them.
Update the current red wolf recovery plan incorporating all that's been learned, and explore additional recovery sites.	

Team assumptions

- There needs to be a fundamental change in direction for red wolf conservation.
- Transitioning to a new direction will take some time and collaboration to get right.
- We must humanely deal with wolves if NENC NEP is being substantially changed or wound down.
- Identify and prioritize new research and opportunities to learn in the transition process.
- Articulate what specifically we are going to do with the landowners and community as the program transitions.
- Build new biological and sociological components.
- Utilize existing refuge lands.
- Determine where future wild population(s) will be.
- Utilize wild wolves for populating new restoration sites.
- Address rule-making needs and policies for dealing with the predator reintroductions on private lands.
- Develop a communication strategy that supports future restoration.

An expanded summary of the views of individual Recovery Team members is provided in Appendix B.

II. LESSONS LEARNED AND IMPLICATIONS FOR THE FUTURE

The Recovery Team felt is was important to recognize the considerable body of knowledge that has been built through the history of the reintroduction effort in NENC. Much has been learned about red wolf ecology and management, and there have been important lessons regarding managing wolves on private lands and the need to engage affected communities. These lessons learned are discussed in detail in Appendix C and are summarized briefly below.

Large carnivore reintroductions on private lands are unique. The expectations and fears of the community are serious and often amplified by misinformation. Despite best intentions, wolves moved from federal lands to private lands with better habitat.

Red wolves and coyotes can be effectively managed in the wild. We have learned that given adequate resources and with sufficient community support hybridization between red wolves and coyotes can be effectively managed. Whether that level of management is needed in perpetuity or can be sustained is an open question.

Balancing public trust and private landowner rights is tough. The agreement to remove unwanted wolves from private lands created conflict and an unsustainable situation where some private landowners were tolerant of wolves, while others demanded their removal. The Service was unable to keep original commitments to relocate undesired wolves to federal lands. This increased friction. The rights of private landowners must be respected in future efforts, but the mere presence of an animal on their property is not always a problem. Retooling or winding down the NENC NEP should not be used as a precedent to justify future landowner “vetoes” of trust species decisions.

Social science is equally, if not more important than biology. It is possible to get the biological science of reintroductions 100% correct and struggle to achieve recovery if human dimensions are poorly understood and legal agreements are ignored.

Communities expect a voice in decisions that affect them. Much of the conflict in NENC can be traced to residents and leaders of the five counties who felt ignored, unheard or saw little benefit of having wolves re-established. Future programs need active human dimensions research and agency outreach well in advance of new introductions. The Service should have an in-depth understanding of the beliefs, concerns and support of prospective communities, and a governance structure that includes the affected community in management of the population. The North Carolina Wildlife Resources Commission’s study of citizen perspectives toward canids in eastern North Carolina will be a valuable benchmark for future efforts.

II. LESSONS LEARNED AND IMPLICATIONS FOR THE FUTURE

- **Fully Understanding community interests can be tough.** The loudest voices do not always represent large constituencies. Public opinion about wolves varies widely. Getting this right takes time and a sustained effort. Public forums were not the best means of community engagement because those with "middle ground" were reluctant to voice their opinions. Future engagement can benefit from more in-person interviews, surveys and 1-on-1 contact.

- **Conditions can and do change rapidly**. Sea level rise and other factors are altering a NENC landscape once thought ideal for red wolf recovery. Also, an improved understanding of red wolf ecology is changing perceptions of ideal red wolf habitat. Future biological conditions on NC refuges do not appear adequate to support a sustainable wild population. Long-term habitat resilience must be an important criterion for consideration of potential reintroduction sites.

- **Coyote arrival in eastern North Carolina changed everything.** Restrictions on coyote hunting, expectations of private landowners to be able to manage their land as they saw fit, and the difficulty of distinguishing wolves from coyotes resulted in a an unsustainable situation and increased wolf mortality. Federal rules did not keep pace with these changing circumstances. Restrictions on coyote hunting in the 5-county area bred resentment and in some cases, vigilante behavior.

- **Nature abhors a vacuum.** There is going to be a large canid on the landscape in North Carolina regardless of the management action and lawsuits.

- **Seize the opportunity to broaden learning and apply lessons learned from similar challenges across the country.** This exercise underscores the limits of law and science in conservation management. Geneticists, managers and policy-makers will continue to wrestle with the role of hybridization in species evolution and its implications for conservation programs for many species. The Endangered Species Act mandates species recovery, but there is limited policy guidance regarding conservation of a growing list of conservation-reliant species that are unlikely to ever return to self-sustaining, free-ranging populations. New thinking is needed for addressing these issues more consistently within the Service. Now may be an opportune moment for connecting lessons learned on reintroductions, conservation-reliant species and hybridization that leads to new thinking, greater flexibility and better policy guidance.

- **It is time to revise the red wolf recovery plan**. But be sure to do it deliberately and apply learnings from the NENC experience before attempting any new introductions.

III. PROCESS

This evaluation drew information from a variety of sources including the currently available scientific literature, the review of the red wolf recovery program conducted by the Wildlife Management Institute (WMI), 2014), a recently completed review of information regarding the probable historic range of the red wolf (WMI, 2016), a recently completed Population Viability Analysis (Faust *et al*., 2016), ongoing research regarding human attitudes toward canids in North Carolina (Serenari, in prep.), and ongoing research regarding canid taxonomy (Pacifici *et al*., in prep). This information was used by the Red Wolf Recovery Team to evaluate a range of possible future directions for red wolf conservation relative to key questions raised by Service senior leadership related to the captive population, wild population, and human dimensions.

The Recovery Team met in person on two occasions and conducted most of the evaluation through a series of five teleconferences. Potential future directions for red wolf conservation options were defined, ranging from options that would discontinue all red wolf conservation actions in the wild to options that would move toward what the recovery team considered full recovery of the species in the wild. Each option was assessed relative to the key factors described below. This process enabled the Recovery Team to discuss the issues surrounding red wolf recovery in a structured way. The Recovery Team identified points of consensus as they emerged and these are captured in this report. Additionally, the many points of disagreement and dissenting views were also captured in order to provide decision makers with as complete an understanding of the complexity of these issues as possible. These areas of agreement and disagreement are noted throughout the evaluation.

Final comments from each Recovery Team member are included in Appendix B.

A. Taxonomy

The correct taxonomic classification of the red wolf was considered by the Recovery Team to be a threshold issue in two senses. First, in order to be eligible for protection under the Endangered Species Act (ESA) a listable entity must be classified as a species, subspecies or Distinct Population Segment (DPS) (Endangered Species Act of 1973, as amended; 50 CFR 424.02). The correct taxonomic classification of the red wolf has long been a point of scientific debate and resolution of this question is fundamental in terms of the status of the species relative to the ESA. Second, ongoing human dimensions research (Serenari, in prep.) suggests that a fundamental component of community support for red wolf conservation efforts is a sense within the community that the red wolf is a valid part of the area's natural heritage. In other words, in order to support conservation efforts the community must first believe that the animal represents a valid taxon and it belongs in that part of the landscape.

The Recovery Team was provided available information regarding red wolf taxonomy. Additionally, concurrent with this evaluation the U.S. Geological Survey initiated an investigation (Pacifici *et al*. in prep.) that is seeking to address the continued uncertainty regarding the taxonomic classification of the red wolf and the implications of hybridization with coyotes to its long-term conservation and management. In May 2016 a top team of scientists and ESA experts met to ask whether hybridization between coyotes and red wolves jeopardized the listing of the red wolf under the ESA. Organized by researchers at North Carolina State University and funded by the U.S. Geological Survey to provide science-based input to the Service, the group included some of the world's top wolf and coyote ecologists, geneticists, taxonomists, and specialists in endangered species biology, policy and law, including some members of the Recovery Team.

Meeting participants agreed to collaborate on a publication to present their findings and the conclusions reached at the workshop are considered preliminary pending such publication. The workshop provided valuable insights regarding these issues, and a summary is provided in Appendix D. The summary of the workshop was not received in time for the Recovery Team to review and discuss its findings.

B. Historic Range

Similar to taxonomy, understanding the historic range of the species was also considered by some of the Recovery Team members to be a threshold issue. In regulatory terms, experimental populations may only be established (except in extraordinary circumstances) within the probable historic range of the species (50 CFR 17.81). Additionally, as noted above a fundamental component of public support for reintroduction efforts is knowledge that the species once occurred in the reintroduction area and in that sense “belongs here”.

The WMI was contracted to conduct a review of information that led to the delineation of the historic range of the red wolf and offer comments on the validity of that delineation. The complete report is provided in Appendix E. Each option was evaluated relative to whether it would confine conservation efforts for wild populations within the probable historic range of the species. Only options that would do so were considered viable.

C. Viability of Captive Population

Red wolf captive management began in 1969. The red wolf was approved for Species Survival Plan ® (SSP) designation by the Association of Zoos and Aquariums (AZA) in 1984. The Red Wolf SSP is managed by a network of institutions and approved non-AZA wildlife/nature centers to expand capacity beyond AZA institutions. The Red Wolf SSP is classified as a Yellow SSP, which includes SSPs for species having populations of more than 50 animals that are not expected to retain 90% gene diversity for 100 years. Today, this network supports approximately 225 red wolves at over 40 facilities across the United States.

A Population Viability Analysis (PVA) was developed in the program ZooRisk for the SSP population (Simonis *et al*. 2015). A separate PVA (Faust *et al*. 2016) was developed in the program Vortex that included both the SSP and wild (NENC) population. These provided the Recovery Team with information about how each option evaluated could affect the captive population. This was done by modeling scenarios within Vortex based on the vital rates we would expect from the SSP population under each option. In most cases it was not possible to specifically estimate what SSP vital rates would likely be under a given option, so a range of scenarios were modeled within Vortex that the Recovery Team felt reflected a reasonable range of likely population responses to management under a given option. The complete Vortex PVA report is provided in Appendix F.

D. Viability of Wild Population

As with the captive population for each option that involved maintenance of a wild red wolf population the Recovery Team had access to the Vortex PVA model to provide information about how the wild population would likely respond to the management described in that option. Options that involved maintenance of a wild population range from those that maintain only a remnant group of animals to those that envision a fully recovered and self-sustaining population. These different management endpoints require different amounts of investment to achieve the target population level and sustain it through time. In an iterative way the information from the PVA enabled the Recovery Team to adjust each option to incorporate the actions that would be needed to implement it for the foreseeable future.

E. Human Dimensions

The Recovery Team recognizes that the advisability of undertaking any predator reintroduction program and that program's long term success depend on the support of affected communities. This is particularly true in the case of red wolf conservation given that it is an effort to reintroduce a large carnivore, of which the vast majority of its historic range is comprised of private lands. The Recovery Team relied on information produced through the on-going study by the NC Wildlife Resources Commission of stakeholder perspectives toward red wolves and coyotes (Serenari, in prep.) to project the degree to which a given option would influence public perceptions regarding the justification for and efficacy of pursuing that option.

F. Resource Commitments

For each option the Service developed an estimate of the resources that would likely be needed to implement each option and sustain implementation of that option through time. Initial implementation includes the time and resources needed for the administrative processes that would need to be completed in order to move toward a specific management approach such as any needed revisions to the ESA Section 10(j) rule which governs management of experimental populations, compliance with the National Environmental Policy Act, the National Wildlife Refuge System Improvement Act, Administrative Procedures Act and other applicable federal and state statutes. The Service also provided an estimate of the annual costs associated with continual implementation of each option.

IV. GENERAL FINDINGS

A. Conservation Reliance

In considering alternative courses of action in pursuit of red wolf conservation we are confronted with two overarching issues: 1) whether the red wolf is a listable entity under the Endangered Species Act; and 2) whether recovery as envisioned by the ESA is achievable.

As discussed above, in order to be eligible for protection under the ESA a listable entity must be classified as a species, subspecies or Distinct Population Segment (Endangered Species Act of 1973, as amended; 50 CFR 424.02). The correct taxonomic classification of the red wolf has long been a point of scientific debate and resolution of this question is fundamental in terms of the status of the species relative to the ESA. If we are certain that the red wolf is not a listable entity then it must be removed from the federal list of threatened and endangered species.

If, on the other hand, the best available scientific information determines that the animal is eligible for listing then the ESA mandates the Service to take actions to further the conservation of the listed entity. This, as laid out under the ESA, means that the agency is to work with others to address the threats that caused the entity to be listed in the first place, and restore it in the wild such that the protections of the Act are no longer needed and it can be therefore delisted (i.e., recovered). The Service has considerable discretion in how it prioritizes recovery efforts and allocates resources among the listed species in its trust, but overall actions must prevent extinction and further the conservation of listed species in the wild. For the red wolf the recovery strategy (as described in the Recovery Plan; U.S. Fish and Wildlife Service 1990) has been two-pronged; a captive population comprised of at least 330 animals and 3 wild populations totaling at least 220 animals.

The wild population forces us to confront the second issue – whether recovery is achievable. In recent years there has been a growing body of literature related to the concept of "conservation-reliant species." These, as defined by Carroll *et al*. (2014), are species that lack the ability to persist in the wild in the absence of direct, persistent, and ongoing human manipulation of individuals or their environment due to the presence of insurmountable technical challenges posed by novel ecological stressors. In the case of the red wolf the threats that arguably place it in the conservation-reliant category are hybridization with coyotes exacerbated by human-related mortality (Bohling and Waits 2015, Hinton *et al*. 2015).

If we are confident that these threats can be reduced to acceptable levels (i.e., the red wolf is not a conservation-reliant species) then the prudent course of action (within the limits of available resources and in consideration of other recovery priorities) would be to proceed toward full recovery of the species in the wild through the restoration of a large population or populations that would be expected to persist post delisting with modest management input.

This is analyzed below as the "Full Recovery" option. The analog for red wolf recovery in this sense has been the eastern wolf (Canis lycaon). This wolf is also intermediate in size between coyotes and grey wolves (Canis lupus) and hybridizes with both species. However, in and around Algonquin Provincial Park, where it is protected from hunting and trapping, the species is able to sustain itself as ecologically and genetically distinct (Rutledge *et al*. 2010).

IV. GENERAL FINDINGS

The red wolf recovery program has been built on the premise that once a population of red wolves was grown to a sufficient size through intensive management it would be able to sustain itself with only modest continued management input. Our experience in NENC has shown that the hybridization threat can be managed (Bohling and Waits 2011, Gese and Terletzky 2015, Gese *et al*. 2015, Bohling *et al*. 2016); however, to date the level of management has been intensive and the NENC population has declined over the past decade as human-related mortality has increased. We have not yet documented a population size or configuration that is persistent in the face of these threats absent continued intensive management and protection under the ESA.

Should we determine that the red wolf is and will likely remain a conservation-reliant species it would seem imprudent to continue to work toward establishing large wild populations that would need perpetual intensive federal management. Instead, it would appear to be more advisable to focus conservation in the wild around smaller populations or groups of animals (below what could be considered a population) if it were determined that these would be more efficient to manage. These groups, which would likely be managed primarily on federal lands, would enable some wolves to maintain natural behaviors and adaptations and afford the opportunity for continued research into means of reproductively isolating the species from coyotes and managing human-related mortality that would be more sustainable than current practices. This option is analyzed below as the “Federal Lands-Focused Option”.

Alternatively, a case could be made for again removing the species from the wild completely in order to eliminate the threat of hybridization until such time as more effective and efficient techniques to manage this threat could be developed. This is analyzed below as the “Terminate or Suspend the NENC NEP Option”.

In truth, we currently do not know the extent to which the red wolf is a conservation-reliant species. Evidence suggests that red wolves and coyotes do not interbreed randomly (Bohling and Waits 2011, 2015) and that reproductive barriers do exist with the primary barrier being differential body size (Frederickson and Hedrick 2006, Hinton *et al*. 2013). Studies further suggests that any reproductive barriers are compromised by human-related mortality particularly gunshot-related mortality which occurs disproportionately during the red wolf breeding season as it coincides with hunting season (Bartel and Rabon 2013, Hinton *et al*. 2015, Bohling *et al*. 2016). The PVA model indicates that if human-related mortality (particularly loss of breeding animals) was reduced and pairings between red wolves and coyotes were limited via management then the population would likely experience positive growth. Human-related mortality does not need to be eliminated; merely reduced to a reasonable level.

Nonetheless, it remains unclear whether any set of durable management measures can be implemented that would allow the population to grow to a size and configuration that would mimic the population dynamics of C. lycaon. In the view of some members of the Recovery Team, this uncertainty again argues against continuing efforts to establish multiple large populations that may require perpetual intensive federal management. Rather, it would appear to some to point toward a recovery effort focused on reducing this area of uncertainty. This could mean focusing on one or more small (one or two packs) groups (the Federal Lands-Focused Option) if it were possible to conduct the needed research on such groups. Alternatively it may be necessary to directly test the assumption that a large population, properly managed to control human-related mortality, could sustain itself in the face of introgression as described by Bohling *et al*. (2016). In this case the recovery effort would focus on establishment of at least one large population (a step toward the Full Recovery Option).

Returning to the first issue (eligibility for listing under the ESA) it is important to reiterate that there is scientific uncertainty here as well, as the taxonomic status of the red wolf is not a settled scientific matter. This uncertainty also argues for a more precautionary approach to red wolf conservation and against the large-scale commitment of resources that would be needed for a full recovery effort. Given the current state of knowledge there is clear value in sustaining and expanding the captive population, as mentioned below. This is needed to sustain the red wolf until uncertainty regarding its taxonomy and conservation reliance can be reduced and its prospects for restoration in the wild, and means of achieving this goal, can be clarified. As discussed further below, continuing uncertainty also lends support to taking a more measured approach to red wolf conservation efforts in the wild. These efforts should be narrowly focused and specifically designed to develop and evaluate means of sustainably managing hybridization and human-related mortality in a private-lands-dominated southeastern landscape.

B. Taxonomy

If the red wolf is a distinct taxon suitable for listing under the ESA (species, sub-species or Distinct Population Segment) then the Service is mandated under the ESA to pursue its recovery in the wild. If it is not then the Service should pursue delisting.

The most recent Service-sponsored publication on the topic of red wolf taxonomic status is the WMI report (Wildlife Management Institute, 2014). Though WMI was not asked to look at the taxonomic issues in their review they indicated that the issue arose repeatedly with people they talked to, so they hired Dr. Randy Young to review the existing literature on the subject. Dr. Young provided an assessment of many aspects of red wolf genetics including taxonomy, hybridization, inbreeding, and related management strategies. On the specific issue of the taxonomic classification of the red wolf after reviewing the relevant scientific literature, he concluded that although the hybrid origin hypothesis (the idea that the red wolf is not a distinct species but rather derived via hybridization between grey wolves and coyotes) cannot be conclusively refuted: "Recent genetic data have cast doubt upon the hybrid origin hypothesis and the balance of evidence has tilted towards a North American canid assemblage composed of the eastern wolf, the red wolf, and the coyote as distinct taxa that are descended from a common ancestral canid of North American origin."

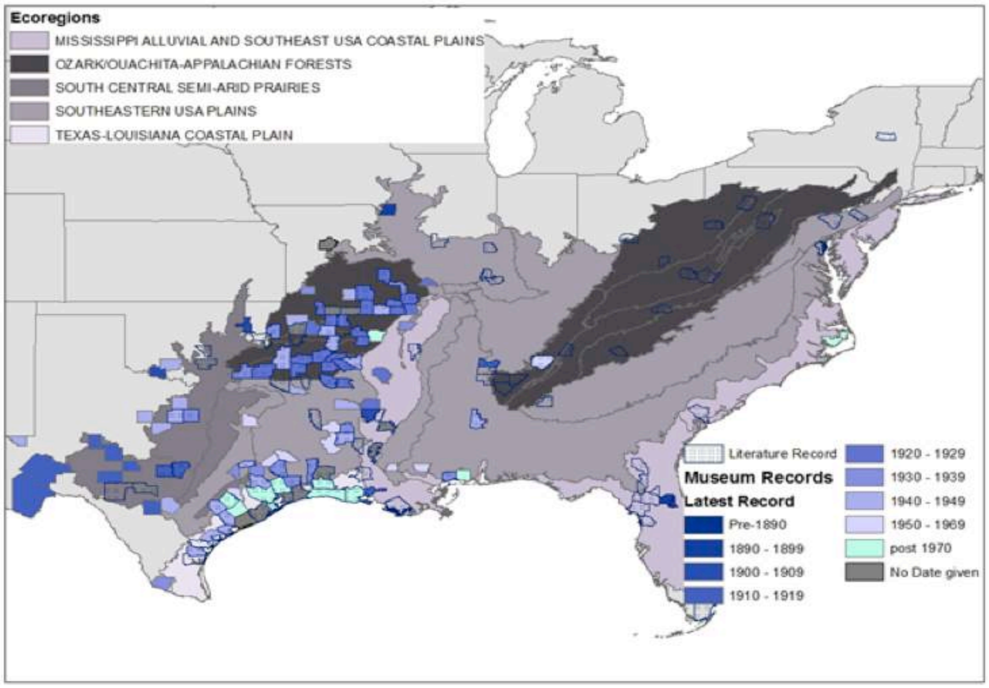
Scientists and legal scholars attending the USGS workshop agreed that the red wolf is a listable entity; though they did not reach consensus on whether it is a full species, subspecies or DPS. This consensus must be considered tentative pending publication of their findings. Additionally, some representatives on the Recovery Team are in agreement that the best available information supports the red wolf as a listable entity. Other members of the Recovery Team do not share this view and continue to feel the red wolf should not be listed.

At the present time there is not sufficient evidence to recommend delisting due to inappropriate taxonomic classification. Research is on-going, but it did not shed additional light within our evaluation timeframe. In fact, the preliminary results of the USGS investigation appear to strengthen the conclusion that the red wolf is a listable entity. The Service needs to be aware that ongoing or future research may possibly demonstrate that the red wolf is not a listable entity, at which point the Service should be prepared to act on that information and remove the animal from the List of Threatened and Endangered Species.

C. Historic Range

The WMI conducted a review of all available information related to the historic range of the red wolf (Appendix E). It concluded that previous range maps developed and used by the Service for the Red Wolf Recovery Program were too restrictive. An accurate predictor of the historical red wolf range includes all or parts of several Level II ecoregions including the Mississippi Alluvial and Southeast United States Coastal Plains, Ozark/Ouachita-Appalachian Forests, South Central Semi-Arid Prairies, Southeastern United States Plains and the Texas-Louisiana Coastal Plains (Figure 1). Ongoing and future recovery efforts should be focused within this area.

Figure 1. Ecoregions of the southeastern US that correspond to the probable historic range of the red wolf (from Wildlife Management Institute, 2016).



There was general, but not 100% agreement with the findings of the WMI report.

D. The Captive Population

The Recovery Team agreed that sustaining and growing the captive red wolf population should be a priority component of any path forward for the Service, provided that the best available scientific information continues to indicate that the red wolf is a valid taxon suitable for protection under the ESA.

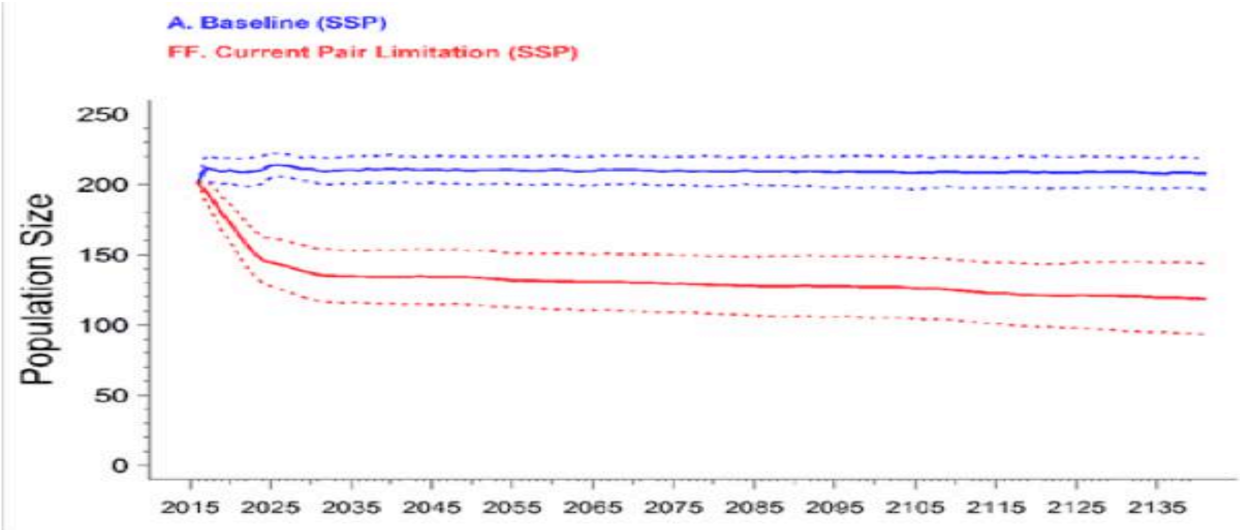
The red wolf captive population has been managed in approved zoos and wildlife centers since 1969. Currently 228 wolves are managed at 44 institutions and these institutions are potentially able to hold an estimated 225 wolves (Simonis *et al*. 2015a). Space within AZA institutions is limited and there is "competition" for space with other large canids managed within AZA (e.g. Mexican gray wolf, maned wolf, generic gray wolf, etc.) and potential wolf spaces are often associated with an institution's zoogeographic theme. The Red Wolf SSP already has double the number of holding facilities of similar AZA SSPs. The median number of holding facilities is only 22 across all 324 Yellow SSPs.

In the recently developed Population Viability Assessment (PVA) models, carrying capacity (K) reflects the number of individuals, but not the explicit number of spaces/exhibits and is not necessarily equivalent to the number of exhibits or enclosures (Faust *et al*. 2016). Because of the social nature of wolves, attempts are made to house two or more animals together depending on enclosure size, location, and intent (exhibit or off-site). For example, currently there are about 90 "spaces" for approximately 200 wolves in the captive population. However these arrangements are fluid. A pair may have pups resulting in a large family group being housed together, but those circumstances may change based on age, gender, temperament, and other factors. For example, with a pack of 8 wolves, if all 6 pups are female, experience tells us that we are on borrowed time with how long all the animals may be compatible resulting in the need to separate some members of the group into multiple spaces. Each of these situations are determined case-by-case based on age, seasonality (breeding season or otherwise), behavior, compatibility, medical issues, etc.

Based on the PVA model (Faust *et al*. 2016), the SSP population appears to have the potential for demographic stability and growth under current conditions, but additional space is needed for the SSP to fulfill its demographic potential. In the PVA model the captive population is "bred to maintain the population at K", meaning that each year the model assesses the current size against K (target population size = 225), taking into consideration the estimated number of deaths expected in the year, average breeding success of recommended breeding pairs, litter size, and pup survival, and determines the number of breeding pairs to make (similar to the captive breeding recommendation process for a given year). This "Baseline" or breed to K = 225 scenario shows the SSP population remaining stable over 125 years, having the capability to sustain itself and supplement the NENC population to some degree as well. However, this demographically stable scenario projects the population would be making average of 52 breeding pairs per year over the first decade, which would produce an average of ~37.4 births/year over the first decade, and eventually approximately 34 births/year to remain at 225 individuals. In actuality, over the past 10 years, the SSP population has averaged 31 births per year produced from an average of approximately 29 pairs breeding pairs.

Current space limitations hinder the ability of managers to accommodate the additional breeding pairs necessary to match the production levels shown in the model, and is compounded by approximately 15 to 20 percent of individuals that are considered post or non-reproductive but still occupy space. Preliminary modeling of the SSP in an alternate scenario indicates the population would decline to approximately 119 animals within a few decades if constrained to only 29 breeding pairs (Figure 2). Furthermore, the space-limited restriction of population size and growth typically requires the use of contraceptives, separating of pairs during the breeding season, and/or delayed or less frequent breeding opportunities for females. Evidence from other carnivore species suggests that all of these types of management actions can negatively impact female fertility and reproductive health (Penfold *et al*. 2014, Asa *et al*. 2014).

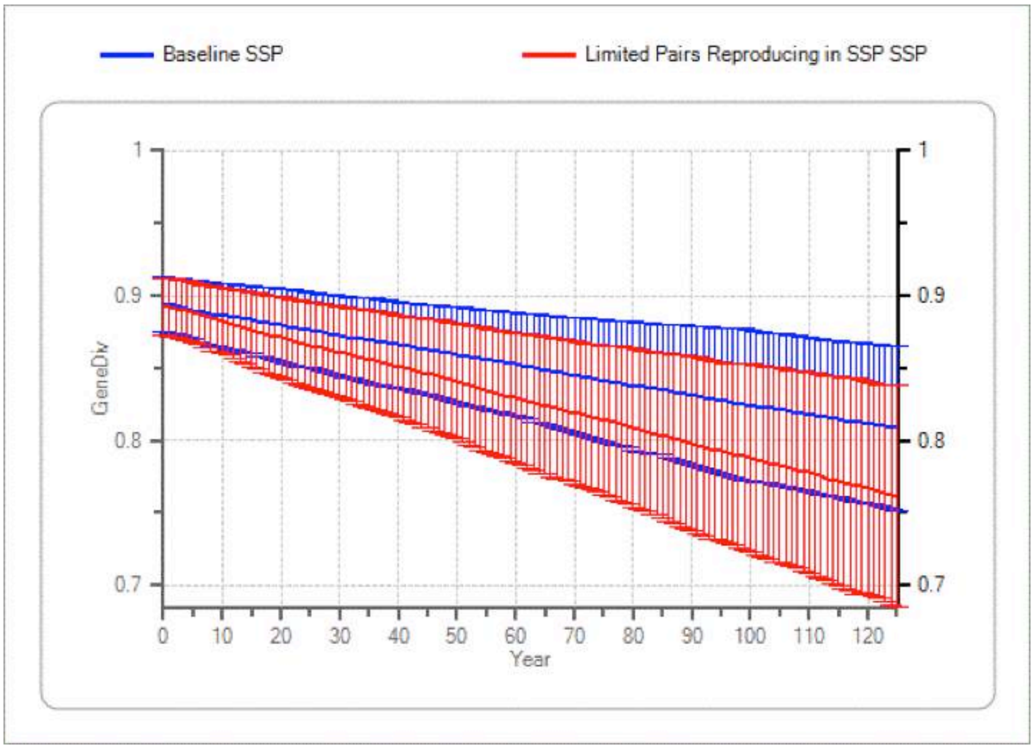
Figure 2. Size of the captive red wolf population projected over 125 years under the "Baseline" scenario (maintaining the population at 225 wolves assuming 52 breeding pairs per year) and in the "Current Pair Limitation" scenario (restricting reproduction to only 29 breeding pairs, similar to the number of pairs the SSP currently can support; Simonis *et al*. 2015, Faust *et al*. 2016).



Additional space and improved breeding rates could improve demographic stability and could substantially improve genetic outcomes. Gene diversity (GD) of the SSP population is currently 89.2% and the mean inbreeding value (F) is 0.076. With a population size around 200, the SSP has a moderate chance of remaining above the 80% gene diversity goal of the Recovery Plan under the optimistic Baseline scenario (assuming 52 breeding pairs and 37.4 births per year). Under the more realistic "SSP Current Number of Pairs" scenario reflecting the constraints of current holding spaces (29 breeding pairs producing an average of 31 births per year), the population is much less likely to meet the Recovery Plan genetic goals, with gene diversity falling to 76% in 125 years (Figure 3; Scenario FF in the PVA report).

Increasing the captive population size to the Recovery Plan target of 330 or 400 results in substantial improvements in gene diversity in the model and, in actuality, could allow the SSP to increase the number of breeding pairs to levels sufficient to meet recovery goals. The probability of maintaining 80% gene diversity for 125 years increases from 65.7% in the baseline to 80% at 330 wolves and 88.5% at 400 wolves. The average inbreeding of the population decreases from 0.1799 in the baseline to 0.1577 and 0.1496, respectively. To reach these target sizes, the captive population would need to increase from 37 births/year in the baseline to approximately 54 births/year if 330 spaces were available or approximately 58 births/year if 400 were available. Coupling these changes with increased breeding rates in the captive population (see Scenarios M, N in the PVA report) results in additional improvements in genetics.

Firure 3. Gene diversity of the captive redwolf population over 125 years under Baseline (breek to K = 225, potential breeding pairs = 52 on average) and Scenario FF, SSP Limited to Current Number of Pairs (target population size = 225 but restricting potential breeding pairs to 29).



The captive population PVA report (Simonis *et al*. 2015a; Faust *et al*. 2016) shows that higher birth rates in the captive population are needed, and are possible. To remain a strong supporting population for any recovery goals, the captive population needs more space and increased breeding rates. In order to increase capacity for the captive population additional spaces would need to be created at existing facilities, and likely combined with adding new facilities to the program. Costs associated with adding spaces vary widely depending of the facility, material and construction costs, enclosure site attributes, etc. and will need to be assessed.

At its current size, the SSP can sustain 3.3 or 4.5 releases per year without major detrimental impacts on demographics, maintaining around 200 wolves. Releases may relieve some of the space pressures experienced in the SSP population and could open spaces for additional breeding pairs.

Releases of 9.6 animals per year causes the SSP to decline slightly and the SSP is not able to produce enough animals to release in later model years. Adding more space to the SSP allows it to remain demographically strong and retain higher GD while carrying out releases: Demographically, adding more space allows the SSP a bit more resilience to high release levels – at 330 spaces 3.3 or 4.5 releases per year do not decrease the SSP size and if space is increased to 400, higher release rates (9 per year) can be tolerated.

The real importance of added space, however, is that it allows the SSP to retain gene diversity while releases occur – the probability of the SSP maintaining 80% gene diversity with releases is high with target sizes of 330 or 400. Adding more space and increasing SSP breeding rate allows the SSP to retain the highest levels of gene diversity and remain demographically strong, and results in the healthiest NENC populations.

The effects of releases to a new site that does not have an existing wild wolf population has not been modeled yet. However, it is likely that a new site would need a larger number of releases initially to establish a wild population than to supplement an existing population of wild (behaviorally and ecologically competent) wolves.

Furthermore, at a new site with coyotes present and fewer wolves, the wild breeding rates would likely lower until more wolf-wolf pairs could take over breeding on the landscape. The scenarios with the largest number of releases per year to the NENC populations (9 animals) require an SSP population with 400 spaces and higher breeding rates in order to maintain demographic stability and genetic diversity of the SSP.

E. Human Dimensions

The WMI report (2014) offered a cursory examination of the social implications of the Red Wolf Recovery Program. Evaluating a wider range of perspectives and uncovering underlying factors for attitudes, beliefs, and outcomes are required to assess a full range of social dynamics and suggest improvements to the program. Consequently, the NCWRC and the Service have initiated collaborative social science research to address these goals.

As part of this larger study to determine the social dynamics of canid management on the Albemarle Peninsula, NCWRC employed key informant sampling to obtain perspectives of knowledgeable and experienced stakeholders (n=61) residing or working within and outside of Beaufort, Dare, Tyrrell, Hyde, and Washington counties in North Carolina (e.g. public officials, landowners, land managers, hunters, biologists, farmers, wolf advocates). In interviews, NCWRC discussed a range of topics including management preferences, canid tolerance, and livelihood impacts. They continued interviewing in each county until responses became redundant (Corbin & Strauss, 2008).

The NCWRC is using a policy goals (equity, liberty, efficiency, security) framework (Stone 2002) to analyze data, evaluate the NENC NEP, and explore the drivers of policy conflict and pathways forward. Results pertaining to each of these goals from the key informant sampling clearly indicated broad spectra of positive and negative opinions and perspectives regarding management of large canids in the NENC NEP area. The NCWRC is using this information to inform and develop a large-sample survey of landowners in the NENC NEP area. Results from that survey will allow them to fully represent the attitudes and opinions of these landowners and to use those data to fully evaluate the NENC NEP and recommend pathways forward for canid management on the Albemarle Peninsula.

V. OPTIONS CONSIDERED

In consideration of the general findings above the Recovery Team identified a number of potential options for the future direction of red wolf recovery efforts starting with continuing the effort in its current form. Options that would result in a significant departure from the Status Quo included suspending or terminating the NENC NEP altogether, reducing the scope of the NENC NEP to focus on managing one or more small groups of red wolves predominantly on federal lands, and moving forward toward building one or more large populations roughly as envisioned in the Red Wolf Recovery Plan. These options are described and discussed in detail below, starting with a description and evaluation of the Service's current management practices (the Status Quo).

The Recovery Team agreed that pursuing any of the options beyond the Status Quo would require a substantial amount of time and resources to properly implement. Regarding three options (Terminate the NENC NEP, Federal Lands Focused NEP, and Full Recovery) the Recovery Team agreed that there were several specific tasks that would in general be common to the initial implementation of any of these options related to management of the wild and captive populations, administrative and rule-making needs, governance and research. These common elements that would occur during a transition period are briefly described below.

A. Elements Common to All Options Beyond the Status Quo

1. Population Management

If the Service were to eliminate the NENC NEP population or refocus its management to federal lands there would need to be an effort to responsibly remove and/or relocate animals from or on the landscape. This would require that any animals captured be handled and housed humanely. As stated elsewhere in this report the current SSP facilities are at capacity. While the Recovery Team unanimously supports expansion of SSP capacity (should the red wolf continue to be considered a listable entity under the ESA) it is recognized that it would take time to add capacity sufficient to accommodate animals removed from the NENC NEP while meeting other SSP objectives. As such, it is the view of the Recovery Team that an emphasis should be placed on expanding capacity within the SSP and that efforts to remove animals from the landscape should be contingent on availability of space and resources to properly care for them. If the Service were to set a future direction for red wolf recovery that included terminating or reducing the scope of the NENC NEP while attempting to establish one or more additional populations elsewhere it would be important to maintain wild wolves on the landscape for use in establishing new populations. Translocated wild wolves that are experienced in the wild are believed to have higher survival rates than captive-reared wolves.

Currently the NENC NEP is widely scattered over the NENC NEP area. This sparse distribution increases the risk of hybridization as young animals dispersing from natal territories are far more likely to encounter coyotes than wolves. As such, should the Service decide to pursue the Fully Recovery option that included efforts to resume growth of the NENC NEP, it is the view of the Recovery Team that it would be initially necessary to consolidate the NENC NEP into a more manageable configuration. As with the Terminate or Federal Lands Focused options discussed above, this would require a period of time to implement and adequate space to accommodate animals temporarily.

It is difficult to say with specificity how long it would take to effectively implement the population management actions described above. The ability to expand capacity within the SSP is in part contingent on funding, but also on the willingness and ability of current or future partner facilities to accommodate expansion. The Recovery Team feels that it is important for the Service to set firm time frames for implementing the chosen course of action to ensure accountability and foster public trust and believes that a 3 to 5-year timeframe would be a reasonable expectation for accomplishing the initial transition from the Status Quo to any of the three options mentioned here.

2. Administrative Actions

Concurrent with the above described population management actions, a number of administrative actions would need to be implemented in conjunction with a major change in the direction of the Recovery Program. First, the Recovery Team agrees that the current version of the Red Wolf Recovery Plan is not an adequate guide for recovery efforts and needs updating and revision. This would be preceded by preparation of a Species Status Assessment. Additionally, rule-making and other administrative actions (e.g., compliance with the National Environmental Policy Act, ESA Section 7, and National Wildlife Refuge System Improvement Act, etc.) would be necessary to varying degrees depending on the option selected. It may be necessary to complete some of these actions prior to initiating changes in population management practices (depending on the option selected), but many could be completed concurrent with population management efforts within the same 3 to 5-year transition timeframe.

3. Public Engagement

The Recovery Team agrees with the findings of WMI (Wildlife Management Institute, 2014) that red wolf conservation efforts have suffered from the lack of a sustained public engagement process. It is agreed that developing and implementing effective processes to inform and engage the public, local and state governments, and SSP partners in red wolf conservation decisions will be essential to the future success of such efforts regardless of where they may be implemented. Continued engagement with private landowners and other stakeholders will be necessary throughout the transition period from the Status Quo to a new approach and it is recommended that the Service use this time to work with the community and affected stakeholders to formulate and test a new framework for engaging landowners and the community in red wolf conservation. This would help through the transition and could serve as an engagement/governance model for future reintroduction efforts. This work needs to be informed and guided by the above-mentioned human dimensions research being conducted by the NCWRC.

It is important to view the ecological issues and the social issues regarding canid management as an interconnected system as opposed to separate issues. These interconnecting ecological and social factors are complex, dynamic and not fully understood. This leads to high potential for unintended consequences resulting from management actions. These relationships must be mapped through efforts such as the continuing research by the NCWRC to answer lingering questions citizens have about these animals, such as benefits, inactiveness, taxonomy, and impact on game animals.

The available information suggests that partial solutions such as outreach, education, or financial incentives, would be largely ineffective by themselves to achieve sustainable red wolf recovery because they do not address deeper issues underscoring historical recovery efforts. Rather, these efforts must be components of a more robust governance structure that enables the Service and NCWRC to differentiate red wolves from coyotes from a regulatory point-of-view, develop clear goals, flexible and innovative regulations, information sharing mechanisms, means to address uncertainty, and share decision-making and authority. In short, there is a need to strengthen the institutions associated with red wolf management and increase acceptance of and capacity for practice-based learning and adaptive governance. This will ensure all interests are addressed promptly, fairly, and effectively and differences are acknowledged and addressed.

4. Science

Much has been learned about red wolves throughout the history of the NENC NEP effort, yet key knowledge gaps persist. The transition period may afford opportunities for further learning, and the Recovery Team recommends that careful consideration be given to the design and implementation of studies aimed at providing further insight into red wolf and coyote management and inter-species interactions, predator-prey relationships, and human dimensions. Of particular importance will be the design and implementation of studies aimed at examining the degree to which the red wolf is a conservation-reliant species and its implications for recovery and management.

B. Status Quo

1. Description of the Status Quo Option

Under this option the NENC NEP would continue to be managed under the Service's existing rules and procedures, with the same or similar level of resources. The current program elements include: fitting adult wolves with VHF, and recently, GPS devices for tracking purposes. Wolves are managed on federal lands and private lands pursuant to written agreements with cooperating landowners. Management includes locating dens with litters, determining parentage of pups (wolf, coyote or hybrid); removing hybrid animals from the population; drawing blood from young wolves for genetic analysis, and pit-tagging each pup for future identification. Trapping occurs mostly in the winter to allow for young of the year animals to be fitted with GPS collars, replacement of old or malfunctioning collars, and verification of animals of unknown status. Animals are also provided with veterinary services (e.g., immunization, vaccination, treatment for injury or disease) as needed.

Wolves are removed from private lands where they are not wanted pursuant to landowner requests. Wolves removed from private lands are released onto federal lands unless health or behavioral issues preclude release. If efforts to remove wolves are abandoned, landowners can be provided written authorization to use lethal means to remove wolves from their property.

The Service works with a number of researchers on investigations designed to improve our understanding of red wolf taxonomy and ecology. The Service has conducted education and outreach activities focused mainly at the Columbia Red Wolf Education and Health Center (REC). While there are currently approximately 40 sterile placeholder coyotes and hybrids in the NEP area that will continue to be monitored, the Service is not deploying additional placeholder animals. There would also continue to be no augmentation of the NEP from the SSP. This option includes the additional involvement of the NCWRC per the 2013 interagency agreement (Appendix F), including development of a collaborative Canid Management Plan for the Albemarle peninsula and establishment of a canid forum wherein stakeholders would meet regularly to share information, concerns and discuss solutions related to coyote and wolf conservation in the NEP area. The Service would also continue to search for other potential NEP sites.

2. Evaluation of the Status Quo Option

Captive Population Viability: Under this option there would continue to be no movement of red wolves from the SSP to the NENC NEP. As such, there would be no adverse effects on the SSP population in that regard. However, it is difficult to predict how current or potential future captive facilities will respond if there is no active conservation beyond efforts to manage red wolves within AZA's SSP program. It is possible that institutions will view it as their conservation mission to continue supporting red wolf recovery. Conversely, others may elect not to participate if there is no apparent future direction to restore red wolves to the wild, which could result in the loss of space or the inability to recruit additional cooperators needed to maintain and grow the captive population.

Faust *et al*. (2016) reported that the PVA model results for the SSP baseline scenario showed a moderate chance of maintaining 80% gene diversity identified in the Recovery Plan. Under this scenario, an average of 52 breeding pairs/year would be required and approximately 37.4 births/year would need to occur over the first 10 years. After 10 years, the population would need approximately 34 births/year to remain at 225 individuals. If these conditions persisted for 125 years, the model predicts a population of 207 individuals with high levels of inbreeding (F=0.1799) (above that of half siblings, where F=0.125) with 81% gene diversity.

However, due to space (currently 44 facilities) and other constraints, the SSP has been producing approximately 31 births/year over the last 10 years and only 29 breeding pairs for the past 3 breeding plans. Model results from these constraints (e.g., making only 29 breeding pairs per year) show that the SSP may not be able to sustain itself and would decline, producing an average of only 22.6 births/year over the first 10 years. In this scenario, the population would decline to around 119 individuals, has a slight chance of extinction (PE = 0.5%), the probability of maintaining gene diversity at or above a level of 80% would decline to 76%, and inbreeding would increase to F=0.2201 (approaching that of full siblings) over 125 years. As a result, the SSP would require continued careful management to maximize the population's future genetic health. The SSP would continue to receive support from the Service to coordinate the captive program, in-kind support from SSP facilities would continue to be provided to the Service, and efforts would continue to be made to grow capacity within the SSP. Growth of the SSP would require additional public and private funding.

Wild Population Viability: The PVA model estimates that continuation of current management practices will likely result in extirpation of the NENC NEP within 40 years with some model runs resulting in extirpations within 8 years (Faust *et al*. 2016). Because the population has declined further to 45-60 individuals since the model was developed and mortality and reproduction data from 2015-2016 are not incorporated into the model, these projections may actually be overestimates, with extirpation occurring even sooner. These results are driven by projected continued high mortality (particularly due to loss of breeding-aged animals to gunshot) and low breeding rates. Low breeding rates result from a combination of the low number of potential breeders remaining in the population and limited Service access to private lands to identify and prevent hybrid pairings, leading to an effective loss of breeding animals to the red wolf population resulting in inbreeding depression and lack of recruitment of offspring. Even with the removal of factors affecting inbreeding depression from model runs, the population may increase for the first decade, but eventually begins to decline again because of current mortality and reproductive rates. The extirpation of this population would also represent the loss of behaviorally competent wild wolves needed for re-establishing wolves back on the landscape in any future NEPs. Behavioral competence would have to be re-built again and any new NEPs would likely experience lower reproductive rates and higher mortality rates during the re-establishment process. It was the view of the Recovery Team that continued implementation of Status Quo management would do little to alter these dynamics in the NENC NEP area. Sustaining a wild population within the NENC NEP area was deemed unlikely within the confines of the Status Quo option.

Human Dimensions: The Status Quo option, as described herein, includes a number of program features that have been incorporated into the program over the past three years in response to concerns raised by the stakeholders. These include the formalization of a collaborative canid management agreement between the Service and NCWRC, increased efforts to remove wolves from private lands where they are not welcome, the issuance of letters of authorization to use lethal means to remove wolves from private lands, the cessation of releases of red wolves from the captive population into the wild, and the cessation of efforts to deploy placeholder canids. These changes were collectively intended to ease landowners and NCWRC concerns regarding program implementation; however they appear to have done relatively little to address the concerns of residents of the NENC NEP area and have upset other stakeholders.

Regulatory Implications: Implementation of the Status Quo Option would not require any additional regulatory compliance measures or rule-making.

Costs: Though it is predicted that the number of animals in the NENC NEP would continue to decline, the costs of managing the NENC NEP would remain approximately level or slightly higher than current spending due to the need for continued monitoring and management of the population throughout the area and the need for contracted trapping services to respond to removal requests on private lands (See Table 1 for cost breakdowns). Additional funding in the amount of $250,000 is also needed under this option for additional fencing/repairs to the captive facility at Sandy Ridge. It is important to note here that historically nearly all the costs of managing the NENC NEP have been borne by the Service. As a result, red wolf conservation has consumed an outsized proportion (relative to other listed species) of the Service's endangered species recovery budget in the Southeast Region.

Table 1. Estimated costs for the Status Quo Option, including those associated with increasing trapping capacity to respond to removal requests. Annual costs are shown, as well as the one-time cost of additional fencing and repairs to the captive facility at Sandy Ridge. Total cost is calculated based on the first 5 years of implementation.

STATUS QUO OPTION	Annual Cost	Timeframe (yrs.)	Total Cost
Program Management/Field Work			
Annual program management expenses (monitoring, research, captive population, planning, staff support)	$1,300,000	5	$6,500,000
Increased trapping capacity to respond to removal requests (contracted)	$150,000	5	$750,000
SSP			
Additional fencing at captive facility at Sandy Ridge	$250,000	1	$250,000

3. Summary of the Status Quo Option

The Recovery Team reached consensus that the Status Quo option was not an acceptable future direction for red wolf conservation. Current management is resulting in unsatisfactory results for many residents in the NENC NEP area, for stakeholders who advocate for red wolf recovery, for the agencies (Service and NCWRC) tasked with program implementation, and for the species.

In addition to the Status Quo other options initially identified included suspension or termination of efforts to sustain a wild population in NENC; refocusing recovery efforts on federal lands within NENC or elsewhere; continuing to sustain a large population in NENC within improved management measures and/or modified regulations; and, establishment of additional large populations as called for in the Red Wolf Recovery Plan. As the process of evaluating these options progressed the Recovery Team determined that the options sustaining a large population in NENC through improved management and/or modified regulations was most appropriately considered as a component of the "full recovery" option as opposed to stand alone options. Therefore, the options considered in detail in addition to the Status Quo include suspending or terminating efforts to sustain the species in the wild, refocusing wild conservation efforts on a smaller population or populations centered on federal lands, and pursuing full recovery.

C. Suspend or Terminate the NENC NEP

1. Description of the Suspend or Terminate the NENC NC Option

This option would suspend or terminate reintroduction efforts in the NENC NEP. Attempts would be made to remove as many red wolves as possible from the landscape. Captured wolves would be placed in SSP facilities to the extent possible; however, space is limited within the SSP and it is unclear how well wolves would transition to the captive program; as such if this option were implemented in the immediate future many if not most wolves removed from the NENC area would be euthanized. If the program were terminated by formal rule-making it would remove the NEP designation from the 5-county NENC NEP area and preclude future re-establishment of an NEP at this location. The Federal Register notice accompanying the rule-making would contain a "lessons learned" analysis that would explain the reasons for termination of the NENC NEP and the conditions that would be necessary for establishment of any future NEP at an alternative site(s). Suspension of the program would mean that the same management actions would be taken but without the formal removal of the NEP designation. This would leave open the possibility of re-populating the NEP at some later date.

2. Evaluation of the Suspend or Terminate the NENC NC Option

Captive Population Viability: Moving animals from the wild population to the SSP would place a near-term strain on the capacity of the SSP. This would reduce the ability of SSP managers to establish breeding pairs and would likely result in short-term reduction in the productivity of the SSP population. The PVA model results for this option show a small genetic benefit as a result of bringing the capturable NENC wolves into the SSP, which can be fully maximized if additional space is added to the SSP (Faust *et al*. 2016). The probability of achieving at or above 80% gene diversity under the current option with no additional space would be 71.4%, an increase from the baseline of 65.7%, but that probability could be increased to 87.1% with the expansion of the SSP. Therefore, to maintain the genetic health of the species and avoid permanent loss if the NENC is terminated, the addition of spaces to the SSP will be essential. If additional spaces are not available in the SSP, it will be extremely important to maintain NENC genes by developing a plan to cryopreserve genetic material and conduct research on assisted reproduction to optimize the use of the genetic materials to benefit the species.

Wild Population Viability: Although efforts would be made to remove as many wolves as possible from the NENC NEP area, it is highly unlikely that it would be possible to capture all animals. The PVA work group estimated that approximately 20 animals would remain in the NENC NEP area despite removal efforts. Modeling estimated that the remnant red wolf population would persist for approximately 25 years (range = 3-78 years). Red wolves and hybrids would exist on the landscape, but over time it is anticipated that the red wolf genome would be subsumed within the eastern NC coyote genome rendering animals with remnant red wolf DNA genetically indistinguishable from coyotes.

On the one hand, pursuit of this option could be viewed as a step backward in terms of red wolf recovery. This option would again extirpate the species from the wild and would appear on its face to be contrary to the ESA's mandate to "provide a program for the conservation of … endangered species". On the other hand, if the Service were to conclude that the red wolf is a conservation reliant species that is incapable of sustaining itself against the threat of genetic introgression with coyotes without perpetual intensive federal management, then it could perhaps be argued that continued efforts to maintain a large free-ranging population is placing the red wolf genome (and the species) at risk, which is also contrary to the purposes of the ESA. To a degree the resources needed to manage the NENC NEP are scaled to the size of the population and the difficulties in managing hybridization and introgression increases as the size of the population and the amount of occupied space increase.

In short, the larger the NENC NEP population becomes, the more difficult it is to manage. If this is indeed the case and there is no size or configuration that would allow the NENC NEP population (or any wild red wolf population) to be more or less self-sustaining with modest management input, then the case can be made that continuing to pursue establishment of a large wild red wolf population, or populations, is placing the red wolf genome at an unacceptably high risk. This argument is somewhat undercut due to the existence of the captive population which is not at risk of genetic introgression. Still, the more hybridization is allowed to occur in the wild, the less distinct the red wolf genome is likely to become over time. It is important to consider the benefits of attempting to restore this species to the wild against the risks of compromising the genome's uniqueness.

Human Dimensions: Implementation of this option is the stated preference of many residents of the NENC NEP area and several members of the Recovery Team. Pursuit of this option would also be in keeping with the desires of the NCWRC as expressed in their January 29, 2015 resolution. Conversely, this option is adamantly opposed by non-governmental conservation organizations, SSP partners, and wolf advocates living in NENC and around the country.

Regulatory Implications: Implementation of this option would require rule-making. This would entail development and publication of a proposed rule and associated documents including, at a minimum, preparation of an Environmental Assessment or Environmental Impact Statement under the National Environmental Policy Act, completion of a consultation/conference opinion pursuant to section 7 of the ESA, solicitation of public comment, and compliance with other applicable federal laws such as the Administrative Procedures Act. This process would take a minimum of two years to complete during which time Status Quo management measures would remain in place.

Costs: The costs associated with the option to suspend or terminate the NENC NEP are projected over a 2-5-year timeframe. Development of a proposed rule (if deemed necessary) and associated documents to terminate the NEP would likely take 2 years and is estimated to cost $250,000. Program management costs include the current expense level of $1,300,000/year to manage the program to completion (approximately 3-5 years), as well as increased trapping capacity to respond to removal requests, and increased emphasis on public relations (See Table 2 for cost breakdown). Additional funding is needed under this option to expand the SSP population to assimilate captured wolves. Expansion of the captive facility at Sandy Ridge is projected to cost $750,000. In addition, increasing the capacity for holding wolves in the zoo population will likely cost $500,000 and may come from a combination of federal and non-federal sources.

3. Summary of the Suspend or Terminate the NENC NC Option

Given the current finding that the red wolf is a listable entity under the ESA, and absent a conclusion by the Directorate that recovery of the species in the wild is not feasible (discussed above), termination of the NENC NEP and the removal of red wolves from the wild would not further the conservation of the species in and of itself. As a stand-alone measure, termination of the NENC NEP would again render the species extinct in the wild and would strain management of the SSP. These factors would make implementation of this option problematic. The viability of this option could be enhanced if coupled with specific plans to identify new NEP sites based on the lessons learned from the NENC NEP and commitments to bolster and expand the SSP.

Table 2. Estimated costs to suspend or terminate the NEP, including those associated with rule changes, program management, and increasing the capacity of the SSP for housing wolves removed from the wild. Annual costs are shown, as well as total costs, based upon the estimated time to completion of approximately 2-5 years, depending upon activity.

SUSPEND OR TERMINATE NEP OPTION	Annual Cost	Timeframe (yrs.)	Total Cost
Rule-Making			
Termination. Formal removal of NEP designation from NENC (costs are total costs and not apportioned by year)	$250,000	2	$250,000
Alternatively, suspension requires no formal removal of NEP	$0	0	$0
Program Management/Field Work (removal of wolves)			
Current annual program management expenses (monitoring, research, captive population, planning, staff support)	$1,300,000	5	$6,500,000
Increased trapping capacity to respond to removal requests (contracted)	$150,000	5	$750,000
Increased public affairs emphasis (detail of PAO from another office)	$30,000	2	$60,000
Additional SSP Needs			
Expand captive faciity at Sandy Ridge	$750,000	1	$750,000
Increase SSP capacity to accommodate 330-400 wolves	$500,000	5	$2,500,000

D. Federal Lands-Focused NEP

1. Description of the Federal Lands-Focused NEP Option

Under this option management would occur as described under the Status Quo Option but would be focused on federal lands within the NENC NEP area or at another as yet unidentified site or sites. Within the NENC NEP wolves would be removed from private lands to the extent possible, consistent with the existing rules. A small group (one or two packs likely consisting of less than 30 animals) would be maintained on Alligator River NWR and the Dare County Bombing Range. A pack or two may also be maintained on Pocosin Lakes NWR. The Service would do what we can within our means and existing authorities (including refuge policies and management plans) to manage wolf habitat on the refuges. Efforts would be made to ensure that animals that leave the refuge would be captured and returned. The existing rules would remain in effect so the Service could work with landowners to address concerns regarding the occurrence of wolves on private lands. In addition to the measures described under the Status Quo, the Service would augment the population with releases from the SSP to manage inbreeding and offset losses. The Service would use sterile placeholders to manage genetic introgression. The remnant group would be used for research targeted at filling key knowledge gaps to inform future reintroduction efforts at other sites, specifically focused on better understanding the behavioral and ecological factors that reproductively separate red wolves and coyotes with a view toward developing more efficient and sustainable management techniques. This research would focus on predator-prey dynamics, maintenance of genetic integrity, and management of hybridization, and human dimensions. Public education and outreach activities at the REC and on refuges, and efforts to establish the Canid Forum would continue.

Similar groups could be established on other federal properties within the historic range of the species. It was the view of the Recovery Team that federal lands would be the desired location for such groups due to the intensive management that would be required to sustain and study them.

2. Evaluation of the Federal Lands-Focused NEP Option

Captive Population Viability: Maintaining a small isolated group of red wolves on the limited federal land base of the NENC for any length of time would necessitate augmentation from the captive population. The PVA modeled the release of approximately one wolf every other year (on average) to the refugial population. The effect of the releasing 1 animal every other year associated with the federal lands only scenario was very slight. The probability of remaining above 80% genetic diversity decreases from the baseline of 65.7% to 65.1%. With releases of 3.3 animals/year from the SSP the probability of remaining about 80% genetic diversity deceases to 58.97%. These probabilities increase to 78.1% with 330 spaces and 87.6% with 400 spaces. In order to accommodate this level of translocation while allowing the SSP to meet its goals for sustaining and managing the captive population, the PVA study also indicates that the size of the SSP would need to be increased to accommodate a population of approximately 330 to 400 animals.

Wild Population Viability: A group of red wolves managed under this option would be artificially constrained to the federal land base. This constraint would prevent natural growth of the group and would prevent it from ever achieving a size that could be more or less self-sustaining. It would perpetually depend on augmentation from the SSP population. It could not be considered a population in any customary sense of the word and would not be "viable". However, it could be maintained with intensive management. Model runs on populations with only 1 animal released from the SSP into the NENC every other year showed that the hypothetical effect of this simulation still demonstrates a severe demographic and genetic future that would not result in a viable NENC population and a severe bottleneck in the first 15 years with die-offs of existing animals. Even with this release, 67.1% of iterations ended with extinction (Faust *et al*. 2016). Because of the intensive nature of management required to try to maintain group of this nature, additional models to determine the numbers of releases needed to keep animals on the ground would need to be examined.

Human Dimensions: There would be some benefits to maintaining a small group of wolves on the Federal lands. These include preserving the wolf's intrinsic value, as well as conducting education and outreach programs. The presence of a remnant population in the wild could provide some comfort to those who advocate for red wolf conservation; however, pursuit of this option as an end in itself would likely not be seen as progress toward recovery of the species and would likely cause many to question whether the Service was fulfilling its obligations under the ESA.

On the other hand, confining red wolves to federal lands would help address some concerns of many landowners in the NENC NEP area; though it would not eliminate them all. Absent an effort to physically confine wolves to Federal lands through means such as fencing, it is not possible to confine any large carnivore to a specific plot of land. Wolves would continue to move off federal lands and would continue to be of concern to many private landowners. The degree of concern would likely be less pronounced than under the Status Quo option due to the smaller number of wolves. The continued need to address concerns regarding the movement of wolves onto private lands creates an opportunity under this option to explore alternative means of engaging affected communities in management of wolves. This could inform further recovery efforts either in NENC or elsewhere.

Regulatory Implications: At a minimum this option would require a Compatibility Review by the Refuge manager, completion of a section 7 consultation under the ESA, and revision of the Red Wolf Adaptive Management Plan. If implementation of this option included construction of a physical barrier to confine wolves to federal lands (which is not anticipated) it would require publication of an Environmental Impact Statement and compliance with the Clean Water Act in addition to the above requirements. Establishment of additional small NEPs would require rule-making. At present no such sites have been identified.

Costs: If additional NEPs are established, the development of a proposed and final rule and associated documents will be necessary. This is projected to take 2 years and cost $250,000. If no additional NEPs are established outside of the NENC NEP, there will be no costs associated with this category. Program management costs will be slightly less than those associated with the current budget due to a reduction in veterinary costs, flight time and fuel for monitoring, and food to support captive animals associated with the reduction in the number of wolves on the landscape as the program is dialed back to federal lands only (See Table 3 for cost breakdown). Additional funding is needed under this option to expand the SSP population to accommodate 330-400 wolves, which is projected to cost $750,000.

Table 3. Estimated costs to support the Federally-focused NENC NEP Option, including those associated with any necessary rule changes, program management, and increasing the capacity of the SSP. Annual costs are shown, as well as total costs, based upon the first 5 years of implementation.

FEDERALLY-FOCUSED NENC NEP OPTION	Annual Cost	Timeframe (yrs.)	Total Cost
Rule Making			
Only necessary if additional NEPs are established	$250,000	2	$250,000
Program Management/Field Work			
Reduced annual program management expenses (monitoring, research, captive population, planning, staff support)	$1,270,000	5	$6,350,000
SSP			
Increase SSP capacity to accommodate 330-400 wolves	$750,000	1	$750,000

3. Summary of the Federal Lands-Focused NEP Option

Attempting to confine a large carnivore to a relatively small federal land base is highly problematic, as was realized in the very early days of the NENC NEP effort. Considerable resources would need to be devoted to dealing with wolves that leave the Refuge. Additionally, there would be a need to continually move wolves between the SSP and NEP. This intensive management would compromise efforts to conduct the kinds of research that would be a primary purpose of maintaining such an NEP. These difficulties would be multiplied if other such small NEPs were established. In terms of experimental design, working with one or more small groups of animals would present challenges in terms of sample size.

Given the challenges posed by this option, it is likely not appropriate as an end in itself unless it is determined that the red wolf is a conservation-reliant species and maintenance of small groups of wolves is the only practical means of sustaining the species in the wild. Rather, this option is most defensible as an intermediate step toward terminating the NENC NEP all together, moving to another site or sites, or ultimately renewing efforts to establish a large population in NENC.

E. Establishing One or More Large Population to Achieve Full Recovery

1. Description of the Full Recovery Option

For the purposes of this evaluation "full recovery" means achieving the objectives described in the Red Wolf Recovery Plan (U.S. Fish and Wildlife Service 1990). Specifically, achieving a captive population size of approximately 330 animals, a wild population size of approximately 220 animals in 3 locations, and retaining between 80 and 90 percent of the species genetic diversity. The Recovery Team agreed these objectives are not recovery criteria in the sense that they establish benchmarks upon which to base down listing or delisting decisions. The current recovery plan is deficient in this regard. The Recovery Team also agreed with the findings of WMI that these objectives need to be revisited as several of the Recovery Team members believe that achieving these objectives would be insufficient to justify removal of the red wolf from the endangered species list. In particular, there is considerable doubt among several Recovery Team members that 3 wild populations totaling 220 animals would be sufficient to withstand the threats faced by the species. Also, in consideration of the discussion regarding conservation reliance the specific criteria for what would constitute 'recovery' of the red wolf remains unclear. Revising the Recovery Plan was determined to be beyond the scope of this evaluation, but should be a high priority following a decision by the Service regarding the future direction of the program.

To evaluate this option the Recovery Team needed to first describe the conditions and actions that would likely be needed to achieve the recovery plan objectives. As stated above, the Recovery Team recognizes the value in sustaining and growing the captive population and this option incorporates the measures described above for achieving that objective. Additionally, it was recognized that establishing additional wild populations under this option would require increased releases from the captive population. While these effects on the captive population were modeled in the PVA specific to the NENC population, establishing additional wild populations and its impact on the captive population needs to be identified and considered.

The Recovery Team further recognized that in order to establish and sustain wild populations, be it the NENC NEP or other sites as called for in the Recovery Plan, certain ecological and social conditions must be met. The Recovery Team reviewed the report from the 1999 PHVA Workshop (Kelly *et al*. 1999) and additional notes from a 2006 meeting of the Red Wolf Recovery Implementation Team for insight regarding previous discussions regarding the identification of reintroduction sites.

The Recovery Team established a working group to refine and update the ecological criteria and a separate work group to identify appropriate social criteria. The first work group reviewed the ecological criteria developed during the 1999 PHVA workshop and found them to be appropriate with some updating (Table 4).

Meeting these ecological criteria is not sufficient for a location to serve as a NEP site. Certain social conditions must exist or be created in order to provide a level of tolerance of wolves within the community sufficient to sustain recovery efforts over the long term (Table 5).

Sites need not support optimal values for all the criteria identified in Tables 4 and 5, but these factors must be carefully evaluated and sites must be found, on balance, to afford a reasonable opportunity for success. Implementation of this option would necessarily entail the identification of one or more sites that possess desirable combinations of the criteria or where there is an ability to create desire conditions. To date, the only sites evaluated in any detail by the Service have been the Land Between the Lakes Region in Tennessee and Kentucky (which was considered as a potential NEP site in the mid 1980's but not since), the Great Smoky Mountains National Park (which was the site of an unsuccessful attempt to establish and NEP) and NENC.

Table 4. Key Ecological Criteria for identifying potential red wolf reintroduction sites.

Ability to manage hybridization with coyotes
Adequate prey base
Area sufficient to meet the need (as informed by the above mentioned decision regarding conservation reliance)
Low human population density
Site configuration, with a preference for sites that are either roughly circular to minimize edge or have other confining landscape features that provide natural barriers to coyote movement into the area (such as peninsulas or major river confluences)
Minimal competition with other large predators (e.g., Florida panther) or with other managed/listed species
Low road density
Low prevalence of infectious and non-infectious diseases
Minimal conflict with livestock

Table 5. Key social conditions that should exist or be possible to create in order to sustain public support for efforts to establish a red wolf NEP.

Answer critical questions about red wolf taxonomy.
Establish a defensible scientific narrative about red wolf recovery and recognize the media's role in knowledge creation.
Develop comprehensive citizen engagement and conflict response plans. Consider creating citizen science projects or a citizen advisory or management committee to minimize acrimony over contested scientific results.
Restructure public engagement events to boost foster civil and respectful discussion.
Prepare/Train employees to identify and effectively mediate various types of conflicts (e.g., issue; data; structural; value; and relationship).
Pursue research that unites social and ecological systems. For instance, map the interactions between wildlife and human systems.
Pursue social science research to reveal variables and human factors that are currently receptive to apex predator reintroduction and do not show qualities that would help formulate negative attitudes in the future. Social-specific influence recovery efforts and evaluate recovery. Examples of research domains include: • Citizen knowledge about canid behavior, breeding, habitat, predator-prey relations, laws. • Measure large landowner willingness to establish written landowner agreements. • Perceived impacts of coyotes and other predators on hunting and farming groups, citizens, government officials, etc and integrate with biological data collectin efforts and local communities. • Tolerance levels for predators and compare differences among interest groups. • Historic-cultural relations between local residents and wildlife management agencies. • Local citizen expectations and desires about recovery. • Influence of the socio-political contexts on human behavior. • Arrangement of wildlife institutions and how those hinder or facilitate collaboration.
Estimate recovery program capacity to withstand changes to the governing biological and political, economic, and legal conditions and how those changes impact social-ecological outcomes.
Consider population supplementation in areas where hunting is desired or prevalent.
Design ways for recovery to offer measurable economic benefits to communities within economically depresses areas.
Create a compensation program for lost or damaged property.
Create a compensation program for private trapping efforts.
Collaborate with state officials and other stakeholders to find novel ways to reconcile states' defense of private property and allowance of government takings under the ESA and address threats to state trust wildlife
Provide a means for citizens to identify between red wolves, coyotes, and hybrids.
Improve decision making so all interest expect and embrace flexibility, power sharing, policy innovation, and acknowledge mistakes in a timely and deliberate manner.
Improve decision making so that all interest expect and embrace flexibility, power sharing, policy innovation, and acknowledging mistakes in a timely and deliberate manner

If implementation of this option were to include establishment of one or more populations in addition to or in lieu of the NENC NEP it would require a multi-year effort to identify a potentially suitable location or locations, conduct the necessary site specific ecological analyses (e.g., prey base, coyote densities) and properly engage relevant stakeholders in development of an appropriate management and communications framework. The details of these analyses will vary depending on the location, but this work would be time and resource intensive and would need to precede the necessary regulatory and administrative compliance actions.

2. Evaluation of the Full Recovery Option

Captive Population Viability: Although the PVA study did not specifically model a scenario that would involve establishing additional NEP populations outside of the NENC, we can at least comment on the NENC model results as a starting point to discuss what may be needed at a minimum for the SSP to remain viable to support a single NEP. The PVA study states that long-term success of the program will require releases of animals from the SSP in combination with other improvements to demographic rates and increases in the capacity of the SSP (Faust *et al*. 2016). If reproductive rates and mortality rates are similar at future release sites, then this would be especially important for maintaining a healthy SSP, regardless of where releases occur.

With the addition of future NEPs, the SSP would need to be able to support additional releases while remaining sustainable and genetically healthy. To accomplish this would require the addition of spaces to the SSP and improvements to demographic rates, such as reduction of mortality rates and increases in reproductive rates, within the NENC NEP. The model indicated that “best case” changes, which include an SSP population of 400 spaces with 25% breeding success of paired animals and improved reproduction/decreased mortality in the NEP, result in greater probabilities of retention of over 80% gene diversity (80.5% probability for scenario with movement of 3.3 animals/year, 400 spaces and 25% breeding success of paired animals in the SSP, and intermediate mortality in the NENC; 81.5% probability for scenario with same parameters plus increased breeding in the NENC). We can surmise that additional improvements may be needed to support releases to establish additional NEPs.

Wild Population Viability: Without specific information to inform development of a model for establishment of multiple NEPs for full recovery, we must look at the NENC NEP as an example of what any additional NEPs would require to function successfully. Based on what we have learned from the PVA results for the NENC NEP, certain parameters must be met to maximize the likelihood of producing sustainable wolf populations, including reduction of mortality, improvements in reproduction, reduction of coyote impacts, and management in conjunction with the SSP (added spaces for increased holdings, increased reproduction, and sustainable releases for genetic management). Those “best case” changes discussed above for captive population viability also apply here because of their direct tie to the SSP.

Alternative release strategies are also an option if resources are limited, as may be the case with the establishment of other NEPs. These may be designed such that releases occur annually for the first 15 or 25 years and then less frequently thereafter. Developing a program with short-term releases followed by periodic releases will help improve genetic health. The PVA model run for the NENC with intermediate mortality and increased female breeding showed that the probability of attaining 80% or higher gene diversity without releases was only 6.6%. Just by conducting releases every year for 15 years and then scaling back to releases once every 5 years, this would increase the probability to 46%. If carried out annually for 125 years, the probability would jump to 66.7%. Although significantly higher probability is achieved with the 125-year release plan, this may not be logistically feasible, especially when managing more than one NEP. Alternative release strategies provide additional options for consideration. In the future, more specific modeling can be conducted to evaluate release options and how those scenarios might help inform release strategies. In addition, integrated management -that is, managing the NEP population(s) and SSP as a single population- will be essential for achieving the best results under this option.

Our experience with the NENC NEP to date and the available evidence has not shown the population to be sustainable without intensive management. The compounding effects of hybridization and human-related mortality have prevented the NENC NEP population from achieving a stable state that could persist in absence of intensive management. If management actions to improve reproduction and reduce mortality are successfully applied, the rate that the NENC NEP is projected to decline could be reduced (Faust *et al*. 2016). However, significant changes, especially in combination, are needed to ensure persistence of the NENC NEP into the future. Even if the higher reproductive rates documented in 2003-2004 were sustainable, the NENC NEP would still be at risk over the long term without additional changes. Likewise, short-term population increases may be realized if coyote impacts could be reduced to the extent that wolves only mated with other wolves, but modeling results still show a population trajectory that leads to extirpation. Reducing mortality rates has the greatest effect on the NENC NEP over these other management changes considered, but reducing mortality rates alone will not ensure a sustainable NENC NEP because of the effects of inbreeding depression on a closed population. If made in combination, improvements to reproduction and mortality can be expected to produce a healthier NENC NEP with a moderate risk of extinction (16.5%), but the probability of maintaining at or above 80% gene diversity would still decline over time to only 65.6% and inbreeding would increase to F=0.3086 (higher than matings at full-sibling level). However, despite these changes to the demographic rates, the NENC NEP would still not be a genetically healthy population. It is expected that other populations established within the historic range of the species, if isolated from one and other, would experience similar challenges.

Human Dimensions: As mentioned throughout this evaluation the societal ramifications of reintroducing wolves on a landscape dominated by private lands is arguably the most important aspect of the red wolf recovery effort. It is the view of the Recovery Team that to provide any reasonable prospects for long-term success the Service must develop a fundamentally different approach to managing human-wolf interactions at levels from the landowner to governance.

Landowners and other stakeholder require that the Service address factors that undermine citizen's views about equity, liberty, security, and agency efficiency. Using the NENC NEP as an example, a key for it to experience positive growth is for human-related mortality to be held at an acceptable level. This can be achieved through more restrictive regulation of hunting opportunities coupled with increased enforcement. However, this undermines community support by generating a sense of unequal treatment compared to communities outside the NEP area (equity), loss of control of the ability to manage coyotes on their property (liberty), and decreased opportunities to harvest game (security).

This does not bode well for success of the reintroduction effort over the long term. Conversely, development and implementation of a process to more fully include the affected community and stakeholders in the management of the population is not simple. It is time-consuming, controversial, complicated, and messy. There is a lack of available models upon which build such a program related to red wolf conservation, and the ability to achieve community support is hampered by continued uncertainty about the validity of the red wolf as a species, its place in the natural heritage of NENC, and ability for the Service to answer these questions for the public (efficiency). These challenges are not easily overcome. Indeed some Recovery Team members expressed the view that they were insurmountable in NENC and perhaps anywhere.

Regulatory Implications: Implementation of this option would require rule-making to establish additional NEPs. This would entail development and publication of a proposed rule, and associated documents include, at a minimum, preparation of an Environmental Assessment or Environmental Impact Statement under the National Environmental Policy Act, completion of a consultation/conference opinion pursuant to section 7 of the ESA, solicitation of public comment, and compliance with other applicable federal laws such as the Administrative Procedures Act.

Rule-making would also be necessary if this option were limited to a continued commitment to growing and sustaining a wild population in NENC, because as mentioned above under Human Dimensions, substantial changes would be needed to better engage the community in management of the NEP and there must be a better set of tools to address landowner concerns.

Costs: Preparation of rules and associated documents to establish additional NEPs is projected to take a minimum of 2 years and cost approximately $250,000. Because only one NEP could reasonably be expected to be established and maintained during the initial 5 years while developing the rule and associated documents and increasing the capacity of the SSP, program management costs are based upon the current annual budget for maintaining the NENC NEP. Additional funding as a single allotment in the amount of $750,000 would be necessary to expand the captive facilities at Sandy Ridge, and $500,000 per year would be necessary to increase capacity in the zoo population. Incentives for private landowner participation in the form of a “pay-for-presence” program may be established and are projected to cost approximately $100,000 per year.

Table 6. Estimated costs to support the Full Recovery Option, including those associated with rule changes, program management, increasing the capacity of the SSP, and incentive programs. Annual costs are shown, as well as total costs, based upon the first 5 years of implementation.

FULL RECOVERY OPTION FIRST 5 YEARS	Annual Cost	Timeframe (yrs.)	Total Cost
Rule Making			
Establishment of additional NEPs and/or revised NEP rules.	$250,000	2	$250,000
Program Management/Field Work			
Annual program management expenses (with additional monitoring, human dimensions, 3 populations)	$1,300,000	5	$6,500,000
SSP			
Increase SSP capacity to accommodate 330-400 wolves	$750,000	1	$750,000
Incentives			
Landowner incentives or other measures needed to support community engagement	$100,000	5	$500,000

3. Summary of the Full Recovery Option

Prior to actively pursuing establishment of any large population, some key pieces of information are needed. Previously in this document, we discussed the importance of resolving the uncertainty regarding the taxonomy of the red wolf. In addition, as mentioned above the Service needs to determine to what extent the red wolf is a conservation-reliant species. Before additional populations are established, the Service needs to have a better sense of the extent to which a perpetual federal commitment will be needed to sustain those populations and the level of commitment and management needed from state, community, and other partners. It is the view of the Recovery Team that it would be imprudent to establish additional populations without a clearer understanding of the long-term commitment that will likely be needed to sustain them.

V. OPTIONS CONSIDERED

Concluding that the red wolf is a conservation-reliant species that would need continuous intensive federal management to sustain wild populations would not mean that the Service should forego establishment of additional wild populations. It does have serious implications in terms of the long-term commitment of Service resources and the commitments that would need to be sought from state and local partners. Additionally, the extent to which the red wolf is a conservation–reliant species influences site selection criteria. For example, if it is determined that a large well-aggregated red wolf population is able to sustain itself against genetic introgression as appears to be the case with the eastern wolf, then suitable sites would need to be of sufficient size to support a large well-aggregated population. If, on the other hand, it is determined that sustaining red wolves in the wild will require intensive perpetual management to address threats to the species, then smaller more easily managed and controlled sites may be more appropriate, as identified under the Federal Lands Option above.

We currently do not know whether a population of red wolves can obtain a size and configuration that would enable it to persist with only modest management input. This uncertainty argues against pursuit of intensive efforts to establish multiple populations. Instead, conservation efforts in the wild should be designed around research needed to test assumptions regarding conservation reliance. Establishment of one or more small populations would be advisable if we can learn what we need to learn about interactions between red wolves and coyotes through the study of such populations. Sample size could be an issue. Conversely, establishment of a single large population would be prudent if it were determined that the conservation-reliance hypothesis can only be evaluated by testing it directly. In either case the effort must be accompanied by a robust and explicit plan that includes specific metrics and timeframes for determining success and a detailed study design with explicit testable hypothesis and data collection and analysis plans.

It would be possible to identify a fair number of sites within the historic range of the red wolf that support the ecological attributes identified in Table 4 in addition to the NENC NEP area. However, many of the socio-political conditions (Table 5) would need to be established within a community affected by a reintroduced red wolf population. Beyond the threshold-level issue of the willingness of communities and landowners to tolerate the presence of predators on the landscape, the primary socio-political factor affecting red wolf conservation is coyote management. Simply put, the presence of red wolves complicates coyote management activities and tolerance of wolves hinges, at least in part, on the degree to which their presence limits opportunities to hunt and trap (or otherwise control) coyotes.

We have seen in the NENC NEP that coyote hunting, trapping, and control leads to levels of mortality in red wolves that are not sustainable. Efforts to reduce human-related red wolf mortality that severely limit or eliminate opportunities to hunt coyotes, such as those implemented in 2014 in NENC produce a strong negative community response toward red wolf conservation.

V. OPTIONS CONSIDERED

Since 1999 management of the NENC NEP has focused on implementation of the Adaptive Management Plan, which targets hybridization. There has not been a corresponding adaptive effort to develop and implement measures to address human-related mortality. This was noted in the WMI report (Wildlife Management Institute, 2014). Several approaches are potentially available but the only effort implemented to date has been the control of coyote hunting opportunities. Even with this effort there has been no systematic effort to analyze its effects on wolves, coyotes, or human attitudes. Additional measures could include an outright prohibition on coyote hunting or other modifications to coyote hunting seasons and bag limits. There are also a variety of incentive-based programs that have been implemented as components of conservation programs for other species. These include the coexistence council for the Mexican grey wolf (Mexican Wolf/Livestock Coexistence Council, 2014) which includes a pay-for-presence program, and recovery efforts for jaguars in northern Mexico (Northern Jaguar Project).

Ongoing research by the NCWRC suggests that "partial solutions", such as outreach, education, or financial incentives, would be largely ineffective by themselves to achieve region-wide red wolf recovery because they do not address deeper issues underscoring historical recovery efforts. The NEP designation offers flexibility in designing a program that could better achieve red wolf conservation while alleviating security, liberty, and equity concerns for many citizens, build trust, and overcome bureaucratic politics contributing to stakeholder divisions. A more robust system is needed that better differentiates red wolves from coyotes, formulates mutually beneficial relationships for landowners and other interest groups, and/or employs a management system based on developing clear goals, flexible and innovative rulemaking, information sharing, addressing uncertainty, and shared decision making and authority.

There is a need to strengthen the institutions associated with red wolf management and increase acceptance of and capacity for practice-based learning and adaptive governance. This path will ensure all interests are implemented promptly, fairly, and effectively and differences acknowledged and dealt with. The former entails creating settings where the various groups interested in red wolf recovery can share their views and knowledge to help balance the socio-ecological system. Adaptive governance entails thinking outside the box to embrace policy innovation (via prototyping or experiments), institutional flexibility, and bottom-up decision making.

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APPENDIX A: RECOVERY TEAM ROSTER

Name	Affiliation
Bill Rich	Hyde County
Christopher Serenari, PhD	North Carolina Wildlife Resources Commission
David Cobb, PhD	North Carolina Wildlife Resources Commission
Eric Gese, PhD	United States Department of Agriculture
Herb Vanderberry	North Carolina Farm Bureau
Jett Ferebee	Landowner
Lisette Waits, PhD	University of Idaho
Michael Stoskopf, PhD	North Carolina State University
Mike Phillips	Turner Endangered Species Fund
Pete Benjamin	U.S. Fish and Wildlife Service
Sarah Long	Lincoln Park Zoo
Will Waddell	Point Defiance Zoo and Aquarium
Facilitators	
Vern Herr	Group Solutions
Brett Boston	Group Solutions
Supporting Staff	
Kristi Yanchis	U.S. Fish and Wildlife Service
Rebecca Harrison	U.S. Fish and Wildlife Service
Marilyn Knight	U.S. Fish and Wildlife Service

APPENDIX B: SUMMARY STATEMENTS FROM RECOVERY TEAM MEMBERS

Team Member	Things We Can Live With	Things We Oppose
Herb Vanderberry	Things I've learned from December to now: Requirements for the animal to feasibly exist in the wild require large tract of land with minimal interference from coyotes and minimal impact on private landowners. I can live with a captive population. There is too much to be gained to do something otherwise. This includes sufficient resources to maintain the captive population. I concur with a suspension or termination of NENC project. I'm open to other sites outside of NC for small populations of wolves that have very large tracts of public land, minimal coyote presence, and minimal private landowner impacts. Wind down with a date certain. Utilize existing refuge lands, if necessary, but no new introductions! Include a PR effort that includes the landowners who might be impacted if refuge land is used to wind down. We are OK with wind down activities taking place on state/public land. We support program (with learnings) in some other area/region. This will likely require a big land mass that probably includes private property.	Additional experimentation in NC that tries to make recovery work in some way in NC. We oppose continued release of animals in NC.

APPENDIX B: SUMMARY STATEMENTS FROM RECOVERY TEAM MEMBERS

Team Member	Things We Can Live With	Things We Oppose
Jett Ferebee	The NENC population needs to be terminated after 30 years of unsuccessfully meeting the program objectives and violating several key federal rules designed to protect private landowner rights. This process should be expeditious and used as an opportunity to increase credibility between FWS and private landowners. In light of the new Princeton/UCLA genome wide DNA study that determined the red wolf to be a hybrid of 75% coyote and 25% grey wolf, I cannot support spending any more taxpayer money on either the wild population or even the captive population of red wolves. Hybrid animals are not protected by the ESA. Recognition that absolutely no physical evidence has ever been produced by USFWS to prove the red wolves selectively bred in a zoo in Tacoma, Washington were ever native to the state of NC.	Further spending of taxpayer resources on an animal of such questionable origins and the continued trampling of private landowner rights by USFWS and NGOs. USFWS not managing their federal land for the red wolf and then expecting private landowners to host their wolf program (biologists and all). USFWS not honoring the original commitments made to the citizens of North Carolina in federal rules and public meetings. The 1986 and 1995 federal rules governing this non-essential experimental species program were specifically established to protect private landowner rights including the ability to have unwanted wolves removed from their land. Thinking that adaptive management has controlled hybridization of wolves with coyotes in eastern NC. USFWS blaming hunters and landowners for the NC program failing rather accepting that the same conditions of coyote infiltration and hybrid swarm that lead to red wolves being removed from the wild in Texas by USFWS have now occurred in eastern North Carolina.
Bill Rich	I'm honored to be here and voice my opinion. I can live with capturing as many animals as we can. This should be a joint effort with trappers and landowners that gets concluded in a reasonable amount of time. Use the population in conjunction with SSP program and hold for a reasonable amount of time on Albemarle Peninsula as long as they're collared and looked after. I support financial incentives for local trappers.	Any regulation on hunting coyotes. Our preference is to see it around the clock.

APPENDIX B: SUMMARY STATEMENTS FROM RECOVERY TEAM MEMBERS

Team Member	Things We Can Live With	Things We Oppose
Michael Stoskopf	I agree a captive population is necessary and needs to be supported and developed to serve its purpose, which is to support recovery of the red wolf in the wild. I agree the red wolf is a listable taxonomic entity with an historic range at least as extensive as presented by WMI report. I agree that recovery needs to be redefined in the ESA. I agree the status quo, defined as the truncated current project operations, won't work in NENC and retraction to government lands may be a necessary step backward to move forward. I agree winding down any recovery project will require considerable transition time to do it properly. I agree careful attention to Human dimensions considerations is essential for the red wolf program to succeed and this is true for other species recovery efforts as well. I agree that partnerships that can build ownership and shared responsibility for components of a project are beneficial and necessary. I agree it is important to continue efforts on red wolf recovery and that this work needs to be in multiple locations across the historic range. I agree that red wolf recovery is possible with concerted and well-managed efforts, that the red wolf will be a conservation-reliant species, and most endangered species will be/are conservation reliant to some degree.	I disagree with the characterization of the NENC red wolf project or the red wolf recovery effort at large as a failure, there having been many successes and some failed efforts. I disagree that biological conditions preclude a sustainable model for the red wolf program to succeed. I disagree with removing NC as a location for red wolf recovery efforts, particularly for captive programs, research (bench and other), and management on government lands in the state. I disagree with actions that would lose the value of the wild red wolves currently on the ground in NC. I disagree that the attitudes towards the red wolf of the citizens in the NENC red wolf recovery area are symmetrical or independent of situational constructs that go beyond the direct biology of the red wolf.

APPENDIX B: SUMMARY STATEMENTS FROM RECOVERY TEAM MEMBERS

Team Member	Things We Can Live With	Things We Oppose
Will Waddell	The red wolf is a taxonomic entity that is listable under the ESA. I agree that the map provided by WMI validates the red wolf historic range. I agree that the existing recovery plan and status review need to be updated. I agree that exploring additional restoration sites is critical and necessary. I agree that the SSP needs to be supported and grown as a component of the red wolf recovery program equation including captive population management, education & outreach, and to support red wolf recovery efforts in the wild. Continuing human dimension/social science efforts in NENC or elsewhere is necessary.	I don't agree that the SSP should be considered a stand alone option. It should be coupled with be recovery in the wild. I don't agree that the program or the NENC project has been a failure. I don't agree that all citizens of NENC oppose red wolves on the landscape. I disagree with shutting the door at least on the Federal lands option or that complete suspension is needed in NENC. If there are efforts to remove remaining red wolves in NENC (which I don't support), salvaging the "wildness" of those individuals should be a priority so they can be used at other restoration sites in the future.
Sarah Long	I support the current scientific conclusions agreed upon by experts that the red wolf is a unique and listable entity with an historic range throughout the southeastern US. I think red wolves should be managed as a metapopulation, with an intensively managed captive population and a wild population and exchanges between the two to better maintain the demographic and genetic health of both populations and the species. The SSP population needs additional space and resources to sustain itself and support the wild population and species as a whole. I see the maintenance of the NENC continuing even if only as preservation of behaviorally competent wild wolves while the program transitions to a new site. Any future management of wild wolves needs to integrate human dimensions (e.g., formal discussion and cooperation with all relevant stakeholders). Humans are part of any ecosystem; they affect the wolf and the wolf affects them.	I oppose the notion that the NENC wolves are coyotes or coyote hybrids; scientific monitoring and testing of these animals does not support this. I oppose the notion that the entire NENC project has been a failure. The NENC red wolves were one of the most data rich and well-monitored wild populations, and have had documented successes in multiple areas of biological management, including using cross-fostering as a release strategy, managing hybridization, and using adaptive management to grow to a population of nearly 150 wolves representing all 12 extant founder lineages. While some parts did not succeed, we learned a lot.

APPENDIX B: SUMMARY STATEMENTS FROM RECOVERY TEAM MEMBERS

Team Member	Things We Can Live With	Things We Oppose
David Cobb	Commission resolution items: The Commission has called for consideration of RW as extinct in the wild. Terminating the free-range program NENC project. Repealing federal rules that call for red wolf restoration and designating conditions for restoration in NC. Designating all wild canids other than foxes as either coyotes, or coyote hybrids. Designating there are no federal trust canids on the Albemarle Peninsula. Designating all wild canids are state trust resources under the jurisdiction of WRC. Removal of 64 wolves released on private lands. **Other Items:** Supporting continuing social science and opportunities to learn as the program is wound down. Learnings that could benefit future introduction sites. Support for SSP. Red wolf as a listable entity. NC inclusion in red wolf historical range.	Termination of the Red Wolf Recovery Program.

APPENDIX B: SUMMARY STATEMENTS FROM RECOVERY TEAM MEMBERS

Team Member	Things We Can Live With	Things We Oppose
Christopher Serenari	Terminating the project in NENC as it is currently designed or scaling back and overhauling the program because of current cultural, political (governance and policy), and legal conditions. There has been measurable erosion within these domains creating a difficult context for the red wolf to persist. My research does not indicate that these trends are moving in the reverse and are compounded by the coyote hunting ban, lawsuits inciting social tensions, undemocratic processes, and the schism between the USFWS and WRC, influencing doubt, intolerance, mistrust, and illegal behavior. Taking the long view, and considering a scale back, future research (e.g., WRC large-N survey) may reveal that AP citizens support the RWRP in bigger numbers than some think, while also revealing ways to improve governance. Interview data indicated that younger generations may also be more accepting of the RW on the AP, while older generations tended to be opposed. We must remain open to these openings to initiate change, as well as the possibility that the USFWS will someday design and implement a sustainable carnivore governance model focusing on equity, liberty, security, and efficiency for the benefit of citizens and RWs and that renders past & current programmatic ills irreplaceable. Current and future "biological conditions" (e.g., refuge characteristics, climate change) don't point to a sustainable model for the program to continue, even as a conservation reliant species. This is my nail in the coffin for the NENC project.	Completely shutting down the RWRP in NC or elsewhere in the historic range for four reasons: • Societal values are changing and "society", including many interviewed AP residents, will tolerate carnivores/RWs on the landscape—terminating such an effort entirely sets detrimental precedent for future carnivore recovery efforts; • Private lands are increasingly required for carnivore conservation efforts (can't ignore it, must find a way to embrace it); • Democratic processes in wildlife conservation are increasingly popular and effective; a new paradigm is required for large carnivore conservation in the US and the NENC case is a heuristic for an innovative governance model that embraces power sharing, flexibility, and policy innovation; Interview results suggest people can tolerate RWs living on public lands if USFWS actively removes RWs from private lands, citizens can shoot or trap coyotes at will, and USFWS overhauls current RW governance model

APPENDIX B: SUMMARY STATEMENTS FROM RECOVERY TEAM MEMBERS

Team Member	Things We Can Live With	Things We Oppose
Pete Benjamin	Thanks to everybody. This was a tremendous challenge going in with a very different type of task…and a short timeline to accomplish. I appreciate your willingness to participate in difficult and challenging discussions. Thank you. I have learned much about red wolf, the future of the overall project and NENC program through these discussions. I support securing the SSP into the future. I support continued social science work and large sample size study. We'll learn more from that. I support a set of common steps for winding down NENC. Support going forward with a different management paradigm for how we deal with predators and predator reintroductions. We will take a hard look at lessons learned and do something different. Innovation in the way we deliver programs is needed. Opportunities to leverage successes and failures to chart a new course. It would be a shame if we don't use this for the benefit of other species. We face similar challenges with other species. I support a change to our current efforts (i.e. gaining control of population in a managed and humane fashion) done in cooperation with State and private landowners. This needs to be inclusive/transparent and be date certain. Provided the time frame is adequate to do it right. I support taking advantages of continuing to learn (wolf/coyote interaction; managing predator reintroduction that inform the next steps: either an alternative site or sealing the future of the animal. Articulating what we're doing next would be critical.	The status quo. I oppose rule changes that are not feasible; rule changes that "feel good but don't work."

APPENDIX B: SUMMARY STATEMENTS FROM RECOVERY TEAM MEMBERS

Team Member	Things We Can Live With	Things We Oppose
Mike Phillips	Termination of NENC reintroduction project. An effort to update red wolf recovery plan, which is essential and long overdue. An effort to modify the red wolf captive breeding program to promote greater expression of the gray wolf component of the red wolf genome as manifest by a substantial increase in the average body size of red wolves. Situating some of the currently free-ranging red wolves that are excess to the viability of the captive breeding program in secure settings of federal land where separation from coyotes can be sufficiently assured through management (e.g., mainland Dare County) or because coyotes are absent from the area (e.g., Bulls Island). A discarding of the Department of Justice's McKittrick policy, which is essential to red wolf recovery.	Coyote harvest in the area is very carefully monitored. Another reintroduction project before research has been completed to determine the relationship between red wolf body size and the frequency of hybridization with coyotes. Continued failure by the USFWS and Department of Justice to pursue and prosecute cases of red wolves being illegally killed. Any free-ranging red wolves that are excess to the viability of the captive breeding program being euthanized or permanently placed in captivity. The USFWS abdicating their mandated duty to recover the red wolf by giving private landowners management authority over free-ranging red wolves that are not causing demonstrable problems
Eric Gese	Discarding the McKittrick policy – illegal killing needs to be reduced and prosecuted. Recognition of the red wolf as a listed species. Recognition that NC is within the historic range of the red wolf. Recognition that the program that was in place 5 years ago had successfully increased the wild red wolf population to over 100 individuals. Designation as "conservation reliant" would be needed and resources maintained in any effort to reintroduce red wolves in the future in other recovery areas.	Termination of the NENC experimental population – it was working several years ago with 100 wolves in the recovery area. By the USFWS "waiting" on the review, they essentially made the decision at that time to allow the program to degrade. Increased landowner participation and agreements must be pursued in any future efforts. Allowing politics to override science. Setting a precedent within the USFWS that a minority of local landowners can get a national recovery program terminated.

APPENDIX B: SUMMARY STATEMENTS FROM RECOVERY TEAM MEMBERS

Team Member	Things We Can Live With	Things We Oppose
Lisette Waits	Scaling back current NENC recovery effort to address the legal and social problems in the region IF there is a clear plan in place to protect remaining wild “pure” red wolves so they can be used for release into a new recovery area and/ or used for captive breeding on island sites. I support financial incentives for landowners and trappers to be involved in the transition process. Need to revise current recovery plan and work quickly to identify possible new recovery areas. I support securing the SSP into the future Human dimensions research and local partnerships are essential for future programs to succeed and should be funded/supported. I support research efforts to evaluate current amount of introgression into wild red wolf gene pool as a result of changes to field efforts and increased red wolf mortality or other studies that would provide valuable information for future release efforts.	The Status Quo. Immediate removal of red wolves from current recovery area and/or euthanasia of animals on private land. We need a good clear plan that protects the valuable animals that remain.

APPENDIX B: SUMMARY STATEMENTS FROM RECOVERY TEAM MEMBERS

Team Assumptions
Humanely deal with wolf populations as we're winding down
Take advantage of research and opportunities to learn
Designing and articulating what specifically we're going to do with the landowners and community as the program winds down
Build new biological and sociological components
Determine what we're going to do with the animals. Where will the wild population be?
Utilize wild wolves for planning new restoration sites
Address rule making needs and policies for dealing with the animals
Develop a messaging and public relations communication strategy that supports future restoration

APPENDIX C: LESSONS LEARNED & FAQs

A summary of lessons learned and frequently asked questions (FAQs) was complied by Mr. Pete Benjamin of the USFWS.

There is an African proverb that says, "If you want to go fast – go alone; if you want to go far – go together." In the case of red wolf conservation, the U.S. Fish and Wildlife Service (Service) went too far alone. The bottom line is that our people and our agency were primarily focused on confronting and overcoming the multiple urgent scientific challenges posed by red wolf conservation at the expense of addressing the equally daunting social and political issues surrounding wolves.

First we must take a moment to recognize the successes. We successfully established a captive breeding program to ensure the survival of the species. We achieved the first successful re-introduction of a large carnivore that had been declared extinct in the wild. We pioneered the use of placeholder animals to manage genetic introgression between species. We grew a wild population from nothing to approximately 130 animals. These are conservation milestones of which we are very proud.

In terms of the human dimension it is a gross oversimplification to say the Service went at this alone. The successes listed above and many others were achieved by and with a multitude of great scientists and conservation partners. Additionally, our biologists have built meaningful and lasting relationships with many leaders and landowners throughout the Albemarle Peninsula of eastern North Carolina. We value those relationships and the contributions of all these individuals and organizations.

Nonetheless, throughout the history of the reintroduction effort key constituencies were left behind, and too many important decisions were made by the Service without appropriate and adequate dialogue and collaboration. Communication is important in most if not all conservation initiatives; however, it is particularly important when it comes to wolves, because of the intense cultural, social and economic values linked to these iconic animals. The wolves of North America were very nearly persecuted to extinction, and their continued survival and recovery depends entirely on the decisions and actions of people.

Wolves mean very different things to different people depending on our individual interests, experiences, and values. The farmer, hunter, environmentalist and business leader all view the wolf through a different lens. In areas such as Yellowstone National Park the grey wolf is a leading attraction for tourists and thus provides an economic benefit. To ranchers in the area around Yellowstone the wolf is a threat to livestock and an economic liability. To the farmer the wolf helps control deer that threaten crops, but to the hunter the wolf is a competitor for game. To the environmentalist the wolf is the embodiment of wilderness. All are reasonable points of view based on the differing perspectives and values of these different segments of society. These views are not mutually exclusive and Individuals and organizations representing all these varied interests have a stake in decisions regarding wolf conservation.

Because of the intensity of interests from all angles regarding wolves, wolf conservation efforts must seek to include all stakeholders in the process of crafting and implementing wolf conservation programs. This is particularly true of red wolf conservation because not only is it a large carnivore introduction effort, it is a carnivore reintroduction effort that must necessarily include a large segment of private lands. Unlike the western United States, the Southeast (which is the former range of the red wolf) is overwhelming comprised of private lands. So private landowners and the local organizations and governments that represent their interests must play a greater role in red wolf conservation, and as such must have a greater voice in the design and delivery of red wolf conservation programs.

This did not happen consistently throughout the history of red wolf recovery efforts on the Albemarle Peninsula. To be sure there were public notices and meetings at key points in the 30-year recovery effort. Landowners were consulted and relationships were built as mentioned above. But a structured process for routine consistent dialogue and community engagement in the development and implementation of the program was lacking.

On a few occasions the affected public were offered opportunities to ask questions and express concerns, but rarely if ever, were they afforded an actual voice in the decision-making process. ,

This is important because the nature of the red wolf recovery program in eastern NC has changed repeatedly over the years as our scientific understanding of red wolves has evolved. This led to several important decision points and forks in the road where the Service acted unilaterally or in consultation with mostly our science partners, but without the community as a whole. The result is that important constituencies came to feel isolated and left out of the process, unclear regarding the direction and intent of the Service, and questioning of our decisions and motives. When this is allowed to persist with an issue as intensely value-laden as wolf conservation opinions quickly become galvanized and politically charged. Trust is lost and our efforts grind to a halt.

Henry and Lucash (2000) summarized lessons learned through the first 12 years of the red wolf reintroduction efforts in eastern NC and the Great Smoky Mountains National Park. These lessons included recognizing the importance of private lands, taking steps to minimize conflicts with other land uses and practices, the need for public outreach and state agency involvement, and the need for transparency and consistency in our actions. While these lessons have been acknowledged it is clear that the Service has not taken these lessons sufficiently to heart to produce a lasting change in the relationship between the agency, the community and other key partners.

To go forward toward the distant goal of red wolf recovery we must go together. That means slowing down as an agency and embracing a process that engages all stakeholders in as much dialogue and debate as is necessary so that we may take each successive step as one.

Part of slowing down is taking stock of the lessons learned from our experiences to date. In addition to the overarching themes expressed above there are a number of specific issues and events that can serve as teachable moments. These are discussed below.

A. Communication of Government Intent

When the northeastern North Carolina red wolf non-essential experimental population (NENC NEP) was first established in 1986, the Service said that the wolves would be managed on federal lands (Alligator River National Wildlife Refuge and Dare County Bombing Range) and would pose no threat to, and place no encumbrances upon, private lands. This commitment was based on our understanding at the time of red wolf ecology, which was based on limited observations of the habitat use, movements, and diets of the few wolves that existed in southwestern Louisiana and southeastern Texas. Our assumptions quickly proved unfounded as wolves soon left the Refuge and we discovered that their habitat preferences and space needs were much different than we originally believed.

This created two problems. First, as we altered our management practices in response to our rapidly changing knowledge of red wolf ecology we fundamentally altered the premise upon which the relationship between the red wolf and the community was founded. Wolves that were supposed to be confined to the Refuge were now routinely, even predominantly, occupying private lands. The fact that we did not immediately and publicly acknowledge and correct our error created problems that persist to this day.

Hindsight is of course 20-20, and it is not fair to criticize the work of program staff who were undoubtedly doing great work to deal with a very complicated, challenging and unprecedented reintroduction effort. We know now that as soon as wolves began leaving the Refuge we should have made a public statement of our changed understanding of red wolf habitat and space needs, and should have engaged the community in a dialogue of the meaning of this new information to the recovery effort and its relationship to the community. In 1993 we published a review of the first 5 years of the reintroduction effort in the Federal Register (58 FR 62086, November 24, 1993). This notice talked briefly about wolves inhabiting private lands and referenced a series of meetings that were held to discuss the findings of the review with the public and local officials.

It does not indicate that public concerns were taken seriously. Instead, it took until 1995 (nearly 8 years) for the Service to change its rules to better reflect the extent to which wolves used private lands and even that process did not provide a full accounting of our original miscalculation (60 FR 18940, April 13, 1995); nor did the rule-making process sincerely engage the community in the process of determining how to proceed in light of this new knowledge. In the minds of many within the community this was an example of the government saying one thing and doing another, which served to undermine our credibility and degraded public trust in our agency.

Lesson 1: Any high profile endangered species reintroduction effort (especially involving predators on private lands) must be accompanied with early and frequent communication regarding all aspects of the program. The community must be made aware and engaged in issues as they arise and be continually informed as new information comes to light and adjustments are needed in program implementation. A standing community forum or similar body should be a standard component of any such reintroduction effort.

Second, being wrong about these fundamental early assertions regarding red wolf ecology undermined our scientific credibility early in the recovery effort in the minds of many in the community. If we could be this wrong about such fundamental aspects of red wolf ecology, how could the community be expected to put faith in our findings regarding more complicated aspects of red wolf conservation including taxonomy, management of hybridization, and predator-prey relationships? This could have been addressed had we been more forthcoming about what we were learning about red wolf ecology and engaged the community is a dialogue regarding the consequences of this new information.

Lesson 2: Do not overstate what we know or understate what we do not know.

B. Communication of Scientific Uncertainty and Management Precision

Related to Lesson 2 is the inherent difficulty in conveying the limitations of scientific findings and the uncertainty surrounding conclusions that are drawn from research. This extends to communicating the precision with which our monitoring efforts inform us of the true status of the population at any given time.

Every study has limitations. Additionally, different studies may lead to differing conclusions. The collective body of scientific information regarding the red wolf provides a large number of insights with varying degrees of uncertainty and remaining areas of relative ignorance. When conveying scientific information to the public it can be difficult to explain things concisely while also providing the appropriate context.

Often a finding is reported accurately at first (including the necessary caveats and limitations) but over time the caveats and limitations become divorced from the finding, leading to statements that convey an inappropriate sense of certitude. For example, there has been a large body of scientific research on canid taxonomy, which is a very complicated subject. The techniques used to classify species have evolved from morphometric-based classification techniques of the 20th century to highly advanced and specialized genomic analyses of the 21st century. Many efforts have been made over the last 100 years to answer the question: "Is the red wolf a distinct species?" A careful objective analysis of the entire body of work related to this question leads to the conclusion that the most appropriate answer is "we don't know". Yet, the Service has been guilty of making statements that over-emphasize studies that support the red wolf as a distinct species; just as others have over-emphasized studies that do not support the species designation. The Service also falls victim to government-speak. Oftentimes, when we have attempted to communicate scientific findings regarding the red wolf to include all the appropriate nuances and uncertainty, we have used bureaucratic jargon and other cumbersome language that renders the message nearly indecipherable to the reader.

The public needs information to be clear and concise yet complete. Overstating or understating the limits of our knowledge leads to miscommunication which in turn leads to trouble.

Just as failure to acknowledge mistakes as new information comes to light undermines credibility (Lesson 2), so too does failure to carefully stay within the bounds of what the entire body of scientific knowledge will support. Accuracy must not be compromised for the sake of simplicity. Albert Einstein is reported to have said: “Everything should be made as simple as possible, but not simpler.”

Lesson 3: Be clear and concise when relaying scientific information to the community, while also explicitly convening the limits of our knowledge.

C. Transparency

There have been several instances in the history of the reintroduction effort where the Service made significant changes in program management, but only informed the community after the fact if at all. Examples include the decision to stop proactively removing wolves from private lands, the decision to enter into agreements with landowners to allow for management (including releases) of wolves on private lands, the arrival of coyotes in the NENC NEP area and our decision to deploy sterile placeholder animals to manage hybridization. Additionally, other aspects of program management are not well-documented or communicated to the public. For example, the means by which we monitor the population are not widely known or understood. Most wolves and placeholder are equipped with radio collars. This leads to a public perception that we have the ability to know where every wolf and placeholder is at any given point in time, which is not the case. We have not clearly articulated the specific purposes of our monitoring efforts or the limitations of the information gained via those efforts.

When people do not know what a federal agency is doing they tend to speculate, and they almost never speculate positively. The absence of clear, timely information from the Service provides a breeding ground for suspicion and mis-information that if left untreated (as has been the case with the red wolf reintroduction effort) leads to distrust and loss of confidence. Today, certain segments of the community believe we are determined to expand the range of the red wolf throughout North Carolina and beyond, while other stakeholders believe we are managing the wild population to extinction. Neither is accurate, but how is anyone to know given the lack of accurate and timely information from the Service?

Lesson 4: State clearly what you intend to do before you do it, and then follow through.

These lessons are easy to acknowledge and understand, but difficult to adhere to on a day-to-day basis. Nonetheless, the consequences of not abiding by these lessons consistently and faithfully are so detrimental to the Service, the species in our trust, and the communities we serve that they constitute mission imperatives. Failure to heed these lessons, even for a day, has negative consequences that can last for years.

APPENDIX C: LESSONS LEARNED & FAQs

Frequently Asked Questions

Through this process a number of recurring issues and questions have emerged. In addition to the broad lessons above there are a number of specific issues, questions and concerns that have been raised repeatedly by members of the Red Wolf Recovery Team, community, and other stakeholders. Here, we offer responses to those issues to the best of our ability.

1. What evidence supports historic red wolf presence in NENC?

The Wildlife Management Institute (WMI) was recently asked by the Service to conduct a review of information related to the historic range of the red wolf. The report (Wildlife Management Institute 2016) included the following findings: 1) The previous range maps developed and used by the Service for the Red Wolf Recovery Program were too restrictive; 2) The lack of documented records for red wolves in the Carolinas, Virginia, and Georgia were due to poor recordkeeping and/or specimen preservation by early settlers, since other historical documents indicated the presence of a wolf species occupying those areas during settlement; 3) Coyote introgression into the historic range of the red wolf, driven by systematic extirpation of red wolves and human-related coyote movement, historically and continues to be a confounding factor on range determination for the red wolf; 4) Several Level II ecoregions, including all or parts of the Mississippi Alluvial and Southeast USA Coastal Plains, Ozark/Ouachita-Appalachian Forests, South Central Semi-Arid Prairies, Southeastern USA Plains, and the Texas-Louisiana Coastal Plains are accurate predictors of historical red wolf range.

2. Is the red wolf a valid taxonomic species?

The correct taxonomic classification of the red wolf was considered by the Recovery Team to be a threshold issue in two senses. First, in order to be eligible for protection under the Endangered Species Act (ESA) a listable entity must be classified as a species, subspecies or Distinct Population Segment (DPS)(Endangered Species Act of 1973, as amended; 50 CFR 424.02). The correct taxonomic classification of the red wolf has long been a point of scientific debate and resolution of this question is fundamental in terms of the status of the species relative to the ESA. Second, ongoing human dimensions research (Serenari, in prep.) suggests that a fundamental component of community support for red wolf conservation efforts is a sense within the community that the red wolf is a valid part of the area's natural heritage. In other words, in order to support conservation efforts the community must first believe that the animal represents a valid taxon and it belongs in that part of the landscape.

If the red wolf is a distinct taxon suitable for listing under the ESA (species, sub-species or Distinct Population Segment) then the Service is obligated under the ESA to pursue its recovery in the wild. If it is not then the Service should pursue delisting.

The most recent Service-sponsored publication on the topic of red wolf taxonomic status is the WMI report (WMI 2014). Though WMI was not asked to look at the taxonomic issues in their review they indicated that the issue arose repeatedly with people they talked to, so they hired Dr. Randy Young to review the existing literature on the subject. Dr. Young provided an assessment of many aspects of red wolf genetics including taxonomy, hybridization, inbreeding, and related management strategies. On the specific issue of the taxonomic classification of the red wolf, after reviewing the relevant scientific literature he said that although the hybrid origin hypothesis (the idea that the red wolf is not a distinct species but rather derived via hybridization between grey wolves and coyotes) cannot be conclusively refuted: "Recent genetic data have cast doubt upon the hybrid origin hypothesis and the balance of evidence has tilted towards a North American canid assemblage composed of the eastern wolf, the red wolf, and the coyote as distinct taxa that are descended from a common ancestral canid of North American origin."

So, the short answer is "we don't know." That said, we do not have sufficient evidence to draw any conclusion other than that the red wolf is a distinct species suitable for listing under the ESA. Research is ongoing, but it did not shed additional light within our evaluation timeframe. Any action the Service takes should be based on that finding. The Service also needs to be aware that ongoing or future research may definitively demonstrate otherwise, at which point the Service should be prepared to act on that information and remove the animal from the List of Threatened and Endangered Species.

3. Can a wild population of red wolves be self-sustaining without active management for hybridization?

The honest answer is we do not know. The goals laid out in the Red Wolf Recovery Plan (establishing three wild populations with approximately 220 animals) are based on the premise that a red wolf population that is large enough and stable enough would be able to sustain itself against introgression with coyotes. This appears to be the case with the eastern wolf (C. lycaon) of eastern Canada. It too is intermediate in size between grey wolves and coyotes and hybridizes with both species. Yet, within Algonquin Provincial Park it is able to sustain a core population that appears stable.

It is an open question whether the red wolf can do the same. It can certainly be said that such a situation has not been observed to date. The Service believes that in the period around 2005 the NENC NEP population was approaching a size and configuration (approximately 130 animals in about 20 packs) that may have been sustainable; though this was never demonstrated. Since that time the population has been in decline due primarily to increased loss of breeding animals to anthropogenic sources (primarily gunshot). The increased loss of breeders causes instability in the social structure of wolf packs that facilitates hybridization.

The question remains whether there is any set of conditions that would enable a large stable red wolf population to sustain itself against hybridization with coyotes or whether the red wolf is a conservation-reliant species that will perpetually require intensive management in the wild.

4. Do other areas for establishing experimental red wolf populations exist?

The Service is not currently in discussions with any other state wildlife agencies or other parties regarding the establishment of additional NEP sites. Prior to actively pursuing establishment of additional sites some key pieces of information are needed. As mentioned above the Service needs to determine to what extent the red wolf is a conservation-reliant species. Before additional populations are established the Service needs to have a better sense of the extent to which a perpetual federal commitment will be needed to sustain those populations and the level of commitment and management needed from state, community, and other partners. **It is the view of the Recovery Team that it would be imprudent to establish additional populations without a cle**arer understanding of the long-term committment that will likely be needed to sustain them.

Concluding that the red wolf is a conservation-reliant species that would need continuous intensive federal management to sustain wild populations would not mean that the Service should forego establishment of additional wild populations. It does have serious implications in terms of the long-term commitment of Service resources and the commitments that would need to be sought from state and local partners. Additionally, the extent to which the red wolf is a conservation –reliant species influences site selection criteria. For example, if it is determined that a large well aggregated red wolf population is able to sustain itself against genetic introgression, then suitable additional sites would need to be of sufficient size to support a large well-aggregated population. If, on the other hand, it is determined that sustaining red wolves in the wild will require intensive perpetual management to address threats to the species, then smaller more easily managed and controlled sites may be more appropriate.

5. Why aren't wolves staying on Service refuge lands?

This is a classic example of Lesson 2 (be clear about what we do and do not know). Based on our limited early knowledge of red wolf habitat use and home range sizes, which was derived from limited observations of red wolves along the Gulf Coast, we believed that the dense forested wetland habitat of Alligator River NWR was the preferred habitat of the red wolf and that the Refuge would support a sizable population. We soon learned that this was incorrect, but because we failed to pay heed to Lesson 1 (engage the community), we did not quickly or accurately relay this information to the community. The fact is that the dense, forested wetland habitat that comprises the majority of our National Wildlife Refuges in eastern North Carolina is not the preferred habitat of the red wolf. Rather, wolves prefer lands that offer a mixture of forests and agricultural areas that support their preferred prey (white-tailed deer, raccoons, and smaller mammals such as rabbits, rodents and nutria).

This is not to say that refuge lands are unimportant. The refuges do provide habitat for wolves (particularly where they adjoin farmland). Moreover, the refuges provide areas where the Service can do many of the things needed to manage the population such as temporarily housing animals, establishing acclimation pens prior to the release of animals into the wild, releasing animals that have been removed from private lands in response to landowner concerns, and conducting research.

6. Why are wolf populations failing to keep coyotes from encroaching into new areas?

This is an example of the Service overstating what the scientific information indicates (Lesson 3). Wolves do compete with coyotes for territory; however, it is an oversimplification to state or imply that wolves will completely exclude coyotes from an area. Coyotes are highly adaptable, they are generally smaller than wolves, and do not depend on a pack social structure to the degree wolves do. For these reasons coyotes are able to occupy smaller spaces between and around the periphery of wolf territories. Wolves, being larger, predominate when the two species compete directly, but that is not to say that an area inhabited by wolves will be devoid of coyotes. Additionally, dispersing coyotes are continuously traversing the landscape in search of available space and as such may be encountered nearly anywhere at any time.

7. Why have Alligator River National Wildlife Refuge and the Pocosin Lakes National Wildlife Refuge been rehydrated? It appears to have made this habitat unsuitable to support red wolves.

The Service has been working to restore a more natural hydrologic regime to Pocosin Lakes and Alligator River NWRs to improve habitat quality, reduce the risks of catastrophic wildfires, and enable the ecosystem to adapt to stresses caused by climate change. Landowners adjacent to Pocosin Lakes NWR have expressed concern wetland restoration work on the Refuge has increased water levels and rendered the area too wet to be suitable red wolf habitat. This, they allege, has caused wolves to move onto private lands. These allegations are unfounded. The Refuge consists of 110,000 acres. To date the Service has restored approximately 20,000 acres of wetlands on the Refuge and the overall project calls for restoration of approximately 30,000 acres. Even assuming that all restored wetlands would be unsuitable wolf habitat there would be approximately 80,000 acres of unaltered habitat available to red wolves. Additionally, because the goal of the restoration project is to recreate seasonally saturated soil conditions (not inundation), the majority of the restored wetland areas remain accessible and suitable for terrestrial wildlife including wolves. Our data indicate that the proportion of the overall red wolf population using Refuge lands has remained approximately unchanged as the hydrology restoration work has progressed.

Approximately 30 to 35 percent of red wolf packs have at least a portion of their territories on Refuge lands. This is approximately the same proportion that used Refuge lands prior to the hydrology restoration activities. There are in fact fewer wolves using Refuge lands today than there were 10 years ago because the overall size of the red wolf population has declined from a peak of about 130 wolves to a present size of about 45 to 60 wolves. There are more wolves on private lands because the mix of forest and agriculture on these lands is more attractive to red wolf prey species.

8. What evidence supports Adaptive Management and Placeholder Theory? Why isn't it working better?

The Adaptive Management Plan (Rabon *et al*., 2013) was developed for the express purpose of managing coyote genetic introgression into the red wolf population. Its components include careful monitoring of the population to identify hybrid animals and either removing them from the population or sterilizing and releasing them for use as placeholder animals. It also includes an active research effort to assess the effectiveness of management actions so that adjustments can be made as needed. The research has shown the plan to be effective in limiting hybridization. Bohling *et al*. (2016) found that the current NENC NEP red wolf population contains about 4 percent coyote DNA, and this percentage was actually decreasing up through the time their field work was conducted (2014). This is not to say that hybridization does not occur. Our monitoring of red wolf dens has identified approximately 2 hybrid litters per year in the NENC NEP and there could be more as not all dens are able to be located and accessed. Hybrids are produced, but the rate of hybridization is not significantly affecting the integrity of the red wolf genome due to the Adaptive Management Plan.

The above notwithstanding, the Adaptive Management Plan has limitations. It is labor intensive as noted by the WMI (Wildlife Management Institute, 2014). Additionally, it is important to recognize what the Adaptive Management Plan is and is not. It is a plan 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. It is not intended to control coyote populations. Our ability to implement the Adaptive Management Plan effectively is proportional to our staffing levels and access to wolf packs throughout the NENC NEP area. Implementation of the Adaptive Management Plan does not alter the quality of habitat on Refuge lands. It, in and of itself, cannot address the continued loss of wolves to human-related mortality. The decline in the NENC red wolf population in recent years is less a reflection of a failure of the Adaptive Management Plan to address hybridization as it is our failure, to date, to develop effective and acceptable means to work with landowners and manage human-related mortality without compromising property rights, altering hunting and trapping opportunities or otherwise placing unwanted responsibility for wolf management on the landowner.

9. Why are wolves are not being maintained on federal lands as promised in the federal rules?

514 landowners have now demanded to not have wolves on their land, many of these had signed "partner agreements" and received compensation from the Service. Large tracts have pulled all support for this recovery program based upon unkept promises and commitments.

During the summer of 2014 FWS received a surge in requests to remove wolves from private lands. Our records indicate that we received 405 such requests. We followed up on each and every one. Our records indicate that 24 of the requests represented duplicate requests from the same address (e.g., husband and wife submitting identical requests on or about the same date). Forty-three requests contained no contact information and we were unable to identify the senders. We received no response to repeated attempts to contact 282 requestors. Fourteen requestors contacted indicated that they thought they were signing a petition to protest the NCWRC coyote hunting rules, but had no wolf issues on their lands. An additional 25 requestors reported no problems with wolves on their lands at the time but would contact us if the situation changed. Our staff conducted surveys of 21 properties at the landowner's requests and found no evidence of wolf presence. Those landowners requested no further action. We received no further response from 5 landowners following our original contact with them. Two landowners would not allow access to their property so we could follow-up on their requests. We ended up working with 13 landowners to address concerns regarding wolves using their property.

We are working diligently to uphold our commitments to landowners and work within our 1995 regulations.

10. Why is Service continuing to ignore landowner requests?

See response to Number 9 above.

11. Why have the goal posts moved? The Service must be honest about the end goal of any reintroduction.

Refer to the discussion above under "B. Communication of Scientific Uncertainty and Management Precision" and Lesson 3. There is a misconception (due to our inadequate efforts to inform the public of our actions and their purposes) regarding the level of precision in our monitoring efforts. We do not know the location of all the wolves in the population with the level of specificity that would be necessary to accurately inform all landowners of the presence of wolves on their lands at any point in time. Our routine monitoring is intended only to confirm that wolves are alive and within the general vicinity of their known territories, which may encompass many square miles. During breeding season, we monitor locations of breeding pairs more closely in order to local suspected den sites. If a suspected den is located through radio telemetry we will conduct ground searches. If the suspected den is located on private property we do notify the landowner at that time in order to seek permission to access the property. If access is granted we routinely communicate with the landowner regarding our findings.

Executive Summary: Workshop on Interactions of Human-Caused Mortality, Genetic Introgression, and Management among Wild Red Wolves: Developing Scientific Consensus

Held at the Marriott Hotel in Atlanta, Georgia,

On May 24 – 26, 2016

Prepared by the Workshop Planning Team

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 mostly 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.

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. 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 aboutwolf/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 main contribution of the workshop was the evaluation of the main competing evolutionary origin hypotheses for the red wolf. Specifically, whether the red wolf was a listable entity under the ESA. 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 origin 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 determination, of course, depends 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 origin 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 in the scientific literature. Ideally, an unbiased and qualified group could pursue this next step, but this was not something this group could effectively evaluate in an unbiased fashion and therefore we withheld from expressing degree of support for the different hypotheses.

The agreed upon summary of the workshop 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, and 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.

This workshop was one component of the Service's information gathering process for the Red Wolf Recovery Program. Information gathered during the workshop will be used by the Service in conjunction with other published literature or information submitted by interested parties to evaluate the status of the Red Wolf Recovery Program. The Service is committed to using the best available scientific and commercial information, and will incorporate new information as it becomes available.

A Review and Evaluation of the Red Wolf (*Canis rufus*) Historic Range

Final Report – 5/25/2016

Wildlife Management Institute, Inc.
2016

Executive Summary

The United States Fish and Wildlife Service (USFWS) contracted with the Wildlife Management Institute (WMI) to conduct an independent review and evaluation of the historical range of the red wolf (*Canis rufus*). At the direction of the USFWS, the review focused specifically on using the best available data to presumptively determine an accurate depiction of the historic range. WMI reviewed more than 600 data points to develop this report, which is an evaluation and synthesis of the scientific literature referencing red wolf locations, as well as documented museum specimens. In addition, WMI reviewed historical accounts and records to document the presence of red wolves. Although the historical records primarily referenced "wolves" in the Southeast, based on the physical and written evidence we discovered and the overlap of those specimens within defined ecoregions, WMI concluded that historical references to "wolves" within the range, referred to red wolves. While reviewing the data and literature, WMI also documented the introgression of coyotes (*Canis latrans*) into the historic range of the red wolf, since hybridization between the two likely played a role in the shifting historic range.

WMI conducted an extensive review of applicable data to create a comprehensive historic range for the red wolf. This search included peer-reviewed journal articles, books, historic references, government documents, and museum records. The search was conducted in several steps, and the results were entered into a database that was used to geospatially identify the range of the red wolf prior to its extirpation. Based on our review of the literature and museum records, mapping the known historical locations of red wolves demonstrated that their range included many of the Atlantic states, the southeastern U.S., Texas and Oklahoma, and the lower Midwestern U.S. The bulk of documentable location data was from Texas, Oklahoma, Louisiana, Arkansas, and Missouri, with fewer records being found in other range states.

The review of the historic red wolf range undertaken by WMI at the request of the USFWS makes the following findings: 1) The previous range maps developed and used by the USFWS for the Red Wolf Recovery Program were too restrictive; 2) The lack of documented records for red wolves in the Carolinas, Virginia, and Georgia were due to poor recordkeeping and/or specimen preservation by early settlers, since other historical documents indicated the presence of a wolf species occupying those areas during settlement; 3) Coyote introgression into the historic range of the red wolf, driven by systematic extirpation of red wolves and human-related coyote movement, historically and continues to be a confounding factor on range determination for the red wolf; 4) Several Level II ecoregions, including all or parts of the Mississippi Alluvial and Southeast USA Coastal Plains, Ozark/Ouachita-Appalachian Forests, South Central Semi-Arid Prairies, Southeastern USA Plains, and the Texas-Louisiana Coastal Plains are an accurate predictor of historical red wolf range.

This report is 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. The report represents the views of the authors and not necessarily those of the USFWS.

Table of Contents

Executive Summary 2
Table of Contents 3
List of Figures & Tables 4
Overview & Purpose 5
Background 6
Methodology 7
Literature Review 10
Discussion & Analysis 12
Findings 19
Conclusions 19
Appendix A. Literature Cited 24
Appendix B. State-Level Occurrence Maps 30
Appendix C. Biographies of Review Participants 44
Appendix D. USFWS/WMI Contract 45
Appendix E. Source and Spatial Databases (Red Wolf & Coyote) 47

List of Tables & Figures

Figure 1. Range of the red wolf as initially delineated by the USFWS (National Fish and Wildlife Laboratory, 1980) in the recovery plan. County level documented locations based on this review are identified by 10-year interval as reference 13

Figure 2. Range of the red wolf as initially delineated by the USFWS (National Fish and Wildlife Laboratory 1980) and later revised (after Paradiso & Nowak, 1972) in the recovery plan. County level documented locations based on this review are identified by 10-year interval as reference 14

Figure 3. Temporal introgression of coyotes into the southeastern U.S. as determined by literature review and examination of museum specimens 18

Figure 4. Ranges of North American Canis lupus subspecies and of C. rufus (after Nowak, 2002) 20

Figure 5. Known county level locations of red wolves based on the results of the current review, which examined documented literature references, museum specimens, and historical documents 21

Figure 6. Five Level II Ecoregions (Mississippi Alluvial and Southeast USA Coastal Plains, Ozark/Ouachita-Appalachian Forests, South Central Semi-Arid Prairies, Southeastern USA Plains, Texas-Louisiana Coastal Plains) that encompass most of the known historic locations of red wolves 23

Figure B-1. Historic locations of red wolves in Alabama 31
Figure B-2. Historic locations of red wolves in Arkansas. 32
Figure B-3. Historic locations of red wolves in Florida. 33
Figure B-4. Historic locations of red wolves in Georgia, North Carolina, South Carolina 34
Figure B-5. Historic locations of red wolves in Illinois, Indiana, Kentucky. 35
Figure B-6. Historic locations of red wolves in Louisiana 36
Figure B-7. Historic locations of red wolves in Maine, New York 37
Figure B-7. Historic locations of red wolves in Mississippi. 38
Figure B-8. Historic locations of red wolves in Missouri. 39
Figure B-9. Historic locations of red wolves in Pennsylvania, Virginia, West Virginia 40
Figure B-10. Historic locations of red wolves in Oklahoma. 41
Figure B-11. Historic locations of red wolves in Kentucky, Tennessee. 42
Figure B-12. Historic locations of red wolves in Texas. 43

Overview & Purpose

The Wildlife Management Institute (WMI) was established in 1911 with a mission to provide leadership and advocacy for the enhancement, conservation, and professional management of wildlife and its habitat. Our mission remains unchanged today. WMI has a 105-year tradition of science-based wildlife management, which values wildlife as a public trust resource, habitat as necessary for wildlife, and conservation education. During our history, WMI has conducted more than 70 independent reviews of state and federal fish and wildlife programs.

In the fall of 2015, WMI signed a contract with the United States Fish and Wildlife Service (USFWS) to conduct a review and evaluation of the historic range of the red wolf. The period of performance for this contract was October 30, 2015 to September 30, 2017. The contract clearly spelled out the components of the project (Appendix D) to include an evaluation of three data sources: reports of red wolves in the peer reviewed literature; museum records of red wolves with documented locations; and ancillary historical reports such as journals, county records, bounty records, etc.

WMI approached this review with the understanding that our evaluation should include findings and conclusions based on the best available science, including peer-reviewed literature, museum records, historical records, and our professional judgment. WMI did not include recommendations with respect to the subject of this report. Decisions made based on our report, if any, are solely within the purview of the USFWS.

WMI's independent review team consisted of 4 academically trained and experienced wildlife professionals with a combined working experience in state and federal agencies in excess of 100 years (Appendix C). The team's expertise included field surveys and research, data analysis, population modeling, population management, and agency administrative experience for wildlife management programs in the states of Montana, Alaska, Texas, Kansas, Kentucky, Pennsylvania, New Hampshire and Massachusetts. Recently, WMI team members conducted reviews of wildlife programs for the USFWS including the Migratory Bird Program and a comprehensive review of the Red Wolf Recovery Program. WMI has also recently completed state-level programmatic reviews for South Dakota, Pennsylvania, Tennessee, Montana, and Texas.

Finally, this report is an evaluation and synthesis of the available scientific literature, reports, documents, and museum records. The report represents the views of the authors and not necessarily those of the USFWS.

Background

The red wolf (*Canis rufus*) is an iconic species that once inhabited much of the southeastern United States and was persecuted to near extinction in the last century. The USFWS has expended extensive effort on the Red Wolf Recovery Program and related research based on a population of red wolves introduced to eastern North Carolina in the 1980s. However, outside of Nowak (2002), there has not been a recent effort to comprehensively review all available records to support a more thorough understanding of their historic range. Having a more definitive historic range map is important for many reasons, including increasing the knowledge of their early habitat preferences, potential impacts from interspecific competition with other *Canis* species, and validation of current and future restoration sites. Understanding the historic range of the red wolf will help increase the public's understanding of this iconic species as well as inform wildlife professionals on the feasibility of current and future reintroduction efforts.

Determining the historic range of any species with such a reduced extant population is problematic due to a variety of factors. Range determination of the red wolf is particularly difficult since they historically occurred in what is now a significantly human-impacted and altered landscape. Additionally, Europeans extensively persecuted many predator species, including red wolves, from the time of early continental settlement, often before accurate records were kept. But perhaps most importantly, the historic range of the red wolf was likely constrained by interspecific competition with gray wolves (*Canis lupus*), Mexican wolves (*Canis lupus baileyi*), and eastern wolves (*Canis lycaon*), all of which are now either extirpated or occur at greatly reduced population numbers throughout their historic range in the lower 48 states. Current restoration efforts have also been confounded by the recent introgression of coyotes (*Canis latrans*) into the southeastern United States. The apparent propensity of coyotes and red wolves to hybridize is one modern example of what might have occurred with historically sympatric canids. Finally, in many instances, early accounts of wolves in the East were not specific or descriptive enough to discern which accounts describe the red wolf or other canid species.

To better understand the historic range of the red wolf, WMI worked to address these important questions related to the historic (i.e., pre-colonization) range of the red wolf in North America. Collaborating with WMI, researchers at the Conservation Management Institute (CMI) at Virginia Tech and the United States Geological Survey Cooperative Research Unit at North Carolina State University (NCSU-CRU) developed a spatial representation of the red wolf historic range, based on existing records published in the literature, museum specimens, historical accounts, and other available sources. Using this location data, we made comparisons to ecoregions within the United States developed by the U.S. Environmental Protection Agency (U.S. EPA, 2009) as a surrogate for habitat suitability.

To develop the most accurate presumptive historical range of the red wolf, we started with documented records, rather than references to likely or assumed presence. For example, some sources noted that red wolves historically occurred throughout

Mississippi; however, based on our research, there were few records or specimens to support this assertion. Comparatively, there were significant number of records supporting their presence throughout much of Texas and Arkansas. By focusing on actual documented occurrences and their distribution across recognized ecoregions, we intended to address the confounding issues surrounding red wolf historic distribution and make more informed inferences about their range.

Methodology

We conducted an extensive review of applicable data to create a comprehensive historic range for the red wolf. This search included peer-reviewed journal articles, books, historic references, government documents, and museum records. The search was conducted in several steps, and the results were entered into a database that was used to geospatially identify the likely range of the red wolf prior to its extirpation. Details about each step of the process are described below.

1) **Library Records:** Two primary searches were conducted using Virginia Tech's online library database. The term "*Canis rufus*" was searched by consecutive time intervals from the beginning of library holdings to 1930; 1931 to 1950; 1951 to 1979; 1980 to 2000; and 2000 to present. The term "red wolf" was searched in the same manner. All relevant titles were reviewed to determine if there was mention of a specimen of red wolf located via observation, kill, or vocalization; identified based on fossil records; or a review of red wolf specimens that were not part of the restored population. To determine if a title was relevant, the abstract was reviewed (if the title did not clearly note red wolf, wolf, mammal, or some other term indicating that the document may contain a reference to red wolf specimens or documented locations). Most documents returned via the searches dated through 1980 had an abstract review to determine relevance. Post 1980, many more references were returned under the searches. A number of the relevant red wolf documents had already been identified with our previous work (2015 Red Wolf Programmatic Review performed by WMI for USFWS); therefore, additional articles not included in the initial review were evaluated to determine relevance to red wolves. Those that were relevant were then screened to determine if the work was the result of the reintroduced population (eastern North Carolina) or if they contained reference to historical red wolf observations, locations, or specimens.

   If a document was found to be relevant and appeared to provide location information, but was not available through the library, an online Google search was conducted. Most titles were available through the University's online system or a hardcopy existed in its library. More than 500 documents were reviewed, but only relevant titles were included in the Source Database (Appendix E). Approximately 30 sources were determined to include actual red wolf location information and subsequently were used to build the Spatial Database (Appendix E). Additionally, all references cited within relevant articles and reports that had not been identified through the initial search were located and evaluated through a targeted search, leading to additional multiple sources.

Caveats: At a certain point, references to new specimens or to any review of red wolf specimens that had not already been documented previously by other authors, began to diminish. It was at this time that we considered the literature review complete, except for review of materials collected previously by the 2015 Red Wolf Programmatic Review. Most post 1980 literature focused on the Red Wolf Recovery Program, the current red wolf population, genetic studies, or referred to previous documents that reviewed museum specimens or cited references to already noted observations. Additionally, some often-cited sources were not available via the Virginia Tech Library System or on Google sites (e.g. Young and Goldman, 1944). Specimens reviewed in those sources were also examined by additional researchers at a later date, and thus captured in the spatial database.

2) **2015 Reference List Review:** All records used as well as those collected but not cited in the 2015 Red Wolf Programmatic Review were examined for relevant red wolf historic observation or specimen location information. There was some overlap between these sources and those conducted through the library search, but care was taken to account for records only once in the Spatial Database (Appendix E).

3) **Museum Specimen Review:** We developed a database of all known red wolf museum specimens in the United States. The database included more than 600 specimen records and was used to develop a spatial database independent from the one described in #4 below. The spatial database was designed and used to create a Geographic Information System (GIS) in the same manner as described in #6 in order to be fully integrated with the layer developed in #6 to identify any additional locations of red wolf not cited in the literature.

4) **Spatial Database:** If a location was recorded/noted for a red wolf observation or specimen within a document, it was entered into a database in MS Excel (referred to hereafter as "Spatial Database" – Appendix E). The following fields were included in the Spatial Database: Identification Code (ID), State (where observation/specimen found), County, Spatial Reference, Year, Source Reference, and Notes. Any observation or specimen noted within a document was given a unique ID. We noted the state where the specimen was found as well as the county, when available. The scale at which the specimen was documented in the GIS database was listed under Spatial Reference. Typically this was at the county level, but in some cases city locations were identified. In other cases, only the state was provided. If the author noted the year the specimen was found or observed, that was also included. Any important notes were also included within the Spatial Database (Appendix E). For example, if the specimen was a fossil or paleontological reference, that was noted.

   We assigned a polygon feature for each record in the database representing its county location. This information was referenced from the most recent version of the U.S. Census Bureau county boundary file. We did not attempt to refine this location within a county or incorporate additional location information associated with the record. We also created a separate GIS file for the museum specimens noted above.

Caveats: Our best attempt was made to avoid creating duplicate records for the same specimens; however, the same specimen was often examined and documented by multiple authors. Thus, we included these as separate observations. For example, Nowak (2002) reviewed many of the same specimens as Paradiso (1968) (for some specimens, he came to a different conclusion in the second review). If the same conclusion was reached in multiple reviews, it was included only once in the database. Additionally, Paradiso (1968) reviewed some of the same specimens as Goldman (1937); and these were counted as separate observations. If an author specifically noted they were referring to specimen another author reviewed, and they themselves did not independently review it, these records were omitted.

Specimens with questionable descriptions, in terms of type of *Canis*, or one "mostly" or "most closely" related to red wolf were not included. Occasionally, information such as distance and direction from a populated place was provided with the record. In these instances, we assigned a county by searching with the name of the populated place, and did not include the distance and directional information. Therefore, it was possible that records could have fallen into a neighboring county, although this instance was likely rare. It is also worthy to note that some of the records were dated and may have referred to county information that has changed during the ensuing decades. Regardless, the relative impact on the spatial location was expected to be small and beyond the target scale of this effort.

5) **Source Database:** All sources used in the Spatial Database (Appendix E) were also documented in a separate Excel file (Source Database – Appendix E) with the following fields: Citation (with a link to the online document); Presence of Location Information; Full Reference; and Notes. Some additional sources that seemed relevant but proved not to be were also included to ensure no apparent errors of omission occurred during the review process.

Caveats: Overall, many titles returned under "red wolf" were either part of an environmental impact statement, part of the Red Wolf Recovery Program review documents, discussion of the Endangered Species Act (ESA) program, or not relevant to the red wolf from a scientific or ecological perspective (novels, newspaper articles, etc.). Titles that related to red wolf distribution based on genetics were not included unless the article included analysis of actual specimens or fossil records.

6) **GIS:** For each record in the Spatial Database, we mapped a corresponding polygon in GIS at the state, county, or city level. Each polygon also included the corresponding citation and date where possible. The resulting map compiled all identified observations, vocalizations, hunter/landowner provided specimens, and museum specimens in a single map representation.

7) **Coyote Expansion:** We conducted an expanded, but not exhaustive, literature review to attempt to determine when coyotes first appeared in the southeastern states. Using Virginia Tech's online library system, we searched the term "coyote" with each of the southeastern state names. Sources were then scanned to determine relevance. Few denoted coyote range or distribution, so we reviewed documents on coyote life history or behavior in the state to determine if they included any reference to first observations in the state. This method proved most effective and was used to identify observations for most of the states. The original sources were evaluated where possible.

   We created a spatial database and source database (Appendix E) for the coyote in the same manner as for the red wolf (#4 and #5 above). All entries in the spatial database referenced the appropriate source and were entered into a GIS database. Entries were color-coded based on year.

8) **Ecoregional Overlay**: We examined the spatial distribution of known red wolf locations developed by our review (#4 above) and compared this distribution to Level II ecoregions developed by the United States Environmental Protection Agency (2009) in order to determine potential habitat suitability for the red wolf across its historic range. We used this ecoregional overlay to indicate where there was a high probability that red wolves likely occurred historically. Data points lying outside of the 5 identified Level II ecoregions were considered to be transient or dispersing animals.

Literature Review

In reviewing red wolf-related literature, it became clear that many of the early records (pre-1930; approximately 40 identified) included observations, such as red wolves that had been killed by hunters or landowners, or by recognized vocalizations. Foundational work included those of Bartram (1791), Audubon and Bachman (1851), and Bailey (1905), which included the earliest documentation of the red wolf. Records through 1950 (approximately 80 identified) include documentation of live wolves, as well as museum specimens, with Young and Goldman (1944) as a frequently cited reference. Most of the red wolf museum specimens were reviewed in the literature after 1950. These included the comprehensive works of Paradiso and Nowak (1971), Nowak (1979), and Hall (1981), among others. It was clear that these works were foundational, as many subsequent sources reviewed, incorporated, and discussed these references. Many of these sources also provided the most comprehensive lists of red wolf locations (Paradiso & Nowak, 1971): more than 50 specimens cited; Nowak (1979): more than 20 specimens cited; and Nowak (2002): more than 34 specimens cited. Given this, we were typically able to trace specimens back to original publications.

Much of the post-1980 literature focused specifically on efforts directly related to the Red Wolf Recovery Program and/or were based on data from red wolves that were a part of that program; thus, many of these articles were not relevant to this review. If post-1980 articles referred to historic distribution, they often cited previous sources, since red wolves had been extirpated from the vast majority of their range by this time. The exception was Nowak (2002) where he reviewed specimens, specifically "the oldest available series of eastern *Canis*" …covering "all available material from the region dating from before that invasion [coyote] – modern, archeological, and paleontological."

Additionally, much of the research on red wolves conducted since 1980 not only referred to the reintroduced population, but also primarily focused on genetic aspects. Interestingly, Wilson, Grewal, McFadden, Chambers, and White (2003) examining eastern canid mitochondrial DNA evidence, suggested that the red wolf and eastern wolf shared a common lineage with the coyote until 150,000-300,000 years ago. Chambers, Fain, Fazio, and Amaral (2012) presented combined morphological and genetic evidence that demonstrated the difficulty in defining historical boundaries between the eastern wolf and the red wolf, primarily due to lack of sufficient overlap of available specimens for genetic testing. This potential for common lineage with the coyote, eastern wolf, and red wolf combined with the lack of available proximal specimens (for eastern and red wolf) demonstrated the difficulty in accurately differentiating ranges between the two species in the Northeast.

Summaries of the foundational sources

Bartram 1791: Bartram (1791) noted in his travel journal that he came across a black colored wolf in Florida. This was one of the earliest records of the wolf in Florida. He named this species *Canis niger*.

Audubon and Bachman 1851: Audubon and Bachman (1851) formally noted the species *Canis lupus rufus* as the red wolf of Texas. The account noted a description, color, size, and habits, stating that they did not believe it inhabited the more northern prairies or Mississippi bottoms, but was likely present in northern Arkansas and Mexico. The account included information from Audubon's travel journal as well.

Bailey 1905: Bailey's (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. Based on his analysis of the specimens and field reports, he noted the likely range of the red wolf in Texas included the whole of southern Texas north to the mouth of the Pecos and the mouth of the Colorado River as well as farther north along the strip of mesquite country east of the plains. He also noted there was no evidence of them in the plains area and they likely do not overlap with the "lighter colored 'lobo' of the plains."

Goldman 1937: Goldman (1937) described the subspecies of wolf in the U.S. as understood at the time the document was written. He noted that specimens primarily collected through predatory animal control provide a "satisfactory" basis for determining species and subspecies. Goldman (1937) named *Canis lupus gregori* as a separate subspecies from *Canis rufus floridanus* and *Canis rufus rufus*. He provided a range of information on *Canis lupus gregori* based on a specimen from the Bureau of Biological Survey collected in 1905 and noted its similarity to the other two 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."

Paradiso and Nowak 1971: Paradiso and Nowak (1971) reviewed all museum *Canis* specimens, including 213 *Canis rufus* skulls, to determine if the red wolf was a distinct species. The following numbers of specimens were found in each state: Texas 30, Louisiana 21, Oklahoma 45, Arkansas 91, Missouri 26, Florida 1, and Alabama 3. Specimens examined from Arkansas, Oklahoma, and Missouri were those dated pre-1930 and pre-1940 in Louisiana due to suspected replacement by *Canis latrans* after those dates.

Nowak 1979: Nowak (1979) set out to determine a better understanding of the systematic relationships between the *Canis* species, to determine the origin and status of *Canis* in the eastern portion of the U.S., and to better delineate the *Canis* species in the U.S., including both extinct and extant species. He examined approximately 5,000 *Canis* skulls and assessed historical delineations, origins, and relationships between species. The work provided geographical representations of the range of *Canis rufus* and provided extensive discussion on the range of *Canis rufus* pre-1930, 1930 – 1950, and 1950 to time of publication. He provided location and date details for specimens by state and also discussed issues relating to hybridization with coyotes. This document and Nowak (2002) provided the most comprehensive review of specimens and discussion on historic range as well as expansion of the coyote eastward and subsequent hybridization with the red wolf.

Nowak 2002: Nowak (2002) reviewed all available *Canis* (*C. lupus, C. latrans, and C. rufus*) material dated prior to the invasion of the coyote east of the Mississippi. This effort included modern, archeological, and paleontological material/specimens. Nowak provided location and date details for both the paleontological record and specimens. Like Nowak (1979), this work provided both the most comprehensive and most recent review of the species.

Discussion & Analysis

Based on our review of the literature and museum records, mapping the known historical locations of red wolves demonstrated that their range likely included many of the Atlantic states, the southeastern U.S., Texas and Oklahoma, and the lower Midwestern U.S. The bulk of documentable location data was from Texas, Oklahoma, Louisiana, Arkansas, and Missouri, with an apparent scarcity of records for other range states. 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.

Early attempts at documenting the historical range of the red wolf were performed by the USFWS during the planning phase for a Red Wolf Recovery Program in the late 1970s (National Fish and Wildlife Laboratory, 1980). Based on the data evaluated during this review, the 1980 range map generated by the USFWS, while encompassing the majority of the documented red wolf locations, appears to be unduly restrictive based on the scientific literature (Figure 1).

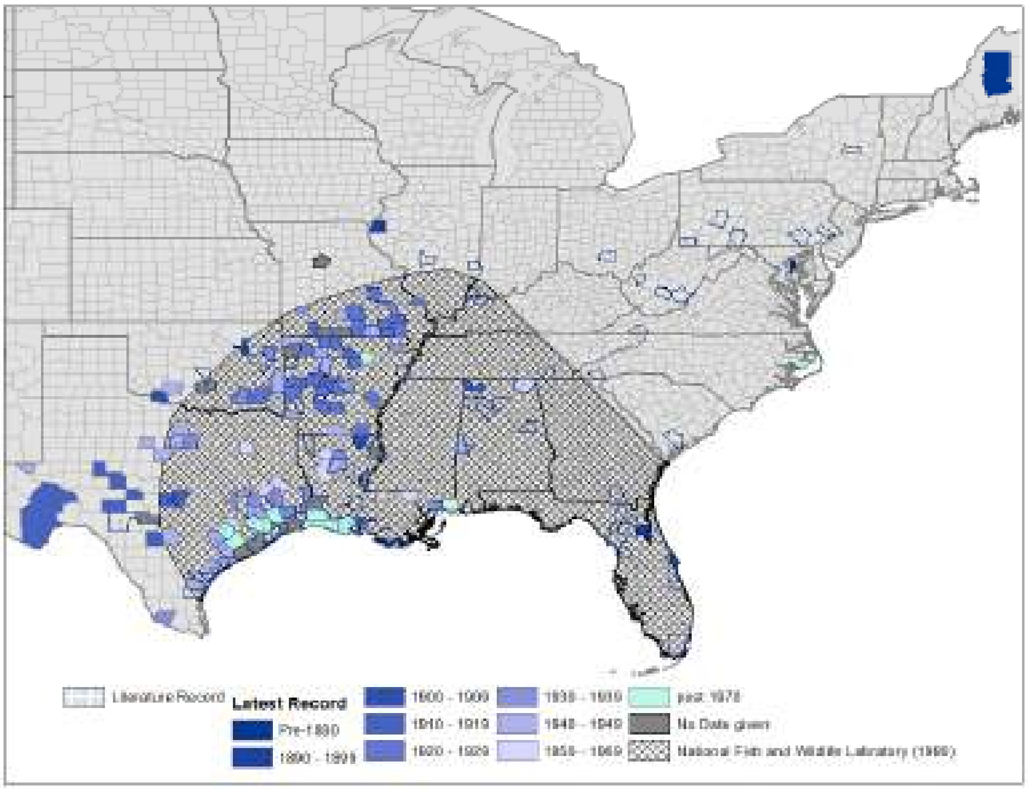

Figure 1. Range of the red wolf as initially delineated by the USFWS (National Fish and Wildlife Laboratory, 1980) in the recovery plan. County level documented locations based on this review are identified by 10-year interval as reference.

While numerous specimens occurred in the western portion of the historical range, no museum specimens were identified from the eastern seaboard. This paucity of documented locations could be attributed to a variety of factors, including poor recordkeeping, local or regional extirpation, lack of suitable habitat, or complete absence. However, based on an examination and review of historical documentation, such as travel journals, bounty laws, and personal writings, the lack of documented locations in the East was most likely attributed to localized extirpation of red wolves and other predators by early settlers to the region (Addington, 1988; Burton, 1800; Bailey, 1907; Camuto, 1997;

Hampton, 1997; Landrum, 1892; Acts of the North Carolina General Assembly; Virginia General Assembly, Legislative petitions of the General Assembly).

The historic range of the red wolf adopted by the USFWS (National Fish and Wildlife Laboratory 1980) was ultimately modified after Paradiso and Nowak (1972) to incorporate the Carolinas, Virginia, eastern Kentucky and Tennessee (Figure 2). This modification appeared to be justified by the significant and intensive evaluation by the authors. However, the current review indicated records that were significantly further north (West Virginia, Pennsylvania, New York, Maine) and west (west Texas) than those incorporated by the authors. Personal communication with Nowak (December 14, 2015) indicated that the reluctance to extend the red wolf range further north and west was driven primarily by the concern for impacts relating to sympatric populations of coyotes (*Canis latrans*) and Mexican wolf (*Canis lupus baileyi*) in the West, Gray wolf (*Canis lupus*) in the upper Midwest, and eastern wolf (*Canis lycaon*) in the Northeast. The primary pressures from these species were likely interspecific competition and the potential for hybridization, specifically the "hybrid swarm" between red wolves and coyotes that likely originated in the Edwards Plateau region of Texas (Nowak, 1979).

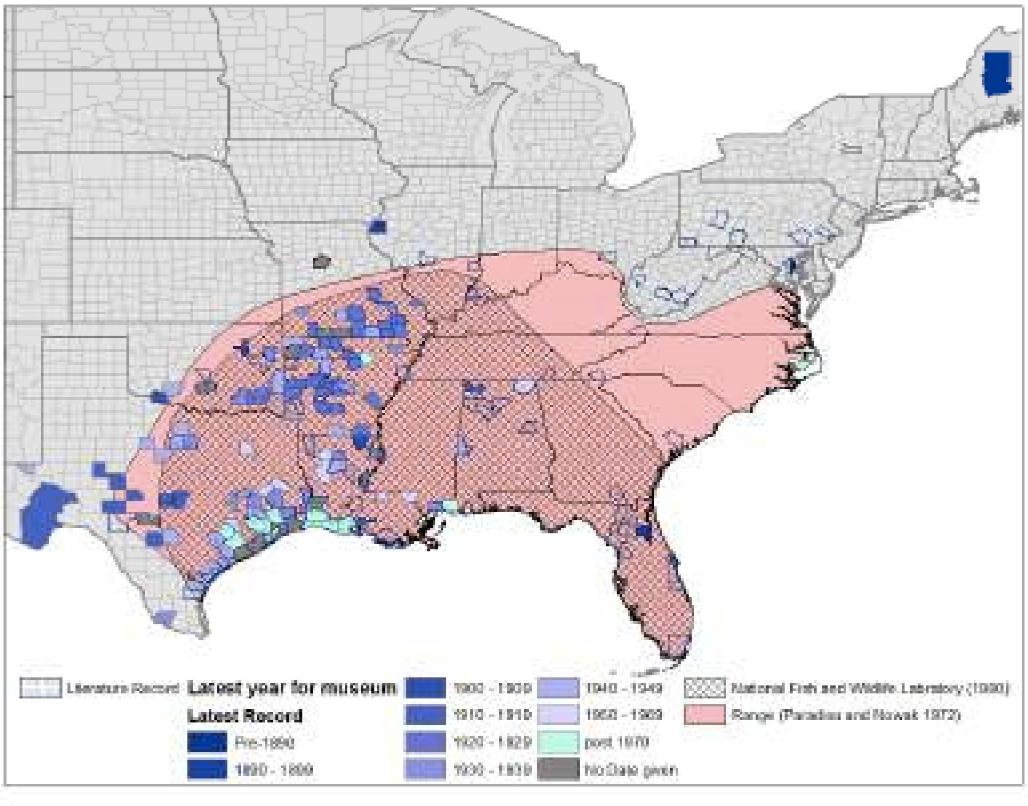

Figure 2. Range of the red wolf as initially delineated by the USFWS (National Fish and Wildlife Laboratory, 1980) and later revised (after Paradiso & Nowak, 1972) in the recovery plan. County level documented locations based on this review are identified by 10-year interval as reference.

Collateral Evidence of Red Wolves in Pre-Colonial Southeastern 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. To better establish the presence of red wolves pre-1900, we searched online state library databases for all states from Virginia to Florida, and conducted basic Internet searches (primary search terms included "wolf," "bounty," and appropriate state name) to identify historical writings and bounty records that documented wolves in these areas during that time. This was not an exhaustive search of all records and documents related to red wolves in the states, but a targeted search aimed at identifying at least several sources per state that support pre-colonial presence of red wolves in the southeastern U.S.

Based on the historical records reviewed, including bounty records and laws from Virginia and the Carolinas, it is apparent that wolves were historically present in the southeastern states from Virginia to Florida, and were likely abundant (Addington, 1988; Burton, 1800; Bailey, 1907; Camuto, 1997; Hampton, 1997; Landrum, 1892; Acts of the North Carolina General Assembly; Virginia General Assembly, Legislative petitions of the General Assembly). However, documents did not state the species of wolf, and little descriptive information was provided in most documents. The exception was Camuto (1997) who noted that travel writer Charles Lanman (a mountaineer in northern Georgia) "routinely distinguished between the black (red) and gray wolf and... encountered them in the southern Appalachian backcountry" in the mid 1800's. 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." Finally, 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).

In Virginia's state library, there were multiple individual electronic records of wolf scalps from several counties (see Virginia Bounty Records below) as well as reference to hardcopies of all wolf bounty laws enacted from 1776-1928 (Auditor of Public Accounts, 1776-1928). Addington (1988) referenced bounties collected in Wise County, Virginia. Virginia also was one of the 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). This likely increased persecution of wolves in the state.

South Carolina established a similar law in 1695 called "An Act for Destroying Beasts of Prey." It required Native American bowmen to bring in a variety of animal skins, including wolves (Hampton, 1997). Landrum (1897) also noted the historic presence of wolves in South Carolina based on historian Dr. David Ramsey's writings. Hampton (1997) noted that wolves were gone from South Carolina by about 1860.

North Carolina established a bounty later in 1748 (Acts of the North Carolina General Assembly). There were also several accounts of wolves in North Carolina based on letters and a personal account recorded in a diary (Letter from William Byrd; McPherson, 1915; Spangenberg, 1704-1792).

Less documentation was identified within the state libraries in Georgia and Florida. However, Camuto (1997) documented the historic presence of wolves in both Florida and Georgia, noting the last remaining wolf was documented in Georgia in 1908, and Florida and South Carolina in 1920. Bailey (1907) stated that wolves were in Florida in 1888 and specifically Bradford County, Florida as late as 1895. Although we cannot state with certainty the species of wolf present in these states, it seems likely that wolves existed historically across the southeast based on this range of accounts.

Virginia Bounty Records

Citizens Petition, Augusta County. (1805). Legislative Petitions Digital Collection, Library of Virginia, Richmond, VA.

Fairfax County (VA) County Court Minute Book. (1749-1751). Local Government Records Collection, Fairfax County Court Records. The Library of Virginia, Richmond, Virginia 23219.

Franklin County (VA) Wolf Scalp Bounties. (1867). Local Government Records Collection, Franklin County Records. The Library of Virginia, Richmond, Virginia.

Montgomery County (VA) Wolf Scalp Bounty Receipt (1801). Local government records collection, Montgomery County Court Records. The Library of Virginia, Richmond, VA. 23219.

Norfolk County (VA) 1753-1775 (bulk 1753-1768.) Norfolk County (VA) Reel 133, Local Government Records Collection, Chesapeake (City)/Norfolk County Court Records. The Library of Virginia, Richmond, Virginia.

Wythe County (VA) Wolf Scalp Bounties. (1837-1838). Local government records collection, Wythe County Court Records. The Library of Virginia, Richmond, VA. 23219.

Coyote Expansion East

In reviewing the literature and considering the red wolf historic range and changes to the range over the last century, it is conceivable that the expansion of the coyote east, and subsequent hybridization with the red wolf, put significant pressure on the species. Similar pressure was presumably exerted by the Mexican wolf on the western range boundary, by the gray wolf on the northern range boundary, and on the northeastern range boundary by the eastern wolf. Nowak (1979) suggested that hybridization between Mexican wolves and red wolves was rare, so this boundary was more likely the result of inadequate habitat conditions, interspecific competition, or hybridization with coyotes (Paradiso & Nowak, 1971; 1972). The Great Lakes population of gray wolves likely had

similar effects on the red wolf range. The eastern wolf may have been much more likely to hybridize with the red wolf (R. M. Nowak, personal communication, December 14, 2015) and in fact, there are competing theories about the origin of both the eastern and red wolf that are unresolved.

While understanding the role that sympatric *Canis* populations could play on the historical range of the red wolf, the fact that each of these competing species is currently greatly diminished in range and/or numbers makes them less critical to red wolf range determination. Coyotes, on the other hand, were historically prevalent along the periphery of the red wolf historic range, currently occur throughout the red wolf historic range, and are known to readily hybridize with red wolves. Consequently, understanding the timeline of the expansion of the coyote eastward could help us also understand the historic range of the red wolf, modification of the range over time, and impacts to continued recovery efforts.

Based on a limited review of sources that were collected from this effort and additional literature searches, several key points can be made about coyotes spreading into the Southeast. Coyotes occupied the same range as the red wolf in Texas in the early 1900s (Bailey, 1905). Coyotes were observed in Louisiana as early as the 1920s but were officially documented in 1959 (Kopman, 1921; Pimlott & Joslin, 1966). Prior to the 1950s, coyotes were found in the extreme western and northern portions of Arkansas, but after the 1950s they became more widespread throughout the state (Young & Jackson, 1951).

Archeological records demonstrated that the red wolf was likely in southern Indiana, southern Missouri, and northwestern Arkansas at some point in time, but replacement by coyotes likely occurred in Missouri and Arkansas in the 1930s and Louisiana in the 1940s (Paradiso & Nowak, 1971).

However, Nowak (2002) noted that coyotes likely did not cross the Mississippi River until the 1960s. Coyotes began expanding into the western portion of Florida's panhandle and into the rest of the state likely in the 1960s and 1970s (Thornton, Sunquist, & Main, 2004). In Georgia, coyotes likely existed before the 1970s as transplants for hunting or other uses, but reports of damage by coyotes were officially documented in the late 1960s, and by 1970, nine counties in Georgia reported damage by coyotes (Fisher, 1977). Additional sources noted that the coyote also likely expanded from the Midwest and North in the 1940s into New York and Pennsylvania (Kays, Curtis & Kirchman, 2010). More recent research indicated that the coyote did not expand into northern Virginia and the Mid-Atlantic region until the early 1990s (Bozarth, Gardner, Rockwood, & Maldonado, 2015).

We identified information for Texas, Oklahoma, Arkansas, Missouri, Mississippi, Alabama, Tennessee, Florida, Georgia, South Carolina, North Carolina, Virginia, West Virginia, Pennsylvania, Maryland, and Delaware. However, it is important to note that searches were not conducted for states north of Virginia. Mastro (2011) included location information on the first recorded coyotes for Virginia, West Virginia, Maryland, and Delaware. We evaluated original sources where possible. Young and Jackson (1951) included information for Georgia, Maryland, and Tennessee. Ruth (2010) detailed the first coyote documentation in South Carolina. DeBow, Webster, and Sumner (1998) provided specific information on North Carolina. Carpenter (1970) outlined the initial observations in Virginia. Hill, Sumner, and Wooding (1987) reported the first observations for multiple states across the Southeast, although the author noted that some of these were likely "liberations." Paradiso (1968) and Nowak (1979) included the most records on the coyote in these states.

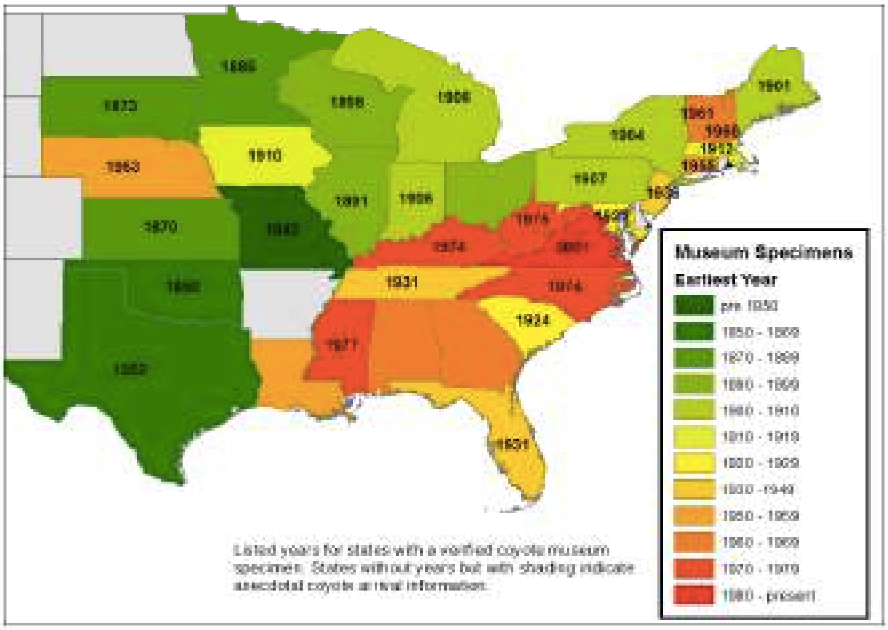

Figure 3. Temporal introgression of coyotes into the southeastern U.S. as determined by literature review and examination of museum specimens.

The introgression of coyotes into the southeastern United States through natural range expansion and movement of animals by man for recreational purposes (coursing pens) created a particularly troublesome issue with delineating historical range of the red wolf. Although they remained allopatric species from their divergence to the early 1900s, the two species began exhibiting a hybrid swarm in the Edwards Plateau region of Texas that soon moved into southern Louisiana (Nowak, 1979). With the concurrent removal of red wolves by government control actions, the coyote was free to occupy habitat formerly occupied by the red wolf (Paradiso & Nowak, 1971), until they essentially filled all available habitat. Currently the coyote, ubiquitous throughout the Southeast, is especially problematic for red wolf reintroduction efforts, since there are so few founders available for new red wolf reintroduction efforts.

Findings

Our findings were responsive to the questions delineated in Task 1 of the USFWS contract (Appendix D)

In summary, the review of the historic red wolf range undertaken by WMI at the request of the USFWS makes the following findings:

1) **The previous range maps developed and used by the USFWS for the Red Wolf Recovery Program were too restrictive.**
2) **The lack of documented records for red wolves in the Carolinas, Virginia, and Georgia were due to poor recordkeeping and/or specimen preservation by early settlers, since other historical documents indicated the presence of a wolf species occupying those areas during settlement.**
3) **Coyote introgression into the historic range of the red wolf, possibly driven by systematic extirpation of red wolves and human-related coyote movement, historically and continues to be a confounding factor on range determination for the red wolf.**
4) **Several Level II ecoregions, including all or parts of the Mississippi Alluvial and Southeast USA Coastal Plains, Ozark/Ouachita-Appalachian Forests, South Central Semi-Arid Prairies, Southeastern USA Plains, and the Texas-Louisiana Coastal Plains are an accurate predictor of historical red wolf range.**

Our findings are not intended, nor should they be construed, to be a decision document with recommendations relative to the fate of the current Red Wolf Recovery Program. These findings represent the views of the authors and not necessarily those of the USFWS.

Conclusions

We based our conclusions on our review of scientific literature, museum records, historical documents, delineated ecoregions as a surrogate for habitat suitability, and on our professional judgment. In this review, we evaluated plausible explanations for the following findings: 1) Previous range maps developed and used by the USFWS for the Red Wolf Recovery Program were too restrictive; 2) The lack of documented records for red wolves in the Carolinas, Virginia, and Georgia were due to poor recordkeeping and/or specimen preservation by early settlers, since other historical documents indicated the presence of a wolf species occupying those areas during settlement; 3) Coyote introgression into the historic range of the red wolf, possibly driven by systematic extirpation of red wolves and human-related coyote movement, historically and continues to be a confounding factor on range determination for the red wolf; and 4) Several Level II ecoregions, including all or parts of the Mississippi Alluvial and Southeast USA Coastal Plains, Ozark/Ouachita-Appalachian Forests, South Central Semi-Arid Prairies, Southeastern USA Plains, and the Texas-Louisiana Coastal Plains are an accurate predictor of historical red wolf range.

Our conclusions are not intended, nor should they be construed, to be a decision document with recommendations relative to the fate of the current Red Wolf Recovery Program. These conclusions represent the views of the authors and not necessarily those of the USFWS.

Previous range maps were too restrictive

Based on our comprehensive review, the historical range of the red wolf likely extended outside the boundaries specified by earlier range delineations (National Fish and Wildlife Laboratory, 1980; Paradiso & Nowak, 1972; Nowak, 1979). Early attempts at documenting the historical range of the red wolf were performed by the USFWS during the planning phase for a Red Wolf Recovery Program in the late 1970s (National Fish and Wildlife Laboratory, 1980) and later revised after Paradiso and Nowak (1972). Based on the data evaluated during this review, the 1980 range map used by the USFWS and its subsequent revision was unduly restrictive.

We identified specimens or literature citations with documentable locations that demonstrate that the range of the red wolf likely extended from the southeastern United States into the Big Bend region (Brewster and Pecos Counties) and Edwards Plateau region (Edwards, Sutton, Tom Green, and Sterling Counties) of Texas, 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), New York (Fulton County), and Maine (Piscataquis County). State level records are provided in Appendix B at the county and Level III ecoregion (U.S. EPA, 2009) for each range state identified by this review. Our range delineation developed by this review was most similar to that of Nowak (2002) (Figure 4).

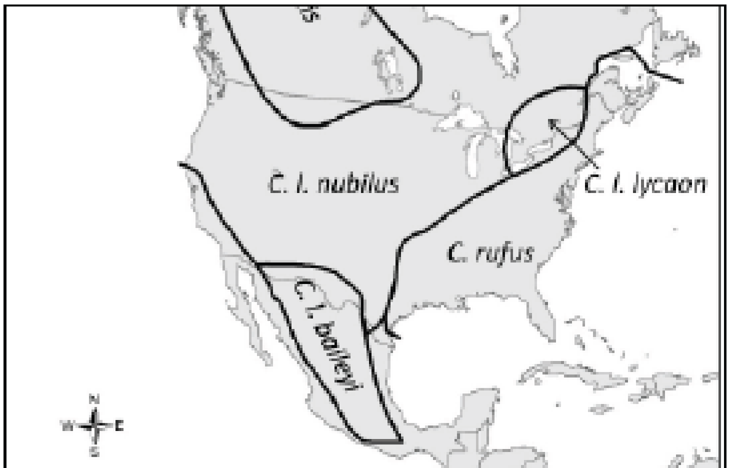

Figure 4. Ranges of North American Canis lupus subspecies and of C. rufus (after Nowak, 2002).

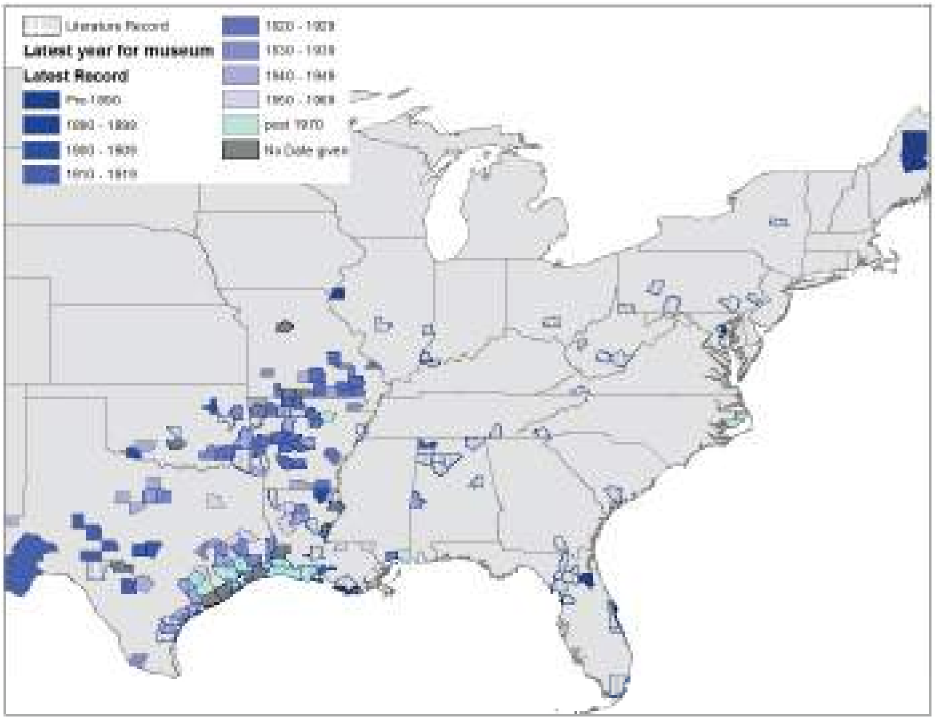

Figure 5. Known county level locations of red wolves based on the results of the current review, which examined documented literature references, museum specimens, and historical documents.

Lack of documented records in the Carolinas, Virginia, and Georgia

There exists a paucity of red wolf location records in Georgia, the Carolinas, and Virginia (Figure 5) despite the fact that these areas were encompassed by the historical range established by Paradiso and Nowak (1972) and Nowak (1979), that they contained and likely still contain suitable habitat for red wolves, and that canids will typically occupy available habitat given sufficient opportunity and lack of external pressures. One theory is that local settlers extirpated red wolves and other predators during a period when recordkeeping was not performed nor deemed necessary. This theory is bolstered by the fact that many records from states west of the Mississippi river were derived from government control actions, when better records were kept. These organized government control actions did not exist at the time of predator removal along the eastern seaboard (R. M. Nowak, personal communication, December 14, 2015).

We conducted a further evaluation of historical documents, including field journals, bounty records, and personal writings to determine anecdotal presence of red wolves in these states. From that research, it appears that wolves were historically present in the southeastern states from Virginia to Florida, and were likely abundant (Addington, 1988; Burton, 1800; Bailey, 1907; Caruuto, 1997; Hampton, 1997; Landrum, 1892; Acts of the North Carolina General Assembly; Virginia General Assembly, Legislative petitions of the General Assembly). Although the historical records primarily referenced "wolves" in the Southeast, based on the physical and written evidence we discovered and the overlap of those specimens within defined ecoregions, WMI concluded that historical references to "wolves" within the range, referred to red wolves.

Coyote introgression into the Southeast

We examined records and literature that documented the introgression of coyotes into the southeastern U.S. to better inform scientists on the potential impacts that sympatric canids, including coyotes, may have on range determination. While other canid species, including Mexican wolf, gray wolf, and eastern wolf likely provided sufficient interspecific competition with red wolves to form the western, northern, and northeastern boundaries, they appeared less likely to have a significant impact on the core range of the red wolf. However, coyotes moved across the landscape from the west and north and into the core range of the red wolf starting in the 1930s and 40s, continuing to the present day. Their ability to easily hybridize with red wolves from the initial hybrid swarm in the Edwards Plateau region of Texas to coastal Louisiana (Nowak, 1979) to the current and continued introgression throughout the Southeast presents considerable challenges to the current and future red wolf restoration attempts.

Level II Ecoregions are a predictor of Red Wolf historic range

The delineation of the red wolf historic range was hampered by numerous factors. Early colonization of the eastern portion of the United States resulted in anthropogenic changes to habitat and fish and wildlife populations. Undoubtedly, early settlers killed wolves due to fear of possible personal and property damage. History is replete with examples of predator control and elimination throughout the nation. The controversy surrounding large predators, such as the wolf, is on-going to this day. The lack of museum records and scientific literature evidence was not surprising due to the lack of both specimen and record retention prior to the 1890s.

However, from an ecological perspective, it is highly unlikely that a large expanse of land comprising the southeastern portion of the U.S. was absent of any canid species. As a comparison, wolves, elk, bison, and grizzlies roamed the Great Plains at the time of early settlement of North America. Humans ultimately either eliminated those species or greatly reduced their numbers. Species typically expand their range to include suitable habitat in the absence of external controls on their population numbers. The wide geographic area where evidence of red wolves has been documented indicated that they inhabited a large historic range encompassing the Southeast and ranged into the Northeast, lower Midwest, and into the Edwards Plateau region of Texas. The lack of evidence within portions of that range can be attributed primarily to human intervention from the early 1600s until the 1900s. The lack of evidence in some portions of that area was not surprising.

WMI believes that the historic range included an area comprising parts or all of 5 Level II Ecoregions (U.S. EPA, 2009): Mississippi Alluvial and Southeast USA Coastal Plains, Ozark/Ouachita-Appalachian Forests, South Central Semi-Arid Prairies, Southeastern USA Plains, and the Texas-Louisiana Coastal Plains (Figure 6).

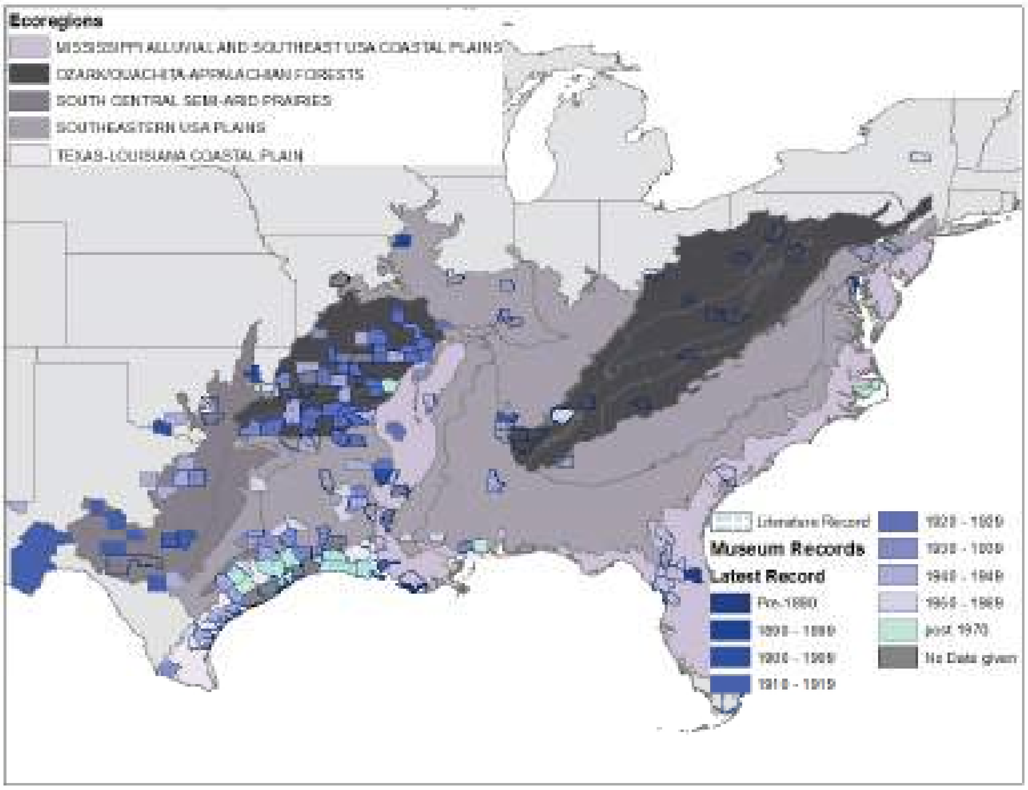

Figure 6. Five Level II Ecoregions (Mississippi Alluvial and Southeast USA Coastal Plains, Ozark/Ouachita-Appalachian Forests, South Central Semi-Arid Prairies, Southeastern USA Plains, Texas-Louisiana Coastal Plains) that encompass most of the known historic locations of red wolves.

Within that area, WMI believes there existed suitable habitat and a high probability of red wolf breeding populations. Outside of that area, WMI believes there was a low probability of red wolf breeding populations. Evidence of red wolves outside the designated historic range may be due to dispersing animals and/or human disturbance or record keeping error. Further, the line delineating the historic range is likely variable due to the uncertainty inherent in a broad-scale evaluation. WMI recognizes that the delineation of historic range of red wolves prior to or immediately after European colonization of the U.S. cannot be determined with absolute certainty. There is scientific evidence that gray wolves, Mexican wolves, and eastern wolves occupied areas of the U.S. and constrained the red wolf historic range due to interspecific competition; however, the use of ecoregions as a predictor of suitable habitat, and ultimately, the historical presence of red wolves is compelling.

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Appendix B. State-Level Occurrence Maps

Figure B-1. Historic locations of red wolves in Alabama. 31

Figure B-2. Historic locations of red wolves in Arkansas. 32

Figure B-3. Historic locations of red wolves in Florida. 33

Figure B-4. Historic locations of red wolves in Georgia, North Carolina, South Carolina. 34

Figure B-5. Historic locations of red wolves in Illinois, Indiana, Kentucky. 35

Figure B-6. Historic locations of red wolves in Louisiana 36

Figure B-7. Historic locations of red wolves in Maine, New York. 37

Figure B-7. Historic locations of red wolves in Mississippi. 38

Figure B-8. Historic locations of red wolves in Missouri. 39

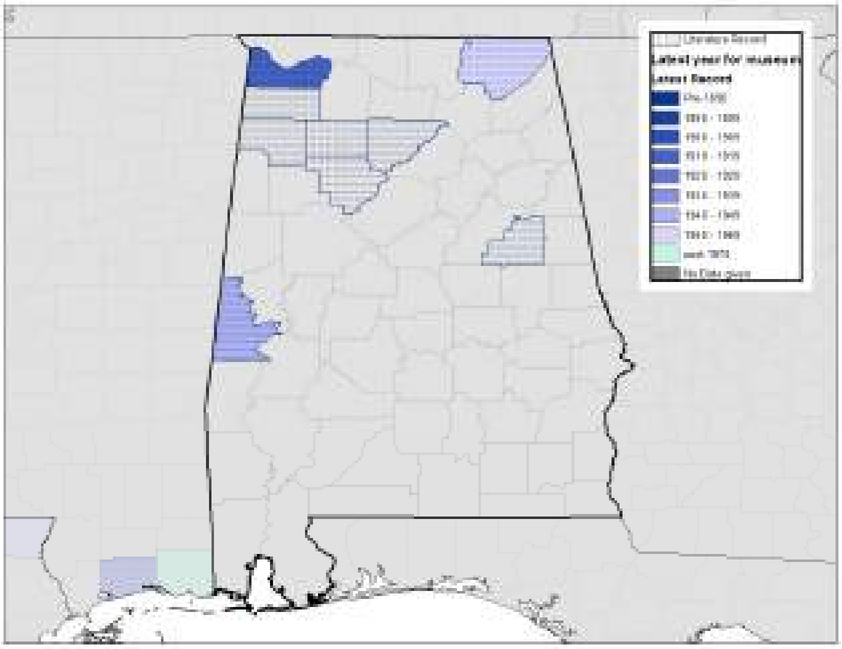
Figure B-9. Historic locations of red wolves in Pennsylvania, Virginia, West Virginia 40

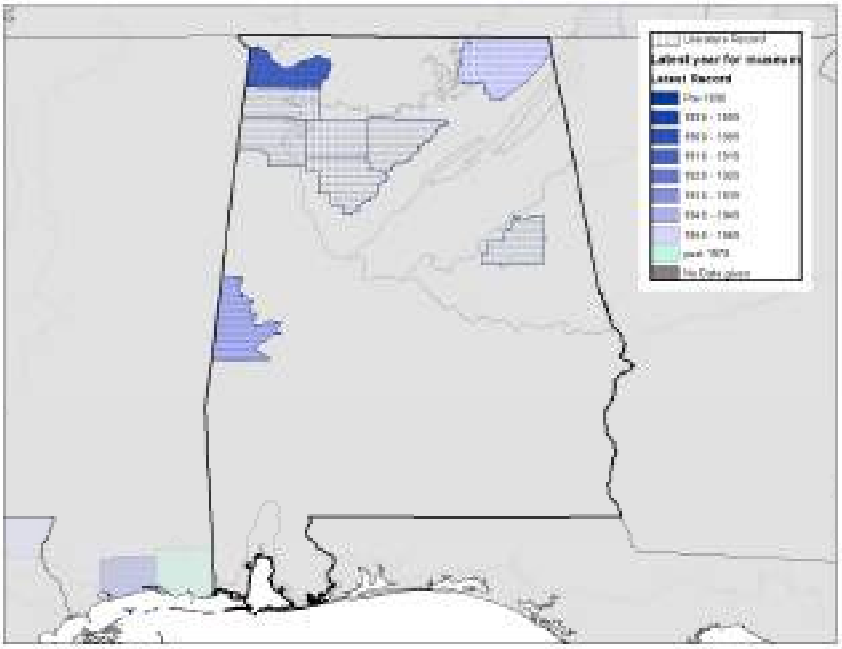
Figure B-10. Historic locations of red wolves in Oklahoma. 41

Figure B-11. Historic locations of red wolves in Kentucky, Tennessee. 42

Figure B-12. Historic locations of red wolves in Texas. 43

Figure B-1. Historic locations of red wolves (county and Level III Ecoregion) in Alabama.





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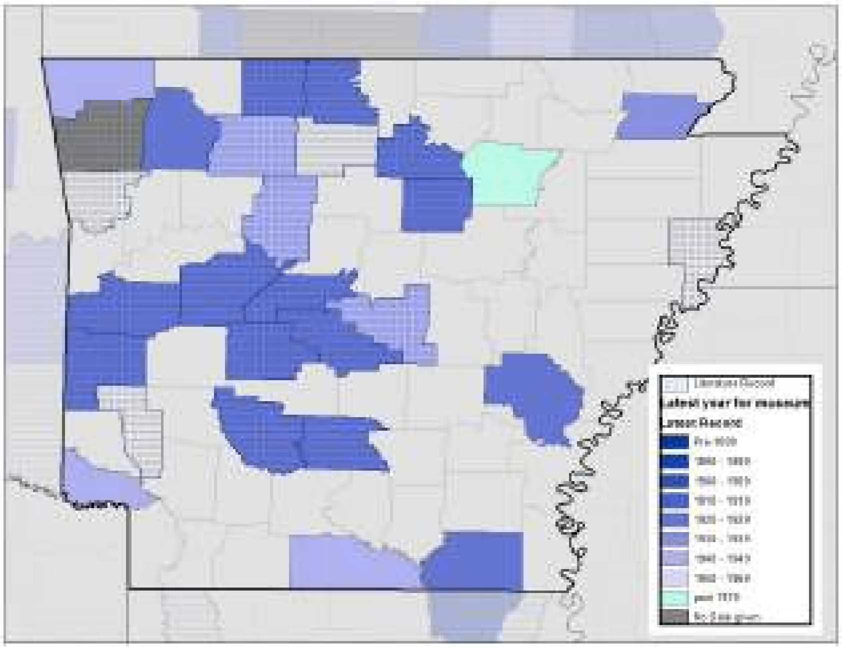


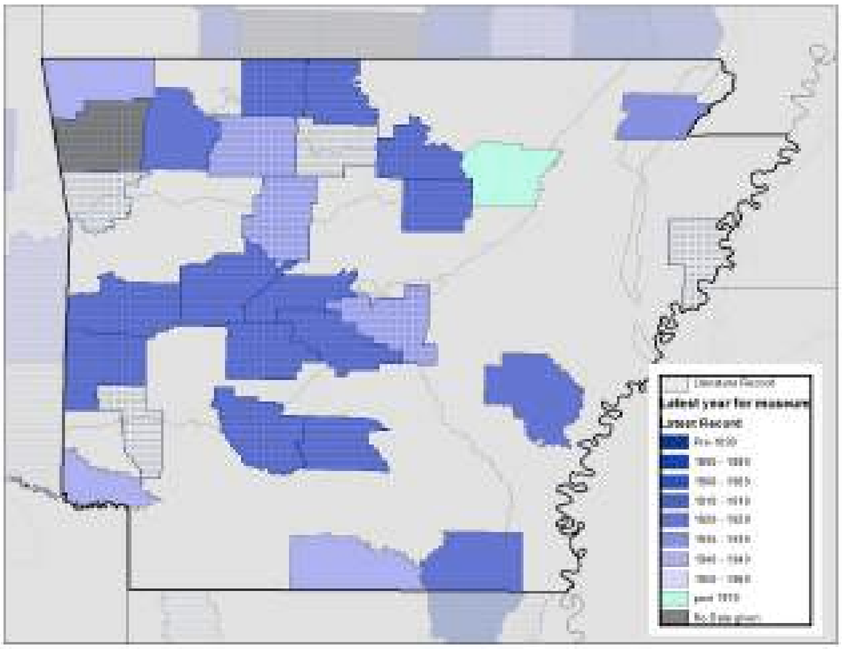
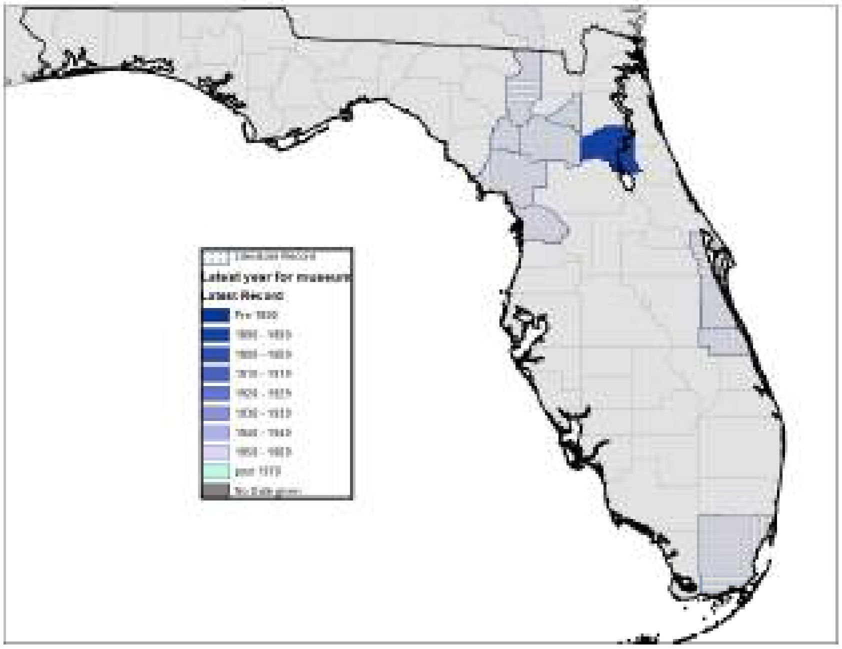


Figure B-3. Historic locations of red wolves (county and Level III Ecoregion) in Florida.



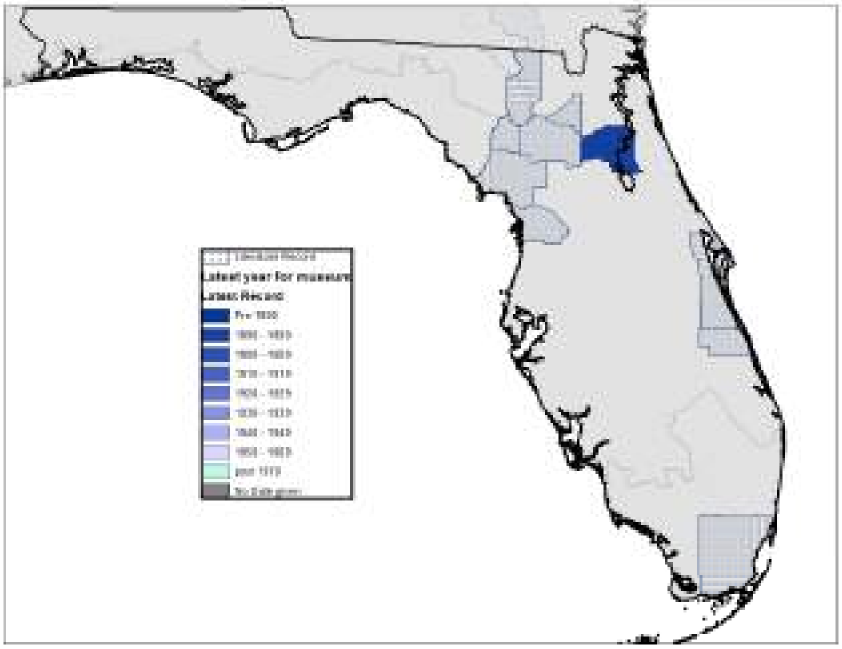
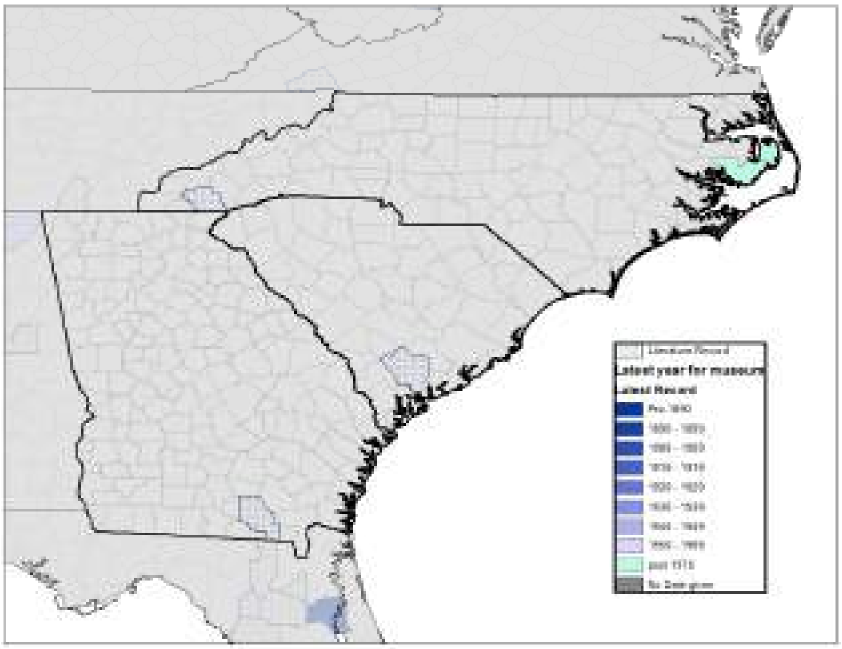


Figure B-4. Historic locations of red wolves (county and Level III Ecoregion) in Georgia, North Carolina, South Carolina.



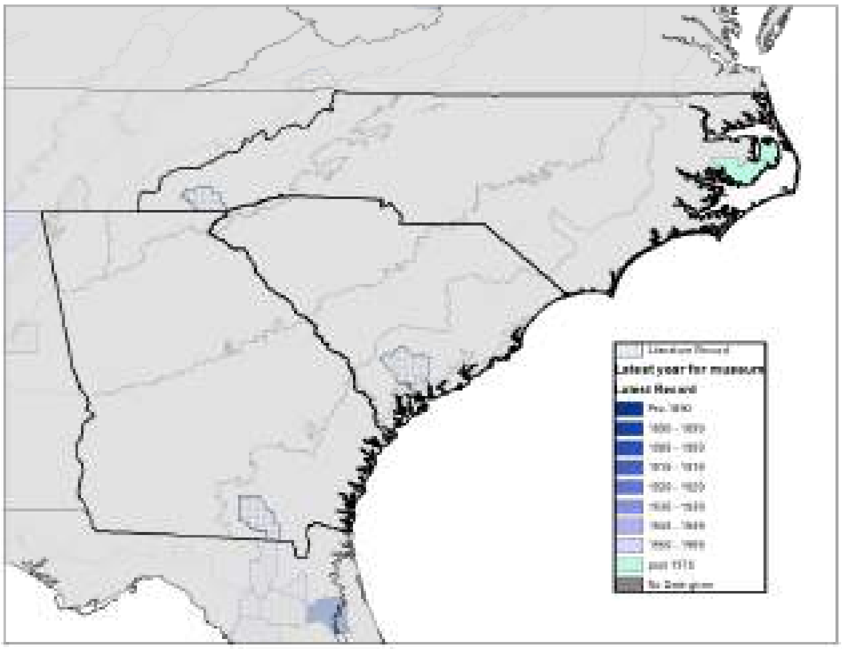
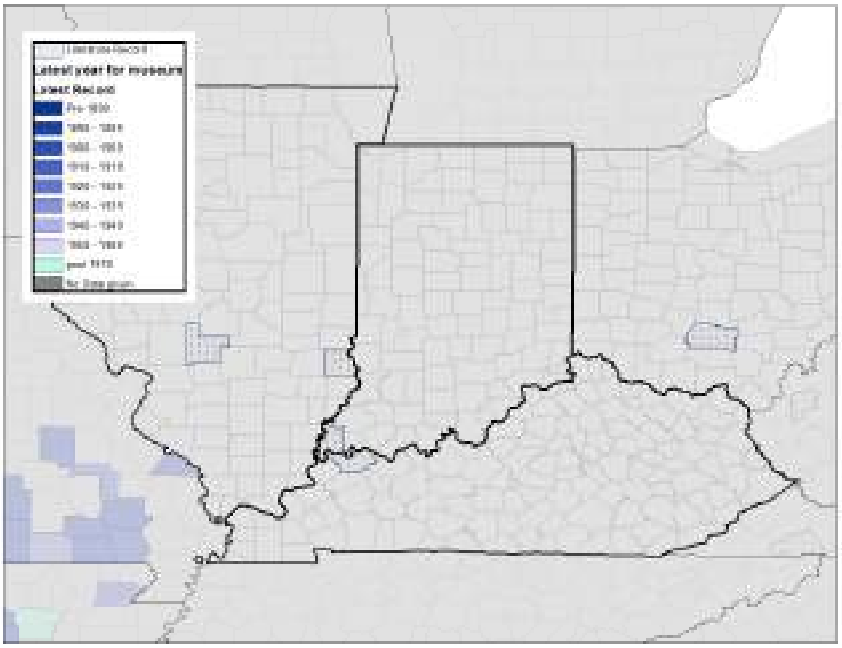


Figure B-5. Historic locations of red wolves (county and Level III Ecoregion) in Illinois, Indiana, Kentucky.



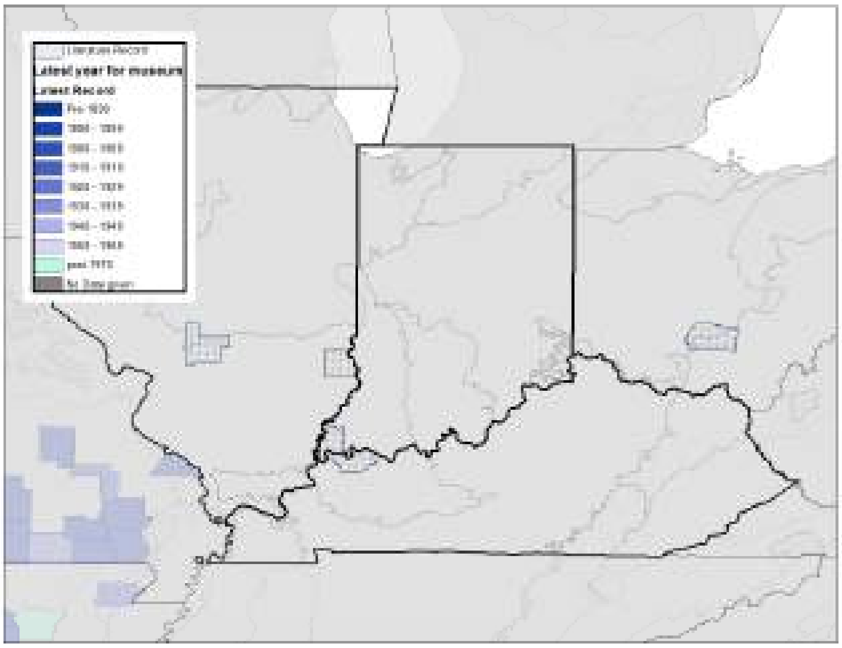
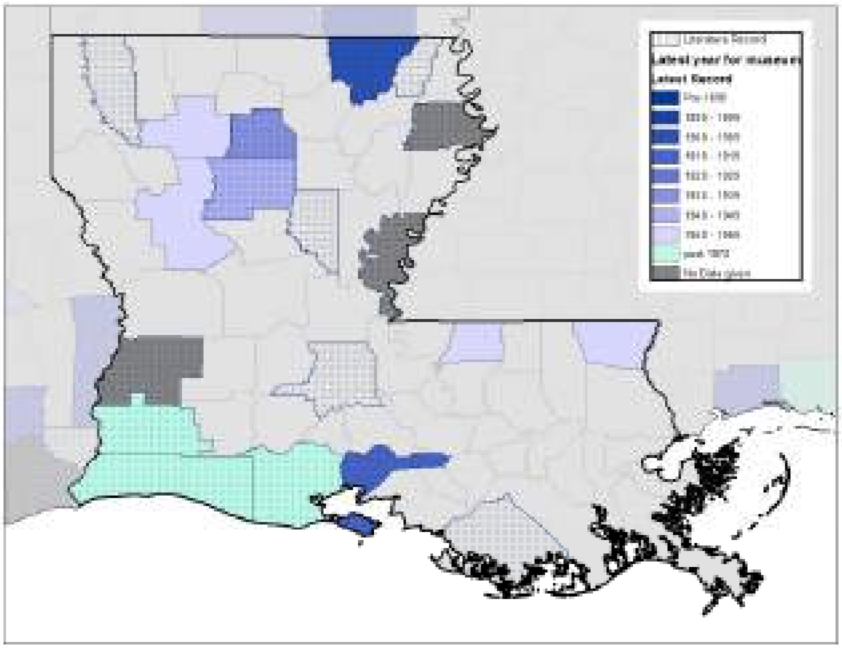


Figure B-6. Historic locations of red wolves (county and Level III Ecoregion) in Louisiana.



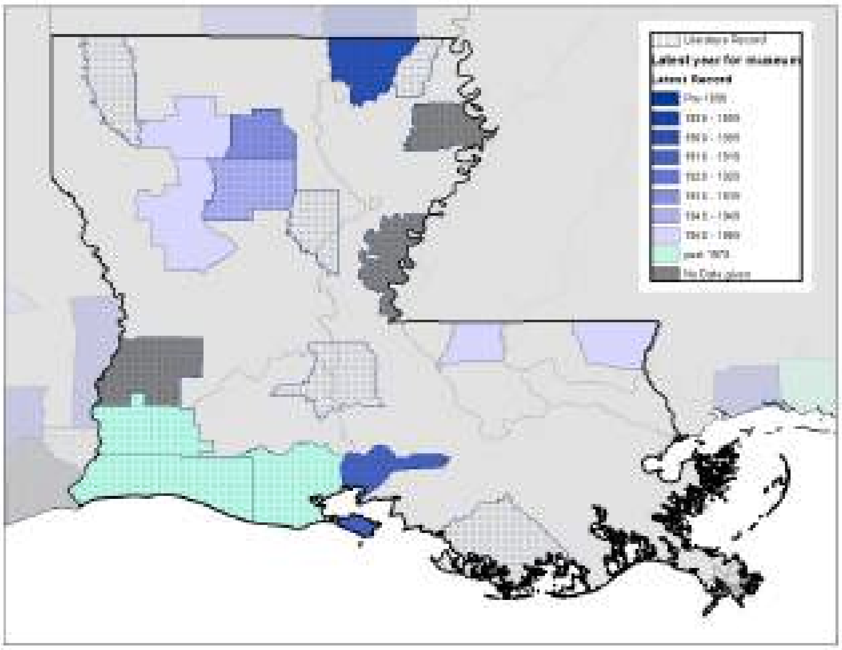
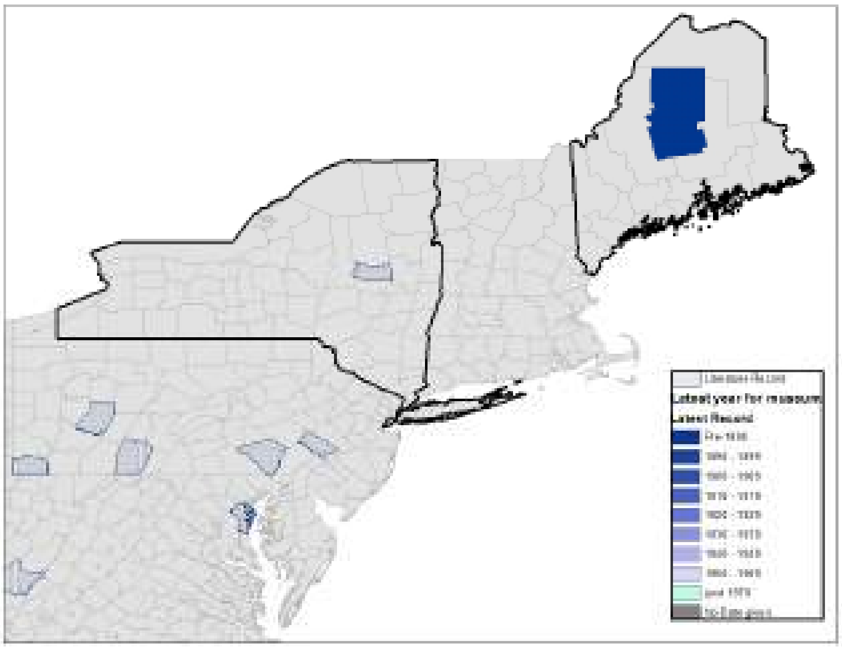


Figure 7. Historic locations of red wolves (county and Level III Ecoregion) in Maine, New York.



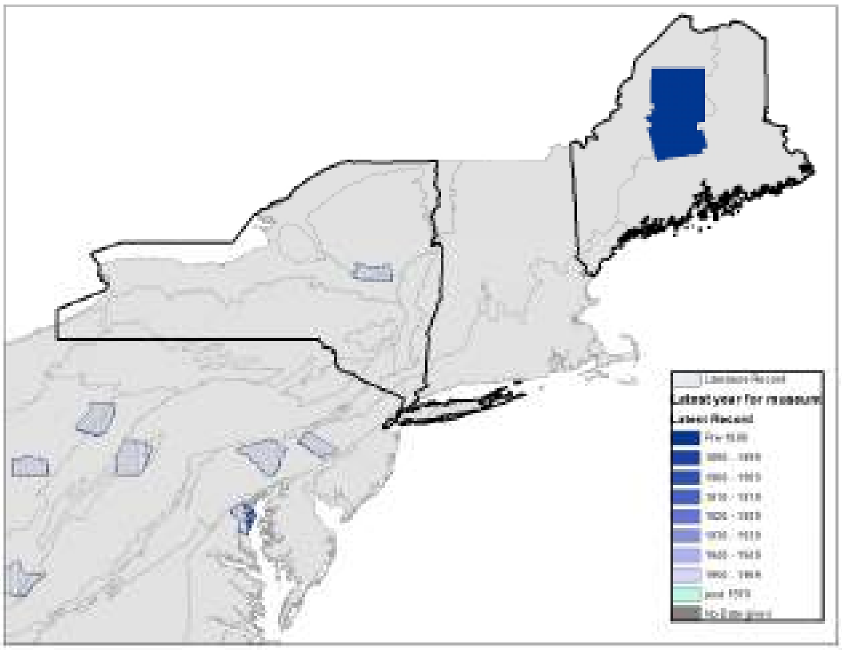
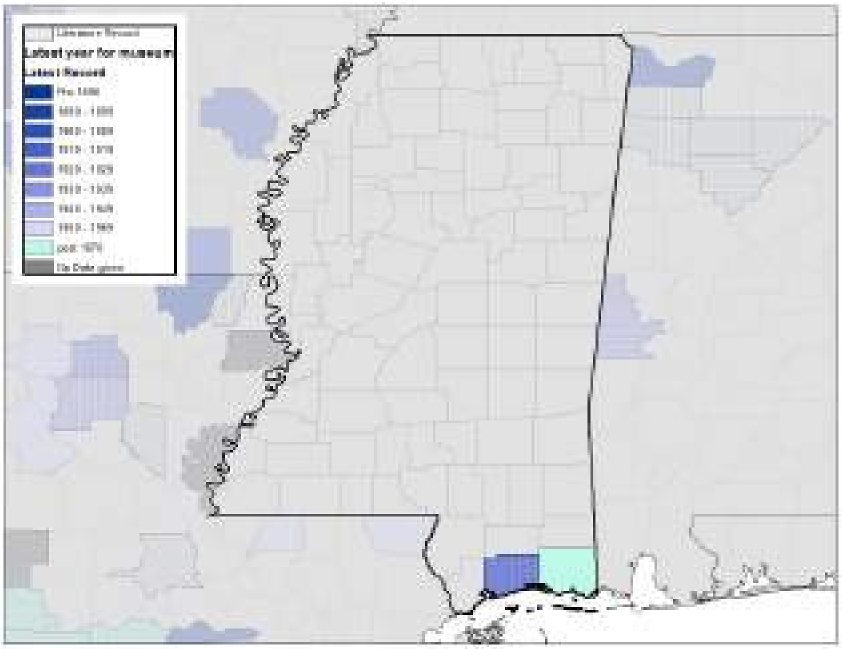


Figure 8. Historic locations of red wolves (county and Level III Ecoregion) in Mississippi.



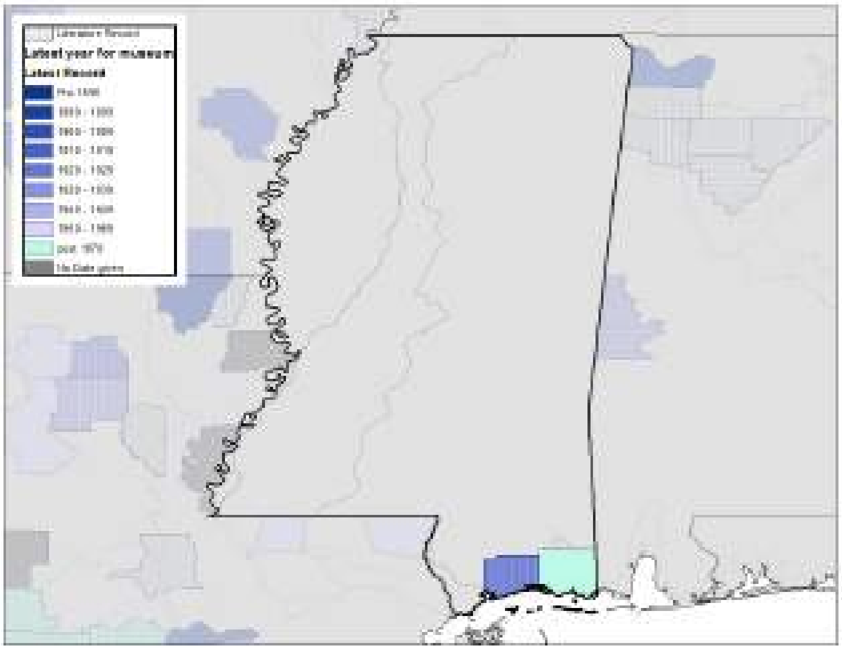
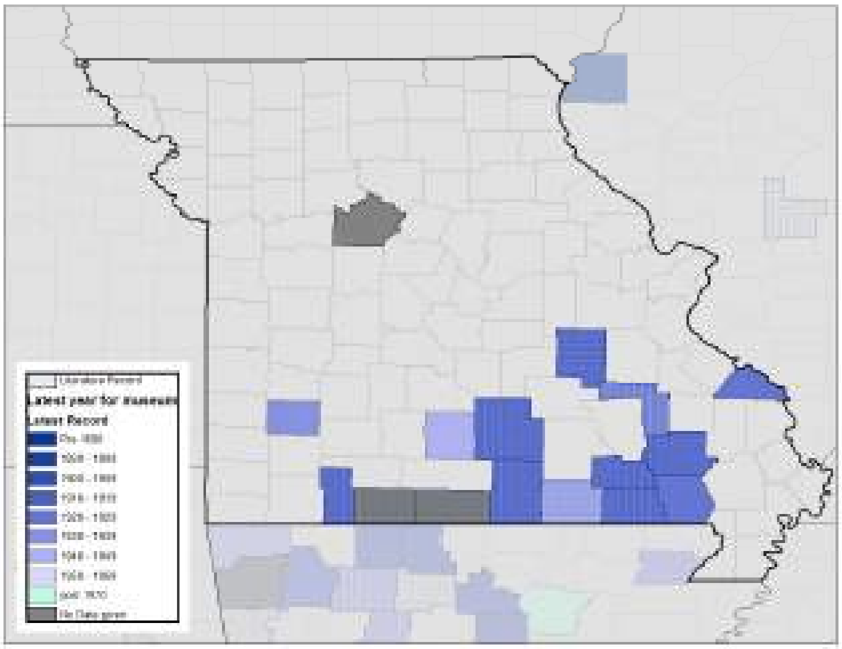


Figure 9. Historic locations of red wolves (county and Level III Ecoregion) in Missouri.



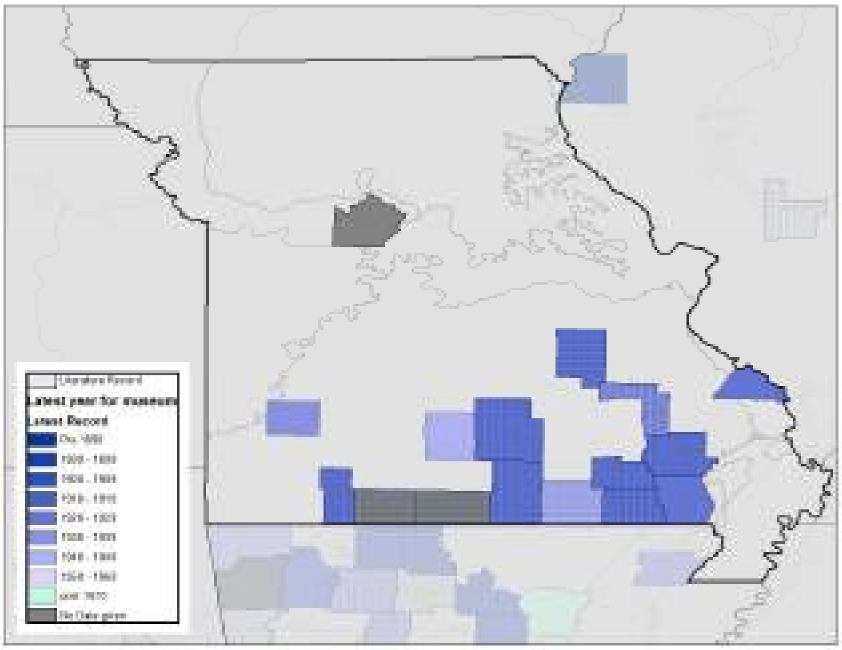
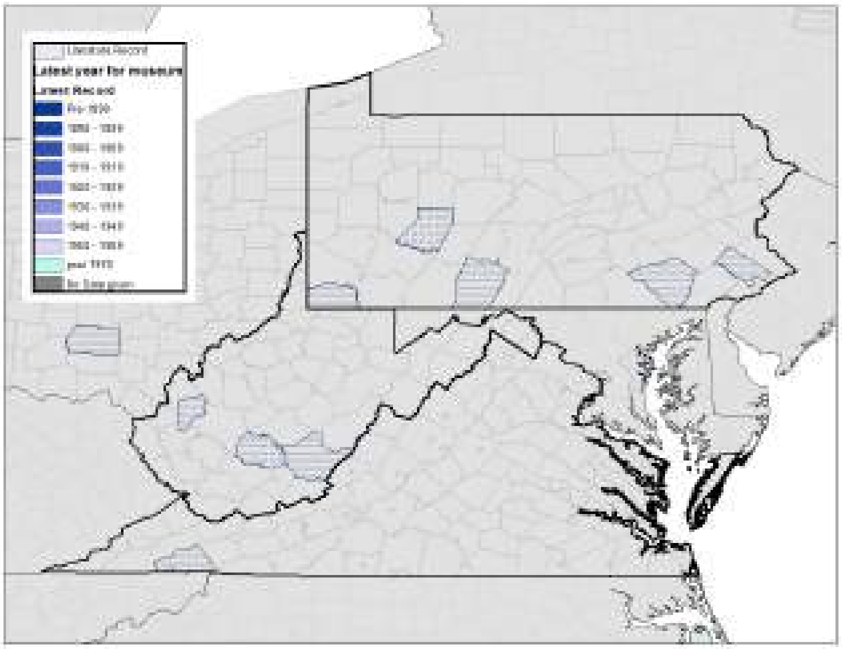


Figure 10. Historic locations of red wolves (county and Level III Ecoregion) in Pennsylvania, Virginia, West Virginia.



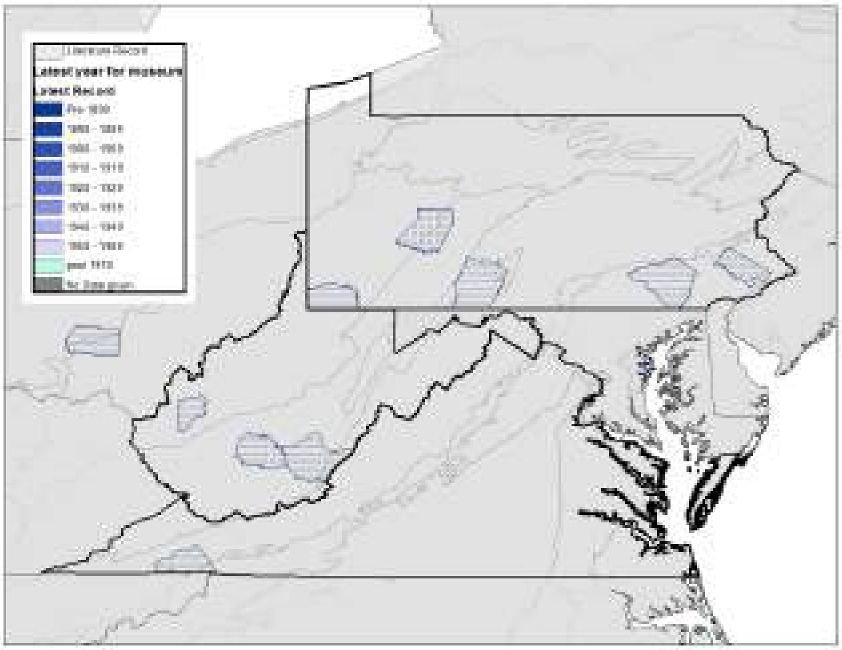
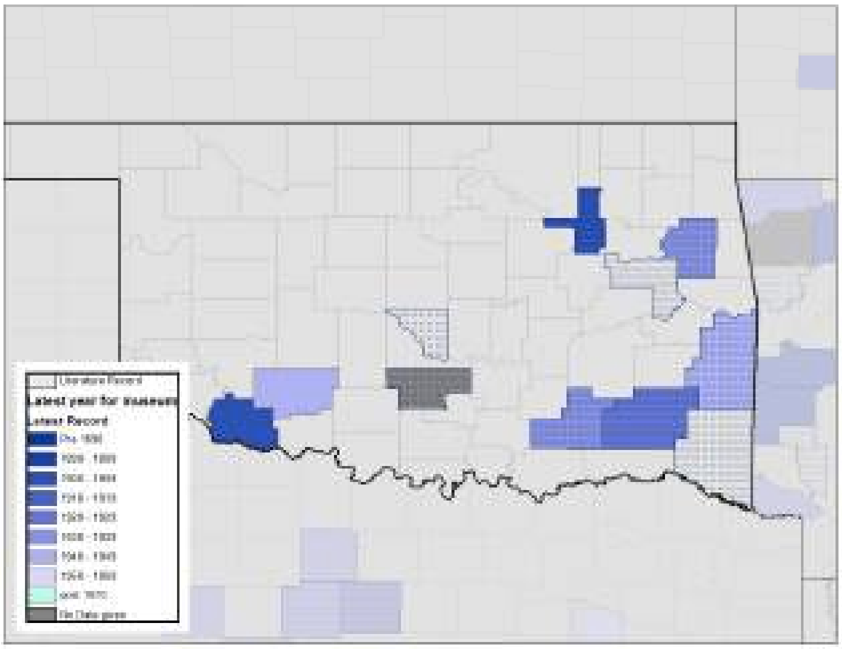


Figure 11. Historic locations of red wolves (county and Level III Ecoregion) in Oklahoma.



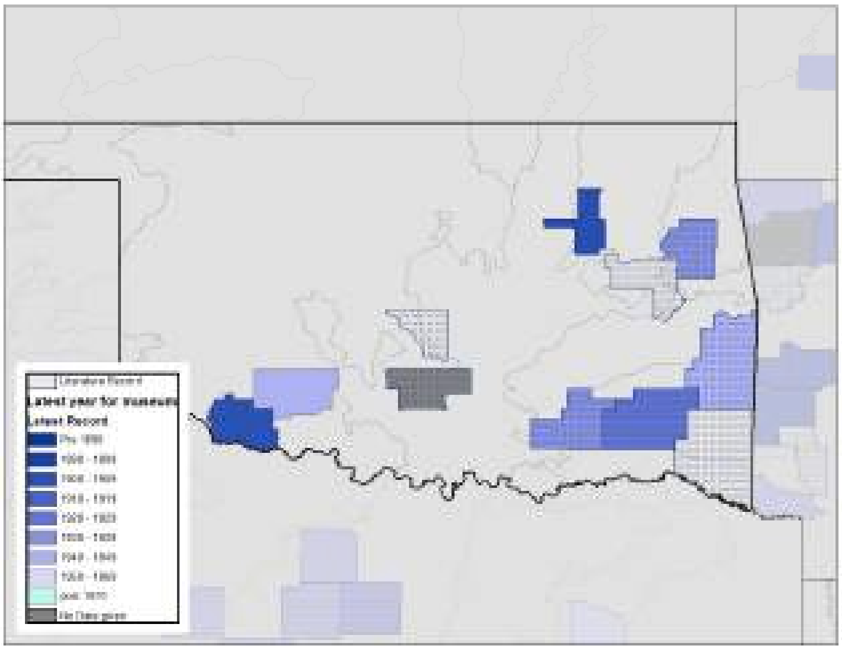
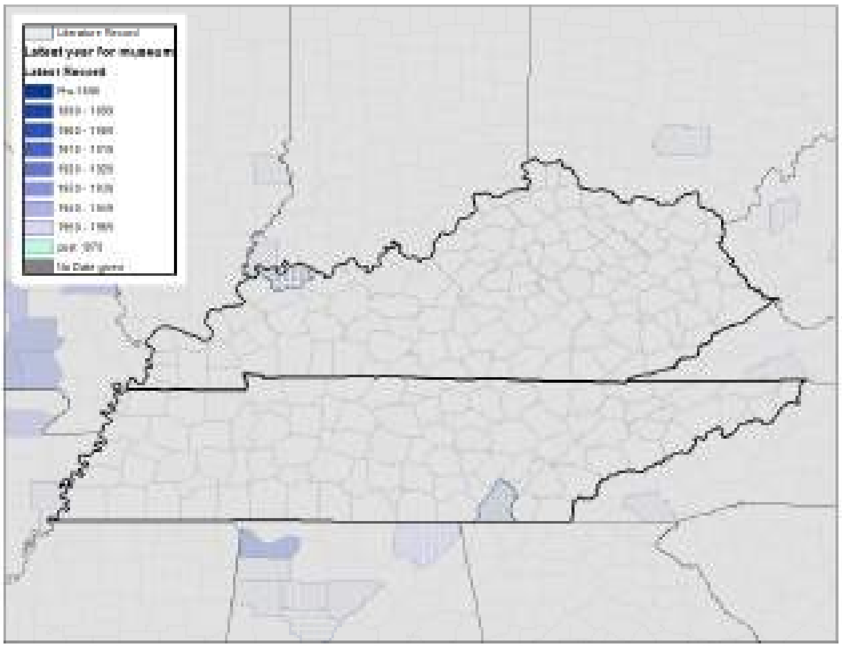


Figure 12. Historic locations of red wolves (county and Level III Ecoregion) in Kentucky, Tennessee.



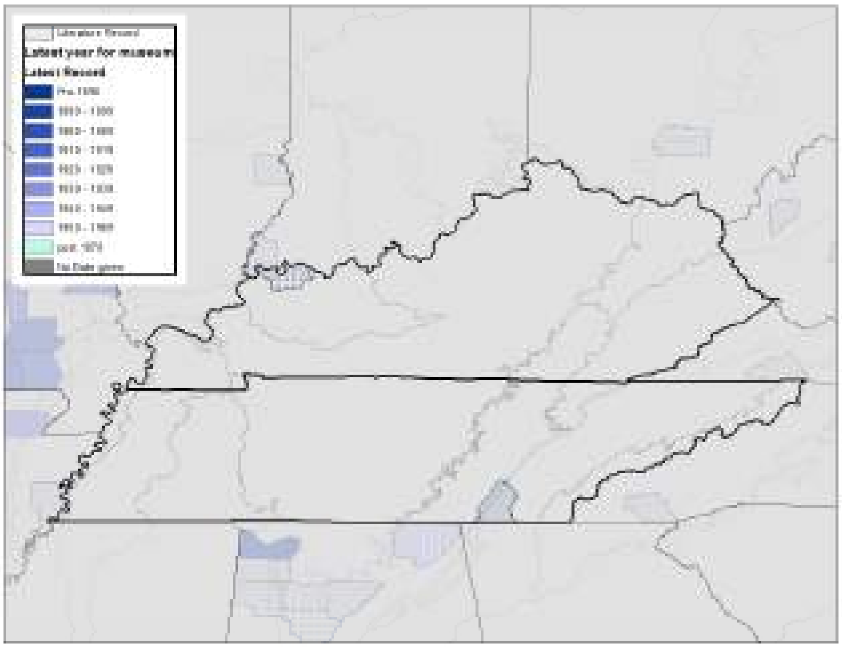
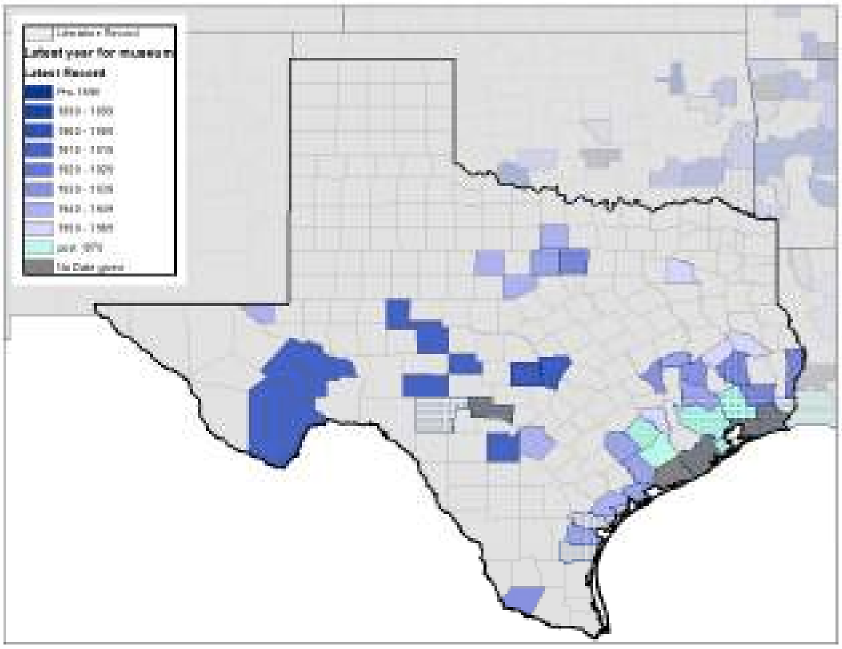
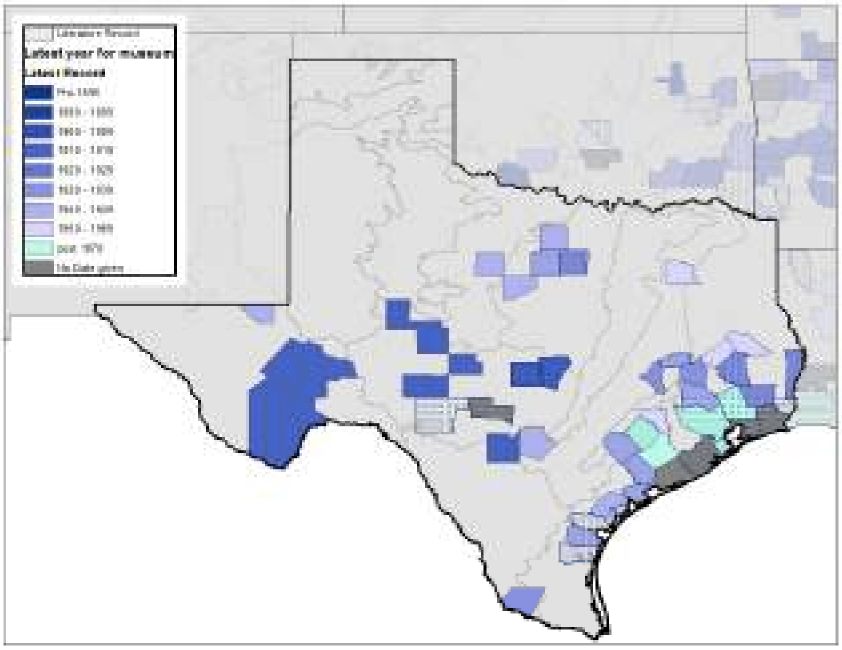


Figure 13. Historic locations of red wolves (county and Level III Ecoregion) in Texas.





Appendix C. Biographies of Review Participants

STEVEN WILLIAMS, Ph.D. – **WMI President** – Steve served as Director of the U.S. Fish and Wildlife Service, Secretary of the Kansas Department of Wildlife and Parks, Deputy Executive Director of the Pennsylvania Game Commission, and Assistant Director for Wildlife and Deer Project Leader of the Massachusetts Division of Fisheries and Wildlife. He serves on the National Fish and Wildlife Foundation board, American Wildlife Conservation Partners, Wildlife and Hunting Heritage Conservation Council, Council to Advance Hunting and Shooting Sports, and National Conservation Leadership Institute.

SCOT WILLIAMSON – **WMI Vice President** – Scot has served as WMI's Northeast Field Representative since 1994. He has coordinated the NEAFWA Regional Conservation Needs program since 1995 and assisted NEAFWA initiatives including conservation and restoration of shrub land-dependent wildlife and advancement of Landscape Conservation Cooperatives. Scot served as Big Game Director for Texas Parks and Wildlife Department and White-tailed Deer Project Leader for New Hampshire Fish and Game Department.

CHRISTIAN SMITH - Chris has served as WMI's Western Field Representative since 2011. He works with all WAFWA states and serves on several WAFWA and AFWA committees. Chris has over 36 years experience with the Alaska Department of Fish and Game (ADF&G) and Montana Fish, Wildlife and Parks (MFWP) including 3 years as Assistant Director of Wildlife Conservation Division for ADF&G and 11 years as Deputy Director of MFWP.

JONATHAN GASSETT, Ph.D. – Jon is WMI's Southeast Field Representative. He works with all SEAFWA states and served as President of AFWA, MAFWA and SEAFWA. He coordinates the Southeastern At-Risk Species (SEARS) Program for SEAFWA and serves as the National Industry-State Agency Liaison, helping to build and improve relations between state and industry partners. Jon is a graduate of the National Conservation Leadership Institute and serves on their Board of Directors. Jon has more than 14 years experience with Kentucky Department of Fish and Wildlife Resources (KDFWR) including 8 years as Commissioner of the KDFWR, 4 years as Director of their Wildlife Division, and 2 years as Big Game Project Coordinator.

Appendix D. USFWS/WMI Contract

The red wolf program evaluation will be structured around three components: Reports of red wolves in the peer reviewed literature, museum records of red wolves with documented locations, and ancillary historical reports such as journals, county records, bounty records, etc.

TASK 1
Title: A Comprehensive Review and Evaluation of the Historic Range of the Red Wolf

BACKGROUND AND OBJECTIVES

Director Ashe has asked the Southeast Region to do an expedited program evaluation (i.e., 60 days) structured around two components: Historic Range of the Red Wolf and Potential Release Sites as Determined by Sufficient Habitats and Life Needs.

The objective of this Cooperative Agreement is to evaluate the original distribution of the Red Wolf.

AUTHORITY

This Agreement is hereby entered into by authority of the Endangered Species Act of 1973, 16 U.S.C. 1531-1543

STATEMENT OF WORK

A. The Wildlife Management Institute agrees to:

The Wildlife Management Institute (WMI) will perform a search of existing literature and best information to identify the historical range of the Red Wolf. The WMI will use the best available scientific and commercial information and will focus this evaluation on the biological and ecological aspects.
(Final Report due to the Service December 15, 2015 – *extended to January 31, 2016*)

B. The Service agrees to:

Substantial involvement on the part of the USFWS is anticipated for the successful completion of the activities to be funded. In particular, the USFWS will be responsible for the following:

1. **Provide $30,000 in funding to carry out this SOW.**
2. **Provide copies of all pertinent documents in their possession (e.g. Maps, Assessments, Reviews, Species Recovery Plans, and Habitat Viability Analysis) or other Service information, data or documents relevant to the review as requested.**
3. **Provide a list of experts that may have a conflict of interest in relation to the**

development, implementation, and/or litigation of the Red Wolf Recovery Program or the project requested under this agreement.

4. Participate and collaborate jointly with the recipient partners, volunteers, scientists, technicians or other personnel, in carrying out the scope of work.
5. Detail federal personnel to work on the project effort.
6. Review and approve one stage of work before the next stage can begin.
7. Review and approve any proposed modifications or sub-grants, prior to award.
8. Direct or redirect the work because of interrelationships with other projects.
9. Immediately halt an activity if detailed performance specifications are not met.

Appendix E.

(Attached as Red Wolf Range Report Database.xls)

Worksheet - Source Database (Red Wolves)

Worksheet - Source Database (Coyotes)

Worksheet - Spatial Database (Red Wolves) – From Literature

Worksheet - Spatial Database (Red Wolves) – From Museum Records

Worksheet - Spatial Database (Coyotes)

FINAL REPORT FOR U.S. FISH AND WILDLIFE SERVICE (USFWS)

FEASIBILITY STUDY

10 June 2016

Developed by the Red Wolf PVA Team:

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Pete Benjamin, USFWS

Report Citation:

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Table of Contents

Executive Summary 3
Background 4
Modeling Approach 5
Model Scenarios 9
Model Validation 12
Model Results Summary 13
Population History and Current Status 13
PVA Results – Baseline (Scenario A) 15
PVA Results – Scenarios With Changes to NENC Parameters 18
PVA Results – Scenarios With Changes to SSP Parameters 20
PVA Results – SSP Population Absorbing NENC Wolves After NENC Termination 20
PVA Results – Release Scenarios (Connecting SSP and NENC Populations) 21
PVA Results – Recovery on Federal Lands Only 27
PVA Conclusions 28
Appendix 1: Vortex Model Setup Documentation & Supporting Analyses 32
Appendix 2. Model Scenario Results Table 52
Appendix 3. Literature Cited 56
Appendix 4. Additional Model Scenarios 59

Executive Summary

BACKGROUND

A Population Viability Analysis (PVA) is a quantitative computer model that can be used to project a population's long-term demographic and genetic future. In 2013, USFWS and the Red Wolf Species Survival Plan® (SSP) captive breeding program approached experts at the Lincoln Park Zoo to create the Red Wolf PVA team. The goal of this collaboration is to model the viability of the zoo-managed (SSP) and wild, northeastern North Carolina (NENC) red wolf populations, to better understand the conditions under which each population can best persist into the future and how movement of individuals between the populations impacts viability in both. This report summarizes modeling results from a stochastic individual-based model built in Vortex 10.1 for use in USFWS' Feasibility Review.

POPULATION HISTORY/CURRENT STATUS

A captive red wolf population has been managed in zoos and partner facilities since 1969, growing to 207 wolves at 44 institutions as of 1 January 2015 (our model starting point). Both the captive and wild populations are founded from only 14 wild-caught individuals from a single site in western Louisiana/eastern Texas; currently 12 founder lines are represented. The SSP has retained 89.2% of its founding gene diversity (GD) and the mean inbreeding value (F) is 0.076 (above that of first-cousin matings, 0.0625). The SSP population is space-limited, with current institutions potentially holding 225 wolves.

In 1987, the Recovery Program initiated the first red wolf restoration effort in northeastern North Carolina (NENC), ultimately releasing 165 wolves into NENC and an unsuccessful second reintroduction site. The NENC population had 74 individuals as of 1 January 2015. In the past this population has been as large as 148 individuals, but it has declined from that size over the past decade (Fig. 1a). Since the initiation of this modeling effort, the NENC population has continued to experience a decline, with current population size estimated at 45-60 (USFWS, 2016). Analysis of historical data indicate that mortality in breeding season has been increasing (Fig. A9, Hinton *et al.* 2015, Hinton *et al.* in review, Bohling and Waits 2015), disrupting reproductive pairs and lowering reproductive success, and that anthropogenic-caused mortality is the leading cause of death (Hinton *et al.* 2015). The NENC population has retained 85.4% of its founding GD and its mean F is 0.129 (above that of half-sibling matings, 0.125).

PVA RESULTS

Current conditions, without releases from the SSP or improvements to NENC vital rates, will result in extinction of the only remaining wild population of red wolves, typically within 37 years but in some iterations as soon as 8 years. Extinction will likely occur earlier than this timeframe because the population has already declined to lower than the model starting point. However, the NENC population can avoid extinction and be viable, but requires assistance to do so. There were several scenarios that would result in low (<10%) probability of extinction in the next 125 years for the NENC population; the most realistic of these involve a combination of reductions in NENC mortality rates, increases in NENC breeding rates (hypothesized to be achievable by reducing the disruptive effects of breeding-season mortality), and receiving releases from the SSP for a short, intense period (15 years) followed by intermittent releases to maintain genetic health after that.

While the SSP population has been maintained at a relatively large population size of more than 150 animals for over 20 years, it needs to increase breeding and increase its population size/space to ensure long-term viability and its ability to serve as a strong source for animals to release to the wild. Model scenarios with growth to 330 or 400 spaces illustrate that the population could benefit substantially in its population genetics and ability to sustain releases from such a change. Currently, space limits population size and, because there are not enough spaces to place pups, fewer breeding recommendations are issued. This management results in the use of contraceptives, separating of pairs during the breeding season, and/or delayed or less frequent breeding opportunities for females. Evidence from other carnivore species suggests that all of these management actions can negatively impact female fertility and reproductive health (Penfold *et al.* 2014, Asa *et al.* 2014). To increase from 225 to a population size of 330 or 400 wolves, new resources would need to be identified.

The 1990 Recovery Plan stated a goal of retaining 80% GD in 150 years (125 years from the 2015 starting point of the model). Under our various modeling scenarios, when considering the populations separately, 13 of the SSP scenarios had a high (>80%) chance of meeting this benchmark, but only two of the NENC scenarios could do so. However, when considered at the species level with the entire metapopulation, there were 22 model scenarios that had a high chance of retaining 80% GD, illustrating that achieving that recovery plan goal is possible with careful management.

These modeling scenarios highlight that red wolves will be a conservation-reliant species, requiring population management: all red wolves will need to be treated as a metapopulation, with occasional movement between the SSP and NENC, and perhaps other populations if they are established, to manage declining gene diversity given its small founding population (Goble *et al.* 2012). Both populations are small and will face rising inbreeding levels, and our model scenarios include the inbreeding effects that have already been detected (Appendix 1), but careful genetic management and continued, occasional releases to the NENC would help mitigate these effects. With NENC demographic changes and releases, maintaining a functioning wild NENC population is possible. This is a key example of a species that can be best preserved by the "One Plan" approach, where all populations, captive and wild, are considered under an integrated plan for species conservation (Byers et al. 2013).

Background

A Population Viability Analysis (PVA) is a quantitative computer model that can be used to project a population's long-term demographic and genetic future (Beissinger and McCullough, 2002; Morris and Doak, 2002). Models can be used to identify key natural and anthropogenic factors impacting population dynamics. PVAs are typically used to compare a baseline scenario, reflecting the population's likely future trajectory if current conditions continue, to alternate scenarios which can explore the impact of potential management changes, shifting environmental drivers, or whether uncertainty in parameter values has an impact on model results. These comparisons can help evaluate the relative costs and benefits of possible management actions. Because the future can be uncertain and difficult to predict, model results are most appropriately used to compare between scenarios (e.g. relative to each other) rather than as absolute predictions of what will happen. A PVA is an especially appropriate tool when robust data exist for model parameterization – both on the species biology and on the threats affecting the species' current and future status. For red wolves, decades of individual-based monitoring has resulted in high quality, long-term datasets that make it possible to base the model on actual historical biological data. This is rare, especially when conducting PVAs for endangered and threatened species. In this sense, the results in this PVA should be especially appropriate for addressing the questions of the USFWS Feasibility review.

Red wolves declined in the wild over the 1960s due to habitat loss and predator control programs. The species was listed as endangered in 1967, an *ex situ* population was established in 1969, and red wolves were considered biologically extinct in the wild in 1980. The first litters of captive pups were born in 1977. In 1987, the Recovery Program initiated the first red wolf restoration effort in northeastern North Carolina (NENC) and began releasing animals from the *ex situ* population; there was also an unsuccessful second reintroduction site at Great Smoky Mountains National Park in the 1990s. Since reintroductions began in 1987, 165 wolves have been released from the *ex situ* population (Simonis *et al.* 2015). Both the captive and wild populations are founded from only 14 wild-caught individuals from western Louisiana/eastern Texas. Currently, the captive and wild populations contain 12 founder lines, with one additional potential founder lineage available via a genome bank if artificial insemination techniques are perfected. The wild population that served as a source for these 14 individuals also went through a severe bottleneck before the capture of these founding wolves.

A Population Habitat and Viability Assessment (PHVA) was previously completed for red wolves (Kelly *et al.* 1999). Much of the PHVA was not based on detailed analysis of red wolf data from the wild, but rather on a combination of expert opinion and data from other wolves and large canids. The authors recognized the shortcomings of this approach and called for additional modeling (Kelly *et al.* 1999). The PHVA projected that the NENC population would increase by 20% annually until 2010; the population did follow this trajectory until ~2005, when it began to decline, with the pace of decline increasing rapidly since 2010.

In 2013, USFWS and the Red Wolf Species Survival Plan® (SSP) captive breeding program approached experts at the Lincoln Park Zoo to create the Red Wolf PVA team. The goal of this collaboration is to model the viability of the zoo-managed (SSP) and wild, northeastern North Carolina (NENC) red wolf populations, to better understand the conditions under which each population can best persist into the future and how movement of individuals between the populations impacts viability in both. The team developed an SSP-only model using ZooRisk software (Earnhardt *et al.* 2008), and published a final report on the PVA to the zoo community (Simonis *et al.* 2015a). This report reflects an updated metapopulation modeling approach using Vortex software, which has additional features that make it suited for modeling spatially separated populations that are connected via movement of individuals between the populations. The model and this report has been peer-reviewed by the IUCN SSC Conservation Breeding Specialist Group (CBSG). In 2016-2017, anticipated products include one or more manuscripts on the PVA. The information in this PVA and subsequent products can feed into future Recovery Planning documents including Species Assessments, 5-year Status Reviews, Consultations, Rule Revisions, and Recovery Plan revisions.

Modeling Approach

We developed a stochastic, individual-based population model in Vortex 10.1.4.0 software, a widely used PVA modeling software package (Lacy and Pollack 2015). For more detailed descriptions of Vortex and how it is applied in PVAs, see Lacy (1993, 2000) and Lacy *et al.* (2015). The red wolf model has two subpopulations: SSP and NENC. The model is individual-based, meaning it tracks every animal (current and future) in the population over time. After being initiated with the starting population, the model steps through an annual event cycle (e.g., births, transfers between subpopulations, deaths, aging, censusing) for all individuals.

For both the NENC and SSP populations, animals are individually identified and tracked in a studbook, an electronic database maintained using PopLink 2.4 (Faust *et al.* 2012). The red wolf studbook contains both populations' demographic and genetic history including births, deaths, transfers between zoos or between the SSP and NENC population, and pedigree relationships tracing back to the original founders (Waddell 2015). Additional NENC data are taken from USFWS databases. We parameterized the Vortex model with data from these datasets.

GENERAL MODEL SETUP

Full details on model parameterization and data analyses are presented in Appendix 1. This is a brief overview of the setup for the baseline model scenario (parameters are bolded and parameter values used in the model are underlined; EV = if a parameter includes environmental variation):

Model Timeframe: 125 years

Model results are reported at 150 years from the 1990 Recovery Plan (i.e. 2140, or 125 years from 2015).

Initial Population: SSP = 201 wolves; NENC = 74 wolves

The model was initialized with a starting population of the living animals in each population as of 1 January 2015, extracted from the studbook. The model tracks these individual's age, sex, subpopulation (SSP or NENC), and genetic relatedness to other individuals over time. In addition, the starting individuals were paired with their existing mate if they were currently paired. As of 1 January 2015, the SSP had 201 individuals (87 males, 114 females) and the NENC population had 74 individuals (34 males, 40 females). For age distributions see Appendix 1, Fig. A5.

Movement between populations: baseline scenario = off

The baseline scenario models the SSP and NENC as isolated populations, since as of 2015 USFWS had ceased releases into the NENC. In alternate scenarios, the model randomly selects animals (within specified age classes based on a specified number of releases) from the SSP population to move into the NENC population. Equal numbers of males and females are moved. Releases can only occur in years where the SSP's population size is larger than 80% of Carrying Capacity (see below). The model is behaviorally naive in that it assumes that as soon as an individual is released to the wild, it behaves like a wild wolf with NENC demographic rates. Note that although in the past some wolves were "removed" from the wild and transferred into the SSP or euthanized based on requests for removals from the NENC population due to human-wildlife conflict, in this modeling exercise we are not including these types of removals from the NENC population.

Inbreeding Depression: Includes observed impacts on litter size, sex ratio and pup mortality for SSP and NENC

In a small population with a limited founder base, mating between close relatives (inbreeding) is often unavoidable and can have potential negative impacts on population demographics and viability. Inbreeding effects were previously documented for the SSP population (Rabon and Waddell 2010), but were not detected for the NENC population (Brzeski *et al.* 2014). As part of this modeling effort, we re-analyzed SSP and NENC data for effects of inbreeding depression, and found statistically significant effects on offspring sex ratio, litter size, and pup mortality for both populations. We included these effects in the model (see parameter descriptions below and Appendix 1).

Catastrophes: 2.9% chance per year of a 50% reduction in survival for NENC population

Catastrophes are rare events that occur stochastically: in any given model year, Vortex assesses whether it is a catastrophe year or not and alters vital rates for that single year accordingly. Potential catastrophes that might threaten the NENC population include disease outbreaks, hurricanes, and fires. Our selected value for catastrophes was based on the frequency and severity of catastrophes observed in a review of 88 wild vertebrate species (Reed *et al.* 2003), which found a frequency of 14% per generation (red wolf generation length = 4.9 years based on wild data, See Appendix 1). It is assumed that the SSP is buffered from catastrophes, as it is spread across multiple institutions and adverse events can be mitigated by human management.

Reproductive system: long-term monogamy

Red wolves form long-term bonded pairs; in the NENC pairs typically remain together until a mate dies and then the surviving wolf may re-pair, while in the SSP pairs are typically kept together unless the mate becomes post-reproductive, the mate dies, the pair is behaviorally incompatible, or genetic relationships become mismatched. In the model the reproductive system was set at long-term monogamy.

Carrying capacity (K): SSP = 225, NENC = 150

This variable is used to limit population growth in the model; when the population is larger than K at the end of the year, Vortex probabilistically culls across all age and sex classes to bring the population back approximately to K.

In the NENC, K = 150 based on a previous estimate by USFWS (Kelly *et al.* 1999) of the potential number of individuals that could be held at the original reintroduction site of Alligator River National Wildlife Refuge if the population had access to the whole landscape of the 5-county NEP area. In the past the maximum estimated population size was 148 individuals, and when at that size there was not strong observed intraspecific competition or density-dependent effects, so the population was likely not truly at ecological K (Gese *et al.* 2015; Hinton *et al.* in review). However, for the model 150 was chosen as a cap that the population would likely not be able to exceed.

In the SSP, K = 225 based on the population size that can be held in the current space available in zoos (Simonis *et al.* 2015a). This size/space is not necessarily equivalent to the number of exhibits or enclosures: because of the social structure of wolves, two or more animals are frequently housed together depending on enclosure size, location, and intent (exhibit or off-site). In the model, K reflects the number of individuals, but not the explicit number of spaces/exhibits. In the model the SSP population is "bred to maintain the population at K", meaning that each year the model assesses the current size against K, takes into consideration the estimated number of deaths expected in the year, average breeding success of recommended breeding pairs, litter size, and pup survival, and determines the number of breeding pairs to make (similar to the SSP breeding recommendation process for the year).

Proportion of females in the breeding pool: SSP = 93%; NENC = 52.5%, EV = 7.9%

Each year, the model stochastically pulls a fraction of reproductive-aged (ages 2-10) females into the potential breeding pool (for both unpaired and paired females). This % of adult females breeding was 93% for the SSP based on the % of non-breeders in the current SSP who are unable to breed for health or reproductive reasons (6/87 individuals, or 7%; Waddell and Long 2014). The NENC rate = 52.5%, EV (Standard Deviation) = 7.9% based on the average observed number of females in wolf-wolf pairs from 2000-2014 (Appendix 1, Table A2).

Proportion of males in the breeding pool: SSP = 94%; NENC = 88%

Un-paired, reproductive-aged (ages 2-12) males are pulled into the breeding pool based on the % of males in breeding pool. The SSP rate = 94% based on the % of non-breeders in the current SSP who are unable to breed for health or reproductive reasons (4/68 individuals, or 6%; Waddell and Long 2014). The NENC rate = 88% based on excluding the average percentage of males in wolf-non-wolf pairs from 2000-2014, 12% (Appendix 1, Table A2).

Criteria for separating long-term pair: SSP only = 25%

In the SSP population, pairs had a 25% probability of being split in any given year and going back into the respective breeding pools. This frequency was based on assessments from the last 15 years of SSP breeding recommendations from SSP Breeding and Transfer Plans. All pairs have an equal chance of being split each year, not based on genetic value or past reproductive performance.

Genetic Management: SSP = on; NENC = off

For both the SSP and NENC populations, the model is initialized with the existing breeding pairs as of January 2015 (for the SSP, this was 37 pairs; for the NENC, it was six pairs). For the SSP, genetic management is turned on to simulate the SSP process of managing by mean kinship (MK), the genetic relatedness of an individual to the rest of the population. In any given year, females in the breeding pool that do not have a mate are paired with the next available male with the lowest MK value (i.e. individuals from more rare genetic lines get paired first). To avoid creating excessively inbred litters, if the kinship between the female and a potential male exceeds 1 – 90% * GD (current population gene diversity), the next male on the list is selected (re-trying a maximum of 10 times). This process uses a static MK list, (i.e., one that is only sorted at the beginning of the model year) rather than resorted after each pair has offspring. In the NENC, genetic management = off; in the model unpaired animals from the breeding pools are randomly paired because wild wolves choose their own mates except under coyote management regimes, which is simulated in other model parameters (i.e. proportion of females in the breeding pool).

Female breeding success: SSP = 19%; NENC = 60%

For any females in the breeding pool that are paired through the pairing process (randomly in the NENC or via genetic management for the SSP), the model stochastically assesses whether the female successfully breeds based on the distribution of litters (which Vortex calls broods) per year (i.e. the percentage of unsuccessful ("0 litters") or successful ("1 litter") per year). For the SSP, 81% of paired females have 0 litters, and 19% have 1 litter based on the proportion of SSP breeding recommendations that result in a litter before the next breeding and transfer plan is issued (2001-2013 data; Appendix 1, Table A1). For the NENC, 40% have 0 litters, 60% have 1 litter based on the average annual % of wolf-wolf pairs that produced a litter (2000-2014 data; Appendix 1, Table A2).

Reproductive success of these pairs is modeled as random and not based on age, genetic value, or reproductive history (i.e. the model does not take into consideration whether the individual is a "proven breeder", a young or old reproductive-aged animal, or a genetically valuable individual); this may be an optimistic assumption. For several canid and felid SSP populations, breeding success of recommended pairs is based on several factors, including female age and past reproductive history (Saunders *et al.* 2014; K. Traylor-Holzer, pers. comm.); however, for red wolves these factors have not been investigated.

Litter Size: Range 1-10; litter size higher in NENC; as inbreeding coefficient increases, litter size decreases;

Females can only have one litter per year, at most. If a female is stochastically selected to have a litter, the *number of offspring per litter distribution* is used to determine the size of her litter. Each litter is between 1 and 10 (based on studbook data), with the number of offspring varying based on statistically significant patterns in the historical data for both populations, where litter size is significantly higher in the NENC population, and as inbreeding coefficient increases in both populations litter size significantly decreases; see Appendix 1 and Fig. A2, A10 for more details.

Offspring sex ratio: as inbreeding coefficient increases, higher probability of male offspring

Offspring sex ratio is assigned stochastically, and does not differ between SSP and NENC populations. Sex ratio varies with inbreeding coefficient based on statistically significant patterns in the historical data for both subpopulations: as inbreeding coefficient increases there is a higher probability of a male-biased offspring sex ratio; see Appendix 1 and Fig. A1 for more explanation.

Model Scenarios

Our modeling was focused on evaluating the population's viability overall as well as the progress towards meeting the recovery goals laid out in the 1990 Recovery Plan:

1. Develop an *ex situ* population of at least 330 animals managed at 30 or more breeding facilities and zoos.
2. Establish and maintain at least three *in situ* red wolf populations totaling at least 220 animals.
3. Preserve at least 80% of the population's founding genetic diversity for 150 years (*i.e.*, until the year 2140).

Specifically, we were interested in:

1. Under current demographic rates and management (i.e. no releases), are the SSP and NENC populations viable for 125 years?
2. What changes to vital rates would create a viable NENC population?
3. If coyote impacts changed (increased or decreased), how would it impact the NENC population?

Table 1 details the model scenarios explored in comparison to the baseline model described above, with alterations in parameter setup noted in the "Description" column; see Appendix 1 for additional details.

Additional model scenarios that were run for the preliminary report but are less essential to highlight the main modeling results are included in Appendix 4.

Table 1. Red wolf PVA model scenarios

Label	Scenario Name	Description
A	Baseline	SSP and NENC populations uncoupled (separate, no releases) with baseline demographic rates as described above
NENC population - demographic rate changes (survival, reproduction)		
B	NENC mortality = intermediate	NENC mortality rates are decreased to "intermediate" levels, calculated as the midpoint value between the SSP and NENC rates, for age classes 1-16 (Table A3). Anthropogenic mortality is the leading cause of death for red wolves (Hinton *et al.* 2015). Evidence suggests that anthropogenic mortality in the population is additive rather than compensatory (Sparkman *et al.* 2011), suggesting that if human-caused mortalities were reduced, the overall mortality rates for the population would be lower. USFWS managers also suggest that in the population's early history there were management and health-related issues which, with experience, are now better managed; this is supported by the decreasing trend in per capita mortality over time (Appendix 1, Fig. A8). Although the mortality values used in this scenario are hypothetical, they generally represent a scenario in which anthropogenic (and other) mortality sources are reduced but not reduced to levels as low as the captive SSP population.
C	NENC mortality = SSP mortality	NENC mortality rates are decreased to SSP mortality rates for age classes 1-16 (Table A3).
D	NENC mortality = Intermediate, no inbreeding depression	NENC has intermediate mortality rates + elimination of inbreeding depression's impact on offspring sex ratio, infant mortality, and litter size as described in scenario DD.

Label	Scenario Name	Description
E	Increased females breeding NENC	% NENC females breeding increased to 70% based on the highest breeding rates observed in the past, when in 2003-4 the population had 71.4% of females in wolf-wolf pairs (Table A2). We hypothesize that these rates can be achieved again by shifting mortality. Over the history of the population, the timing of mortality in the year has shifted such that in more recent years, mortality (primarily anthropogenic) has occurred fall through winter (i.e. in the fall hunting season), which corresponds to red wolf pre-breeding and breeding season (See Fig. A9; Hinton et al. 2015, Hinton et al. in review, Bohling and Waits 2015). When mortality occurs during this time of year, wolves do not have time to form a new pair bond naturally or via USFWS management actions, disrupting reproduction for the season. If late season, anthropogenic mortality is reduced allowing wolves more time to repair if a mate is killed, higher breeding rates should be achievable (Hinton et al. 2015). While shifts in the timing of mortality would support the increased breeding rate modeled here, the actual mortality rates in this scenario remain unchanged.
F	NENC mortality = intermediate, Increased females breeding NENC	NENC has intermediate mortality rates + increased % females breeding. This scenario represents ideal management of demographic rates, where anthropogenic mortality is reduced to the point that overall mortality is reduced, and observed mortality is less concentrated in the pre-breeding and breeding seasons, resulting in higher % females breeding.
G	Reduced coyote impact	% NENC males in the breeding pool was increased to 100%, assuming no males are mated with coyote females. % NENC females in breeding pool was increased to 68.8%, based on the average annual rate of wolf-canid pairs (i.e. pairs with either a wolf or coyote are replaced by pairs with only wolves) that have been observed 2000-2014 (Table A4). If all wolves were able to make wolf-wolf pairs, reproduction would increase. We hypothesize that these effects might take place if the wolf population was large enough that wolves outcompeted coyotes for breeding partners or territories, and/or if the coyote population was managed through a placeholder approach (Gese et al. 2015, Gese and Terletzky 2015, Bohling et al. 2016).
H	Increased coyote impact	Assumes that if the coyote population increases or if coyotes are less managed to avoid impacts on the wolf population, then wolf breeding would be further negatively impacted as coyotes would more frequently pair with wolves. To simulate this, we took the average rate of male and female wolves in wolf-coyote breeding pairs (12% and 16.3%, respectfully) and doubled those rates (to 24% and 32.6%); this reduces the % NENC males entering the (wolf) breeding pool from 88% to 76% and females entering the breeding pool from 52.5% to 36.2%. This reduces the breeding pool (of wolf-wolf pairs), which limits the genetic population dynamics as well (fewer pairs have offspring).
I	NENC mortality = intermediate, reduced coyote impact	NENC population has intermediate mortality rates + increased breeding rates as in Scenario G.
J	NENC mortality = intermediate, Increased coyote impact	NENC population has intermediate mortality rates + decreased breeding rates decreased as in Scenario H.
SSP - increased space and breeding		
K	SSP 330 spaces	SSP carrying capacity increased to 330 based on the target set in the 1990 Recovery Plan (USFWS 1990).
L	SSP 400 spaces	SSP carrying capacity increased to 400 based on previous modeling work (Simonis et al. 2015b)
M	SSP 330 spaces, SSP 25% breeding	SSP carrying capacity increased to 330 + % females producing a litter increased from 19% to 25%. Although the percentage of paired females that successfully breed with their recommended mate in the SSP has achieved a maximum of 34.6% (Table A1), population managers consider this to be overly optimistic for a sustained period of time (Waddell, personal communication). In discussions with population managers, the PVA team decided that 25% was a reasonable, if challenging, value to achieve on an annual basis (Waddell, personal communication).

Label	Scenario Name	Description
N	SSP 400 spaces, SSP 25% breeding	SSP carrying capacity increased to 400 + % females producing a litter increased from 19% to 25%
	NENC individuals brought into SSP	
D	Capturable wolves brought into SSP	Based on an assessment by FWS staff, 32 individuals of the 74 wolves in the NENC at the start of the model could be captured (Harrison, pers. comm.). This scenario assumes that these individuals are moved immediately into the SSP population before the model simulation begins and are subsequently subjected to SSP demographic rates, but the SSP remains at the baseline level of space (225)
P	Capturable wolves brought into SSP, SSP 330 spaces	Bring in the 32 individuals + increase SSP carrying capacity to 330
	Release scenarios - Releases Only	
Q	Movement (3.3 per year)	Release younger SSP wolves into NENC at a rate of 3.3 animals per year, which is based on the average release rate from 2005-2014. Animals are released with these age distributions: 60.4% 0-year olds, 33.3% 1-year olds, and 6% 2-5-year olds (matching age distribution of releases from 2005-2014, Fig. A6), representing primarily a pup-fostering approach. The model randomly selects animals within the given age class range as long as there are individuals available for release. Releases only occur in years when the SSP population size was at least 80% of the SSP's K. Released individuals are then subject to all NENC demographic rates.
	Release scenarios - Releases + SSP changes	
R	Movement (3.3 per year), SSP 330 spaces	Releases as in Scenario Q + SSP carrying capacity is increased to 330.
S	Movement (3.3 per year), SSP 400 spaces	Releases as in Scenario Q + SSP carrying capacity is increased to 400.
T	Movement (3.3 per year), SSP 400 spaces, SSP 25% breeding	Releases as in Scenario Q + SSP K = 400 + % females in the SSP producing a litter increased to 25%
	Release scenarios - Releases + NENC demographic rate changes	
U	Movement (3.3 per year), NENC mortality = intermediate	Release as in Scenario Q + decreased mortality in the NENC population as in Scenario B.
V	Movement (3.3 per year), NENC increased breeding	Release as in Scenario Q + increased breeding in the NENC population as in Scenario E.
W	Movement (3.3 per year), NENC mortality = intermediate, NENC increased breeding	Release as in Scenario Q + decreased mortality + increased breeding in the NENC population as in Scenario F.
X	Movement (3.3 per year for 15 years then every 5 years), NENC mortality = intermediate, NENC increased breeding	Release young animals, 3.3 per year for 15 years and then 3.3 every 5 years from year 16 to 125. NENC mortality = intermediate and increased females breeding as in Scenario F.
Y	Movement (3.3 per year for 15 years then every 20 years), NENC mortality = intermediate, NENC increased breeding	Release young animals, 3.3 per year for 15 years and then 3.3 every 20 years from year 16 to 125. NENC mortality = intermediate and increased females breeding as in Scenario F.
Z	Recovery on federal lands only	Hypothetical effects of only using federal lands for NENC recovery, scenario includes: Increased coyote impact on reproduction as in Scenario H; NENC K reduced to 25 based on estimates of numbers of territories available on federal land; Release 1 animal every other year from the SSP; Initial NENC population reduced to 14 animals (8 adults, 4 pups, 2 juveniles)

Label	Scenario Name	Description
		Release scenarios - Releases + SSP + NENC changes
AA	Movement (3.3 per year), SSP 400 spaces, SSP 25% breeding, NENC mortality = intermediate	Release as in Scenario Q + 400 SSP spaces + increased SSP breeding (as in scenario M) + decreased NENC mortality
BB	Movement (3.3 per year), SSP 400 spaces, SSP 25% breeding, NENC mortality = intermediate, NENC increased breeding	Release as in Scenario Q + 400 SSP spaces + increased SSP breeding (as in scenario M) + decreased NENC mortality + increased NENC breeding
		NENC & SSP populations parameter sensitivity testing
CC	No BSR bias	Offspring sex ratio (birth sex ratio, or BSR) set as 50% males (no bias due to inbreeding).
DD	No inbreeding	Remove future inbreeding effects. Use parameter values based on each population's median current inbreeding level, such that offspring sex ratio = 48.8% male, litter size is a Poisson distribution with a mean of 3.97 for the SSP and 4.64 for the NENC, and first year mortality is 37.7 for the SSP and 47.4 for the NENC. See Appendix 1 for more details.
EE	No genetic management of SSP	For the SSP population, stop genetically managing by mean kinship and allow individuals to be paired and given a breeding recommendation randomly regardless of their mean kinship.
FF	SSP Current Number of Pairs	For the SSP, restrict reproduction to reflect the current number of pairs that are being made within existing space (rather than allowing Vortex to make enough pairs to "breed to K"). Over the past three years, the SSP has recommended an average of 29.3 breeding pairs (Table A1). In the model, this is implemented by allowing the first 29 paired females to have a 19% probability of breeding success and, beyond that, pairs have a 4% probability of breeding success.
GG	No Environmental Variation in any demographic parameters	For the NENC only, evaluate the impact of EV on model results by setting all EV values to 0

Model Validation

Model validation is an important step in any modeling effort, where results are scrutinized, compared against historical population trajectories, and validated with more rigorous methods. Validation builds confidence that the model is free of errors, acting appropriately, predictive of future dynamics based on current understanding, and sound for decision-making. However, validating model predictions for time series analyses is a non-trivial exercise requiring model/system-specific development of statistics that adequately incorporate process and observation uncertainty as well as temporal autocorrelation at time scales relevant to the biological system (King *et al.* 2015). Indeed, recent analyses have shown that previous attempts to validate complex models with simple, out-of-the-box statistics has a very high likelihood of leading to false understandings of model precision and validation (King *et al.* 2015). Given the compressed timeline to produce this report, we have focused on validation to insure that input values are accurate and there are no errors in model setup.

Model Results Summary

Throughout the results, we refer to model scenarios by letter, i.e. (Scenario A) or (A); refer back to Table 1 for full scenario descriptions. We use the following abbreviations for summary statistics:

Abbreviation	Description
P(E)	Probability of extinction in 125 years (i.e. the # of extinct iterations/total # of iterations)
GD	Mean gene diversity retained in 125 years, calculated across surviving (non-extinct) model iterations
F	Mean inbreeding coefficient in 125 years, calculated across surviving (non-extinct) model iterations
N	Mean population size in 125 years, calculated across all 1000 model iterations (extant and extinct)
TE	Median time to extinction for iterations that go extinct (only reported if the population went extinct in at least 50% of simulations)
P(80GD)	Probability of population maintaining 80% GD at 125 years, calculated across all surviving (non-extinct) model iterations

Note that GD, F, and N all have variability associated with them due to the stochastic nature of the model dynamics, and this variability conveys the range of possible future outcomes under a model scenario. For GD, F, and N we also present the standard deviation (± 1 SD) for any mean values reported. See Appendix 2 for a table summarizing all model results across all scenarios for each population.

Population History and Current Status

SSP Population: The SSP population has been managed in zoos and partner facilities since 1969, growing to its 2015 size of 207 wolves at 44 institutions (Fig. 1a). The cooperative nature of the red wolf SSP has aided in reducing significant loss of population gene diversity through intensive genetic management from the start of the captive program, and the population currently retains representation of 12 of the 14 original founder genomes; the other 2 founders were bred initially but don't have surviving descendants. (Fig. 1b). Breeding is maximized within the available space and breeding success is further supported by annual population assessments and recommendations, regular adjustments to keep animals in breeding situations, and a the high rate of institutional compliance in following annual breeding and transfers recommendations set by the SSP. Over the past 10 years, the population averaged 30.9 births per year (range 12-66), as well as an average of 3.4 releases (animals moving from the SSP to the wild population) each year and 0.1 transfers of animals from the wild population to the SSP (Fig. 2a, 2b). The population has retained 89.2% of its founding gene diversity and the mean inbreeding value (F) is 0.076 (above that of first-cousin matings, 0.0625). The population is space-limited, with current institutions potentially holding 225 wolves (Waddell and Long 2014; Simonis et al. 2015a).

NENC Population: As of 1 January 2015, the NENC population was 74 individuals residing within the Recovery Area in NENC. In the past the population has been as high as 148 individuals, but it has declined from that size over the past decade (Fig. 1a). The population has representation of the same 12 founder genomes in nearly the same proportions as the SSP population (Fig. 1c). In its most recent decade, deaths have outnumbered births (Fig. 2c), and releases from the SSP population are much lower than earlier in the population's history (Fig. 2d). GD of this population is currently 85.4% and the mean F is 0.129 (above that of half-sibling matings, 0.125). It should be noted that in the time since our analyses were initiated, the red wolf population has declined further, to an estimate of 45-60 animals (USFWS, 2016).

Metapopulation: Overall, the red wolf metapopulation was 275 animals as of 1 January 2015, with an overall GD = 90.0% and mean F of 0.0894. The population was founded from only 14 individuals, with only 12 of these lineages contributing to the living population (Figs. 1b, 1c), and one potential cryopreserved founder lineage available if reproductive technologies are advanced (Waddell and Long 2014). Note that the species' GD overall is higher than that of either of the subpopulations.

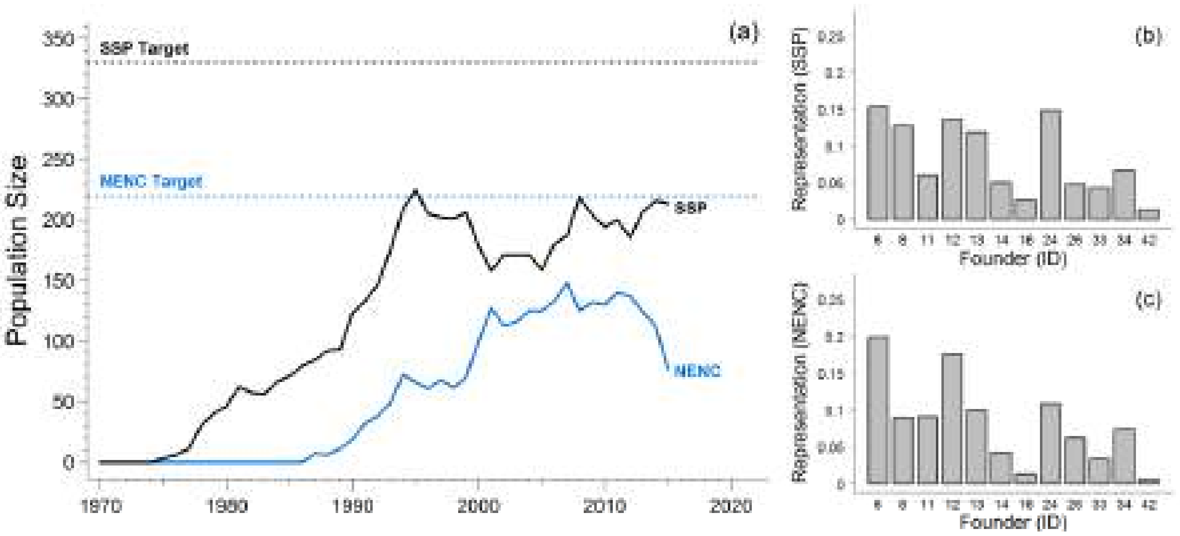

Figure 1. Demographic and genetic status of the NENC (wild) and SSP (captive) populations, including (a) population size over time for both populations; dotted lines represent target population sizes from the USFWS Recovery Plan; and proportional genetic representation of red wolf founders in the SSP (b) and NENC (c) populations as of 1 January 2015.

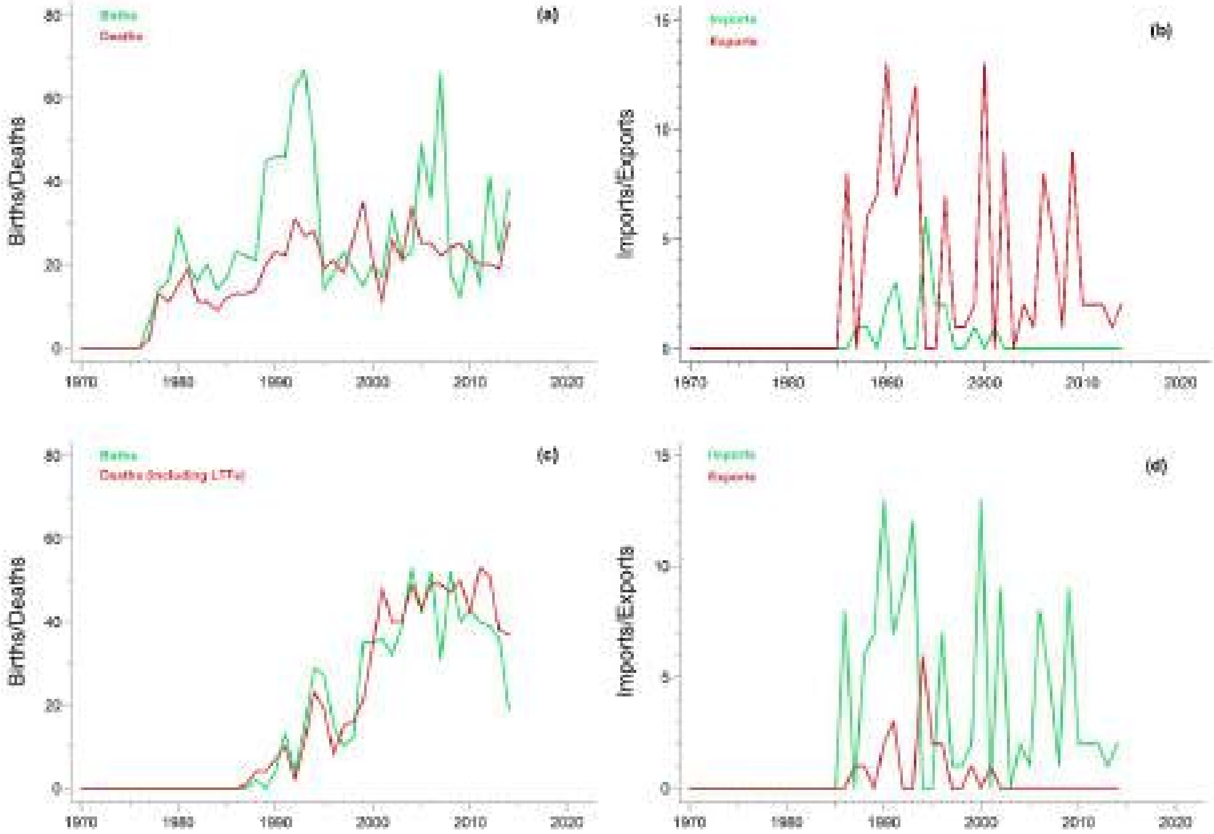

Figure 2. Annual numbers of demographic events for the SSP (a, b) and NENC (c, d) populations. (a) and (c) show births in green and deaths in red (note that the NENC deaths also include individuals that were lost to follow-up or "LTF", which are missing, and presumed dead). (b) and (d) show imports in green and exports in red. Imports/exports are in reference to the focal population, thus in (b), imports are animals returning into the SSP from the wild, and exports are releases into the wild; in (d) imports are releases into the wild, and exports are animals transferred into the SSP.

PVA Results – Baseline (Scenario A)

NENC Population: Under the conditions in the baseline scenario, the NENC population is projected to crash, with P(E) = 100% and a median TE of 37 years (range 8-82 years; Fig. 3). This timeframe for extinction and the baseline model results are likely over-estimates given developments since we initiated this modeling work; the population has already declined to 45-60 animals and mortality and reproductive data from 2015-2016 are not incorporated into our model estimates.

Model sensitivity testing (Scenarios CC, DD, and GG) indicated that, in the short term, this decline is partially due to the effects of inbreeding depression on the small population that is isolated from the SSP (Fig. 4). If inbreeding is removed (DD), the P(E) is reduced to 58.9%, the mean trajectory can increase for approximately a decade, but then eventually begins to decline once again because of the combination of current mortality and reproductive rates, with final N = 31.5 ± 48.2 and median TE = 103 years. Removing the environmental variation included in the model (GG) did not change the NENC population's results – it still had a 100% probability of extinction with TE of 38 years (vs. 37 in the baseline).

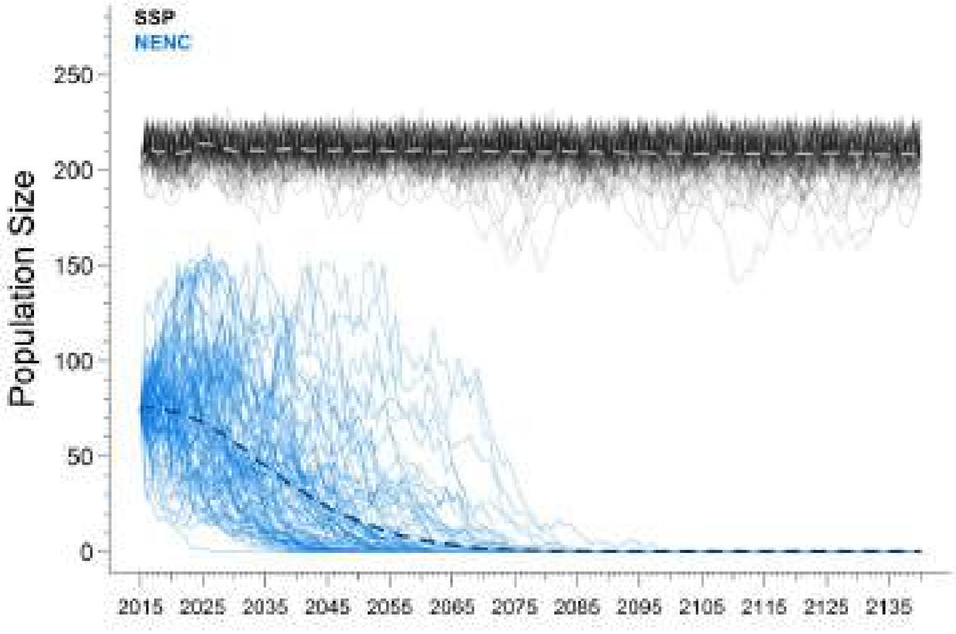

Figure 3. Baseline model results for SSP and NENC populations for a sample 100 model iterations. Dashed lines represent the mean population trajectory across 1000 model iterations.

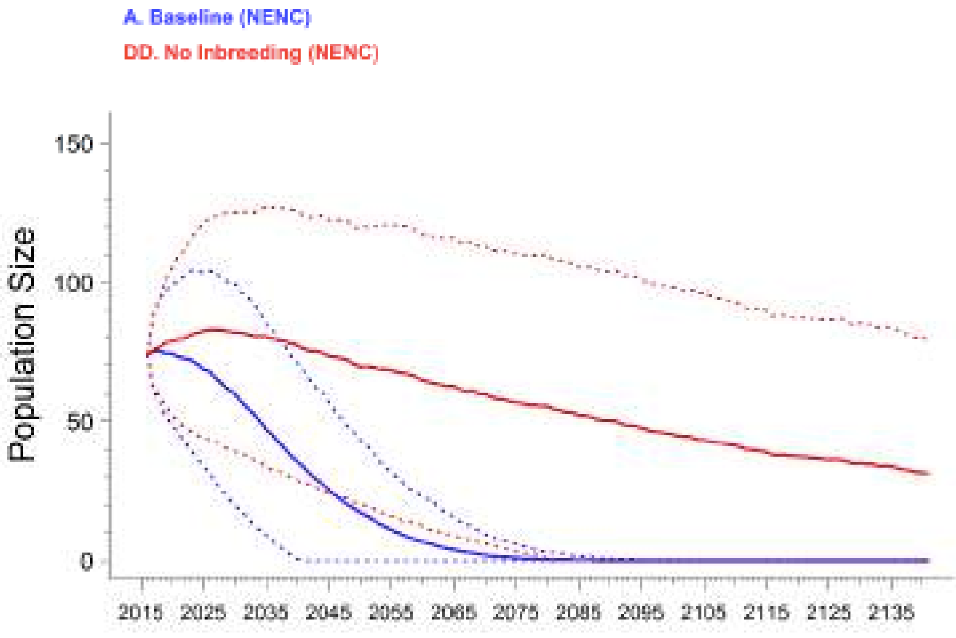

Figure 4. Projected size of the NENC population under baseline conditions (blue) and in the (hypothetical) absence of inbreeding impacts (red). Solid lines are mean, dashed lines show one standard deviation in each direction (minimum at 0), summarizing 1000 iterations of the model.

SSP Population: Under the conditions in the baseline model scenario in which the SSP is bred to maintain the population at K of 225, the SSP population would remain demographically stable (P(E) = 0%) (Fig. 3), maintain its current population size, and have a moderate chance of maintaining the 80% GD set out in the Recovery Plan (P(80GD) = 65.7%). Under this "breed to K" model setup, the population would be making an average of 52 breeding pairs per year over the first decade, which would produce an average of ~37.4 births/year over the first decade, and eventually approximately 34 births/year to remain at 225 individuals. If the population could sustain these conditions, the model projects that in 125 years, N = 207.9 ± 11.4, GD = 0.81 ± .05, and inbreeding is very high at F = 0.1799 ± 0.06 (above that of half-siblings, where F=0.125). Sensitivity testing illustrated that ongoing genetic management of the SSP population (Scenario EE) is important in retaining genetic health – without genetic management P(80GD) is much lower at 30%, final GD = 0.7505 + 0.0834 and F = 0.239 + 0.0897. The rigorous and careful genetic management the SSP currently employs should be continued to maximize the population's future genetic health.

However, in the recent past, the SSP has been producing ~31 births/year (past decade; Fig. 2), and has been only able to make about 29 breeding pairs (past three breeding plans) given its space and other constraints, so the dynamics modeled in Scenario A represents an increase in reproduction over the SSP's recent history. In a scenario that constrained the SSP to only make 29 breeding pairs per year (Scenario FF), the population is unable to sustain itself and declines (Fig. 5). Under this scenario, the population produced an average of 22.6 births/year over the first decade of the model. If constrained in this way, the model projects that in 125 years, the population has a slight change of extinction (P(E) = 0.5%), N = 208.3 ± 11.1, and genetic metrics are worse than if the population can remain stable as in the baseline: GD = 0.7611 ± 0.0785, and inbreeding is even higher at F = 0.2201 ± 0.0947 (approaching that of full-siblings, where F=0.25). In combination, these scenarios indicate that the SSP has the potential for demographic stability (i.e. could sustain its current population size) based on its current age structure and demographic rates, but will need to increase the number of breeding pairs (or the success of those pairs) to avoid a decline. In the real world, additional pairs above 29 (FF) and up to 52 (A) are logistically challenging due to space limitations, suggesting the possibility of an SSP decline without careful management.

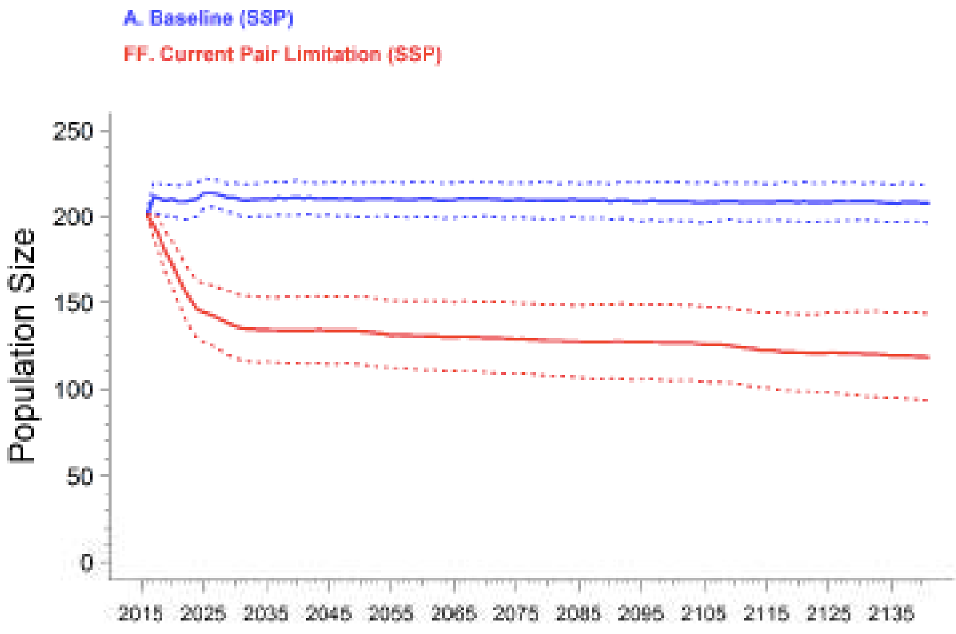

Figure 5. Projected SSP population size under the baseline (Scenario A) and SSP Current Number of Pairs (Scenario FF) scenarios.

PVA Results – Scenarios With Changes to NENC Parameters

If the populations remained uncoupled without any releases from the SSP to the NENC, improvements to NENC mortality and reproductive rates have the possibility of slowing the NENC population's decline, but significant changes to these rates would be required to guarantee a NENC population will persist into the future with certainty. Reductions in mortality rates have the biggest impact of any single variable (more than changes in reproduction or coyote impact). However, intrinsic changes (mortality, reproduction) alone will not guarantee a healthy and sustainable NENC red wolf population, mainly due to the long-term effects of inbreeding depression on the closed population (Fig. 6).

- The "intermediate mortality" rates in Scenario B resulted in a NENC population with a high extinction risk (P(E) = 82%) and low final N (4.2 ± 13.3). Under this scenario, the population is predicted to experience moderate growth for several decades, but then ultimately decline strongly, with a median TE of 102 years. To illustrate the magnitude of this change in mortality, "intermediate" mortality resulted in an average of ~31 deaths in the first model year compared to ~38 in the baseline scenario. It is unlikely that mortality could be reduced to the SSP rates (Scenario C), but if they could the NENC population would eliminate its extinction risk (P(E) = 1.6%); however, it would still decline from its K of 150 eventually (final N = 116.9 ± 42.1).
- In scenarios with "improved" mortality, the downward drag on the population's trajectory occurs because of accumulating impacts of inbreeding depression over time: in Scenario D, which had intermediate mortality but no inbreeding depression, the population's dynamics are stable (P(E) = 0.3%, final N = 138.6 ± 24.8).
- If the NENC could sustain the reproductive rates they achieved in ~2003-2004 (scenario E), the population could do much better in the short term, but still is at risk in the long term. Under Scenario E, the population still had a high P(E) of 99.6%, with the median TE increasing from 37 years in the baseline to 70 years. This indicates that changes in reproduction alone cannot sustain the NENC population, although they would offer short-term population increases.

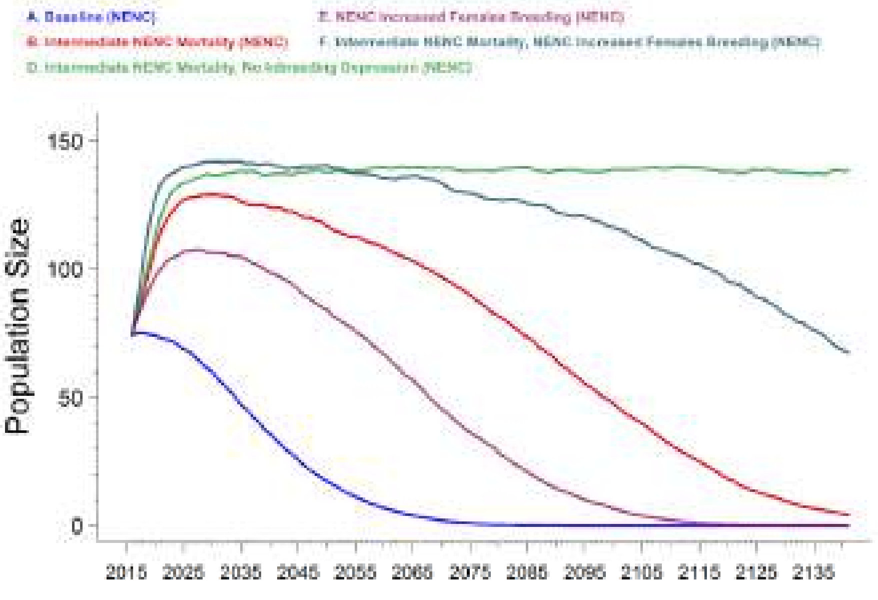

Figure 6. Projected mean population size for the NENC population for various model scenarios. Population size is the mean size averaged across 1000 iterations.

- In combination, improvements in mortality and reproduction (Scenario F) are projected to result in a much healthier NENC population compared to the baseline, with a moderate chance of extinction (P(E) = 16.5%). Because it is a small closed population, eventually as inbreeding accumulates the population size declines (final N = 67.5 ± 54.3) and genetic results are fairly poor: P(80GD) = 6.6%, GD = 0.6568 ± 0.1382, F = 0.3086 ± 0.1535 (higher than matings at full-sibling level, F =0.25). If kept isolated from the SSP population, the NENC population suffers genetically even if demographic rates can be changed.

Changes to coyote impacts

- If coyote impact were reduced such that all red wolves can pair with red wolves (Scenario G), the population trajectory and results are very similar to those for increased reproduction (E) – an increasing population in the short-term, but definite extinction (P(E)=100%, median TE= 66 years; Fig. 7). If those changes were also made in combination with improvements to mortality to intermediate levels (I), the population's extinction risk declines to 16.2%, with a mean final N of 61.6 ± 50.3 and a moderate chance of populations retaining above 80% GD (P(80GD) = 67.6%).
- If increased coyote impact results in lower red wolf reproduction (Scenario H), the population will do even worse than the baseline scenario and decline even more quickly, with a median TE = 23 years (range 6-48 years; Fig. 7). If these changes were paired with improvements to mortality to intermediate levels (J), the population would still have a 100% P(E), but have a median TE of 49 years.
- Note that coyote scenarios do not measure the effects of genetic introgression, but the demographic and genetic effects of wolves being able to breed with other wolves to a greater or lesser degree.

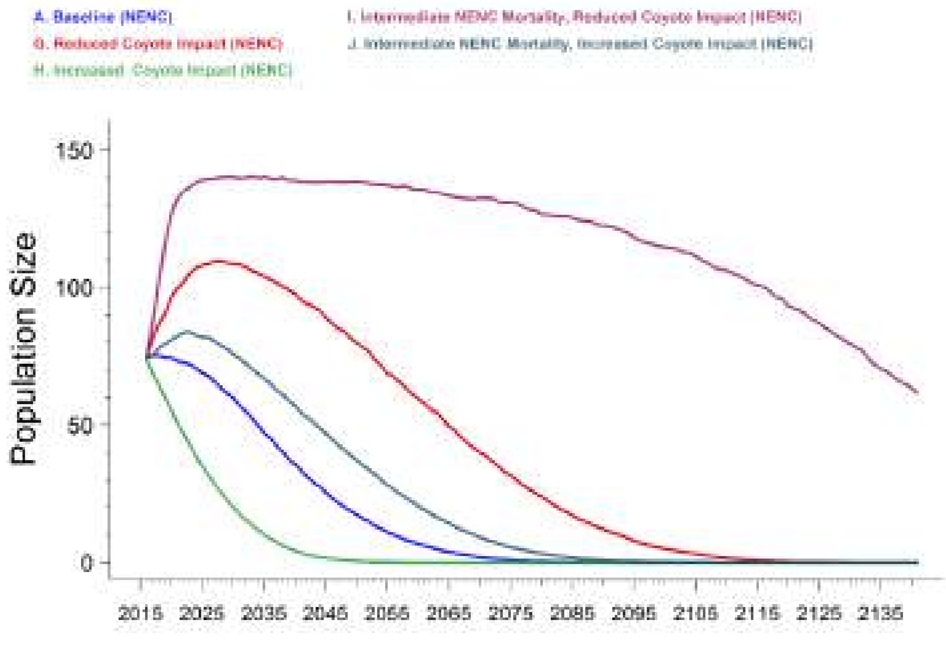

Figure 7. Projected mean population size for the NENC population for various model scenarios with changing NENC demographic rates. Population size is the mean size averaged across 1000 iterations.

PVA Results – Scenarios With Changes to SSP Parameters

The SSP population has the potential to be demographically strong, but additional space and improved breeding rates could substantially improve demographic and genetic outcomes.

- **As highlighted earlier, scenario FF illustrates that the SSP needs to increase births to avoid a decline; that increased breeding illustrated in the baseline scenario (A) will create a demographically stable population.**

- **Increasing the SSP population size to the Recovery Plan target of 330 (Scenario K) or 400 (L) does not change the demographic outlook compared** to the baseline scenario (A), but does result in substantial improvements in genetics – P(80GD) increases from 65.7% in the baseline to 80% at 330 wolves and 88.5% at 400 wolves, and final F decreases from 0.1799 ± 0.0648 in the baseline to 0.1577 ± 0.0508 at 330 wolves and 0.1496 ± 0.0452 at 400 wolves. To reach these target sizes, the SSP would need to increase from making 52 pairs/year in the baseline (averaged over the first 10 model years) to ~76 pairs/year if 330 spaces were available, or ~82 pairs/year if 400 were available.

- **Coupling those changes with increased breeding success in the SSP (Scenarios M, N) results in additional improvements in genetics: P(80GD) = 88.3% at 330 wolves and 91.3% at 400 wolves,** and final F is 0.1477 ± 0.0459 at 330 wolves and 0.1426 ± 0.0423 at 400 wolves. **Under these scenarios, the SSP could make fewer pairs because success of individual pairs would be higher; if that pair success rate could be reached, the SSP would need to increase to ~62 pairs/year at 330 spaces (M) and ~75 pairs/year at 400 spaces (N).**

PVA Results – SSP Population Absorbing NENC Wolves After NENC Termination

If the decision were made to remove capturable NENC wolves from the current Recovery Area landscape and bring them into the SSP, it would not have a large impact on demographics of the SSP; genetically, the benefits of reintegrating NENC genes into the SSP would be greater if additional space is added to the SSP.

- **Bringing NENC animals might benefit the SSP population genetically, but much of that "extra" benefit would not be captured unless SSP population size was increased. Scenarios under current space (O) resulted in higher P(80GD), 71.4% compared to the baseline of 65.7%, but with additional spaces (P), much more GD could be captured, with P(80GD) = 87.1%. Thus adding space to the SSP if the NENC is terminated will be essential to avoid a permanent loss to the species' genetic health. If additional spaces are not available, cryopreservation of genetic materials should be an important avenue for making sure NENC genes are captured, with investments in the research needed to utilize those genes via assisted reproduction.**

- **The remaining NENC wolves that were not captured would persist until death; the modeled TE for the NENC population under these scenarios was 25 years (range 3-78 years).**

PVA Results – Release Scenarios (Connecting SSP and NENC Populations)

Releases will be essential to the NENC population's long-term success. Releases will be needed in combination with other changes to vital rates to ensure healthy future red wolf populations. Release scenarios are grouped for easier comparison; scenario labels such as 4C refer to additional scenarios included in Appendix 4 that include different numbers or patterns of releases.

- ***Releases only, for 125 years (Scenario Q, also see 4C, 4D):***
  - **Releasing 3-4 animals per year from the SSP (Q) helps the NENC population avoid extinction, but is not enough to create a viable NENC without other changes (Fig. 8). The NENC population has significant improvements in P(E), which is reduced to 2.2% because the population receives individuals from the SSP every year (thus avoiding extinction). However, although the population trajectory is improved for the first ~40 years in comparison to the baseline, eventually the population declines despite supplementation (final N for NENC was 29.3 ± 22.8) – releases alone are not enough to secure the NENC population's future in the absence of other changes to NENC demographic rates.**

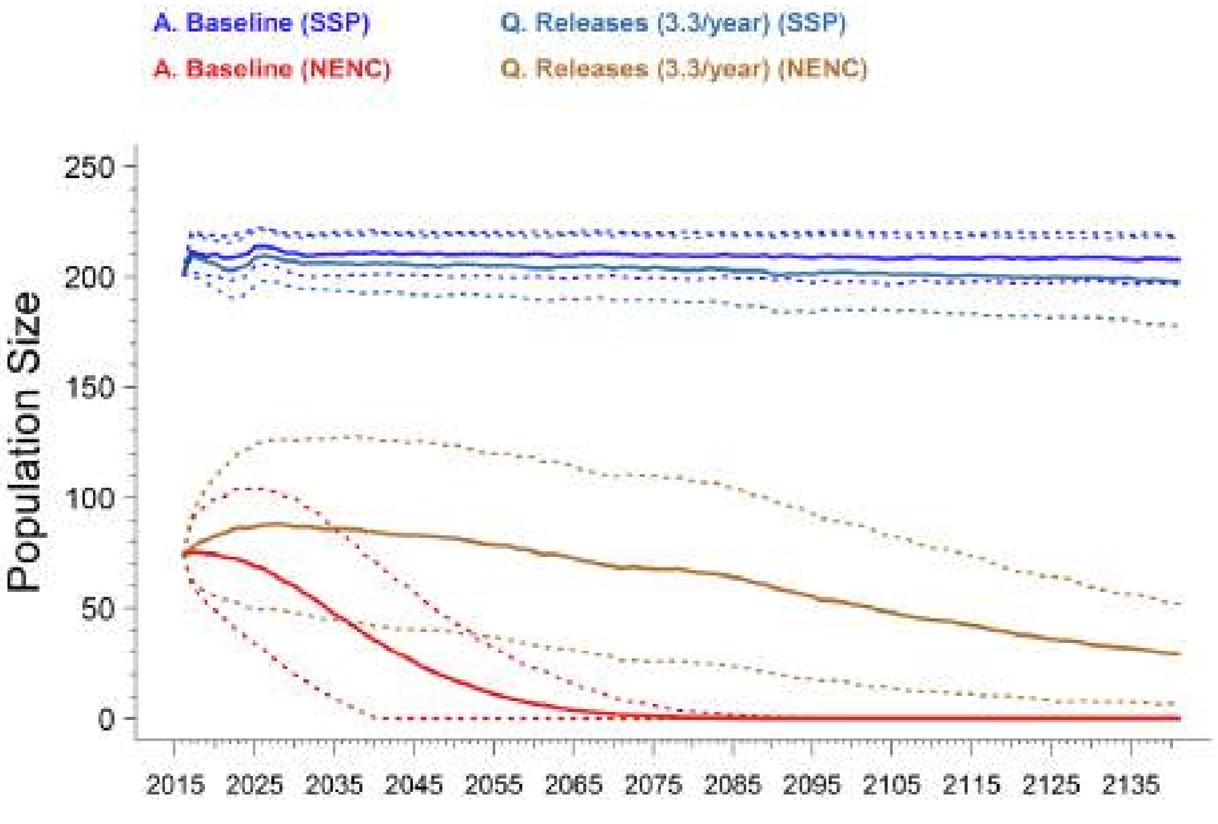

Figure 8. Projected mean population size for the NENC and SSP populations for various release scenarios. Population size is the mean size averaged across 1000 iterations.

- The SSP can sustain this release rate without major detrimental impacts on demographics: final N = 197.2 ± 20.0 in comparison to the baseline scenario (final N = 207.9). Releases do affect the SSP's ability to remain above 80% GD, as the P(80GD) decreases substantially from the baseline of 65.7% to 58.9% - harvesting animals continuously for 125 years for the release program without changes to SSP rates may have detrimental effects. However, in the model releases are randomly selected, and in reality managers may have some ability to genetically select releases that are beneficial to both the wild and SSP populations.
- Releases at higher rates (4-10 individuals per year in 4C, 4D) start to have detrimental impacts on the SSP population without other changes. Releases of 9.6 animals per year causes the SSP to decline (final N = 167.6 ± 26.9), and the SSP is not able to produce enough animals to release most model years.

- ***Releases plus improvements to the SSP such as added space and improved reproduction (Scenarios R, S, T, also see 4E, 4F, 4G):***
  - Adding more space to the SSP allows it to remain demographically strong and retain higher GD while carrying out releases: With 3.3 wolves released for 125 years but additional space (330, Scenario R, or 400 spaces, Scenario S), the SSP has large gains in genetic health: it has P(80GD) of 78.1% with 330 spaces or 87.6% with 400 spaces, substantially higher than the 58.9% chance of retaining 80% GD without any additional space.
  - Adding space <u>and</u> increasing SSP breeding to 25% (T) allows the SSP to retain the most GD and to be the strongest source population for the NENC: With 3.3 wolves released for 125 years, 400 spaces, and higher breeding (T), the SSP has the highest P(80GD) of these set of scenarios, 92.8%, and the lowest F, 0.1412 ± 0.0412 (compared to Scenario Q where the final F for the SSP was 0.1869 ± 0.0676). More importantly, the model illustrates that it would be challenging to provide releases reliably for the NENC while also trying to increase to larger population sizes unless breeding increases (either through increasing the number of pairs or increasing the reproductive success of pairs). The model only releases if the SSP population is at or larger than 80% of its K, and at current reproductive rates the model delays releases for Scenarios R and S until it grows sufficiently large, until 5-10 years into the model timeframe (Fig. 9). Because Scenario T ramps up breeding to fuel the growth to 400, it is able to provide the target number of releases sooner (Fig. 9). In the real world, managers could carefully balance providing releases as they grew to K, with decision-making (which could be supported by further modeling) to prioritize releases and accept a slower growth rate to K, or by increasing breeding to support releases.

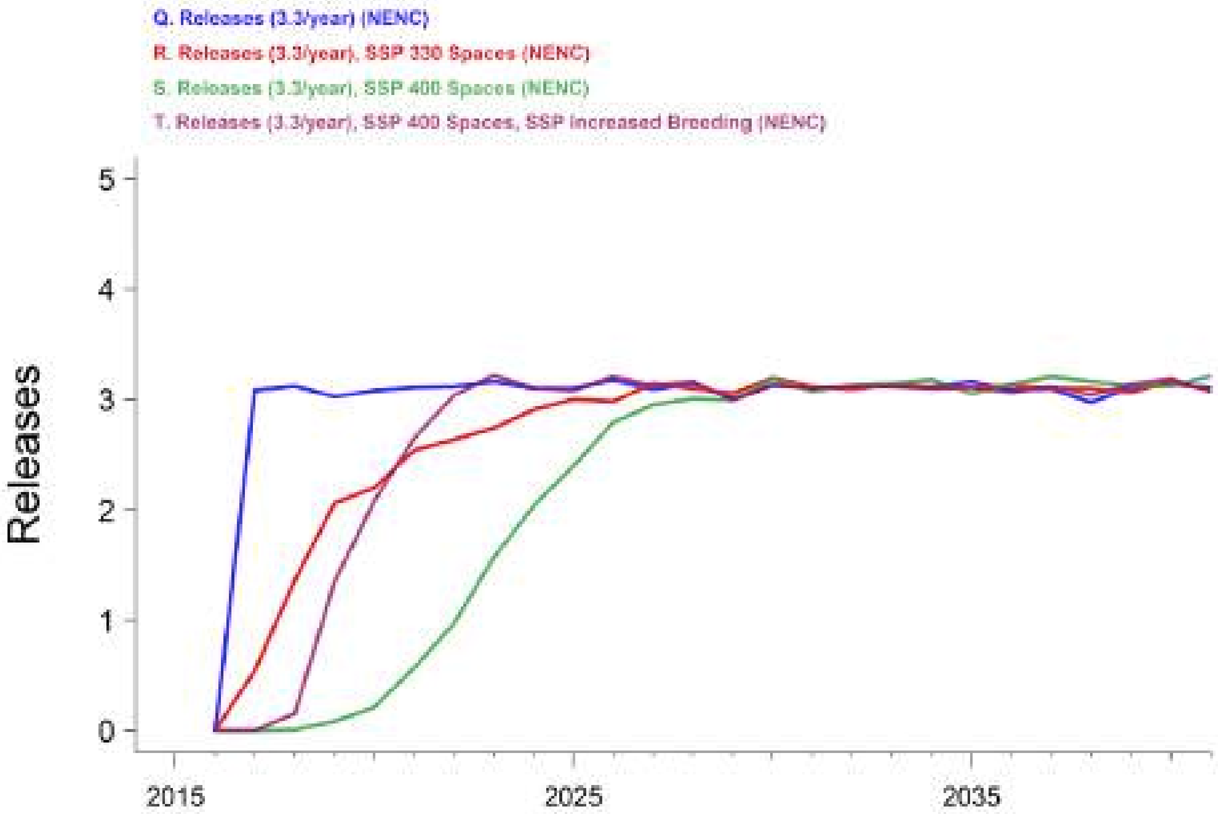

Fig. 9. Projected mean number of releases from the SSP to the NENC population for various release scenarios. Number of releases is the mean size averaged across only extant (surviving) iterations.

- **The NENC population benefits from additional SSP space, and even more so from space <u>and</u> increased SSP breeding.** Although all 3 of these scenarios eventually settled into the same number of animals for release after the first decade (Fig. 9), their early dynamics are different and they do produce very different demographic and genetic results in the NENC population. The NENC final N for Scenario Q (without SSP changes) is 29.3 ± 22.8, while in R and S with increased space final N is 38.7 ± 28.0 and 44.5 ± 31.8, respectively (Fig. 10). More importantly, these SSP changes have a substantial impact on the genetics of the NENC. P(80GD) is only 34.3% for scenario Q, but 50.8% in R and 56.1% in S. If breeding is also increased in scenario T, P(80GD) is even higher at 60.6%. These genetic differences exist even though the SSP is still sending the same number of releases into the population because:
  - The SSP is genetically healthier at higher population sizes and breeding rates (see results above), and because it can retain higher GD and lower F throughout the simulation, it can release genetically healthier animals to the NENC (animals that are less related to each other and to the rest of the NENC population). Larger populations mean more genetic diversity is retained, and that retention helps the NENC's genetics as well

- The NENC still experiences a demographic drag on its population as inbreeding starts to accumulate under these scenarios, which translates into the differences in population size; that drag is much less if the SSP is larger with more breeding (Fig. 10). The NENC's final F in scenario Q is 0.201 ± 0.125; in Scenario R and S, it is 0.175 (± 0.102 or 0.099, respectively); in T, which produces the best results demographically and genetically it is as low as 0.1577 ± 0.0879 (all still above that of mating of half siblings, where F = 0.125). However, without changes to the NENC population's vital rates, releases with SSP improvements (more space, better breeding) are helpful but still cannot counteract the NENC decline due to low survival and breeding rates and inbreeding depression.

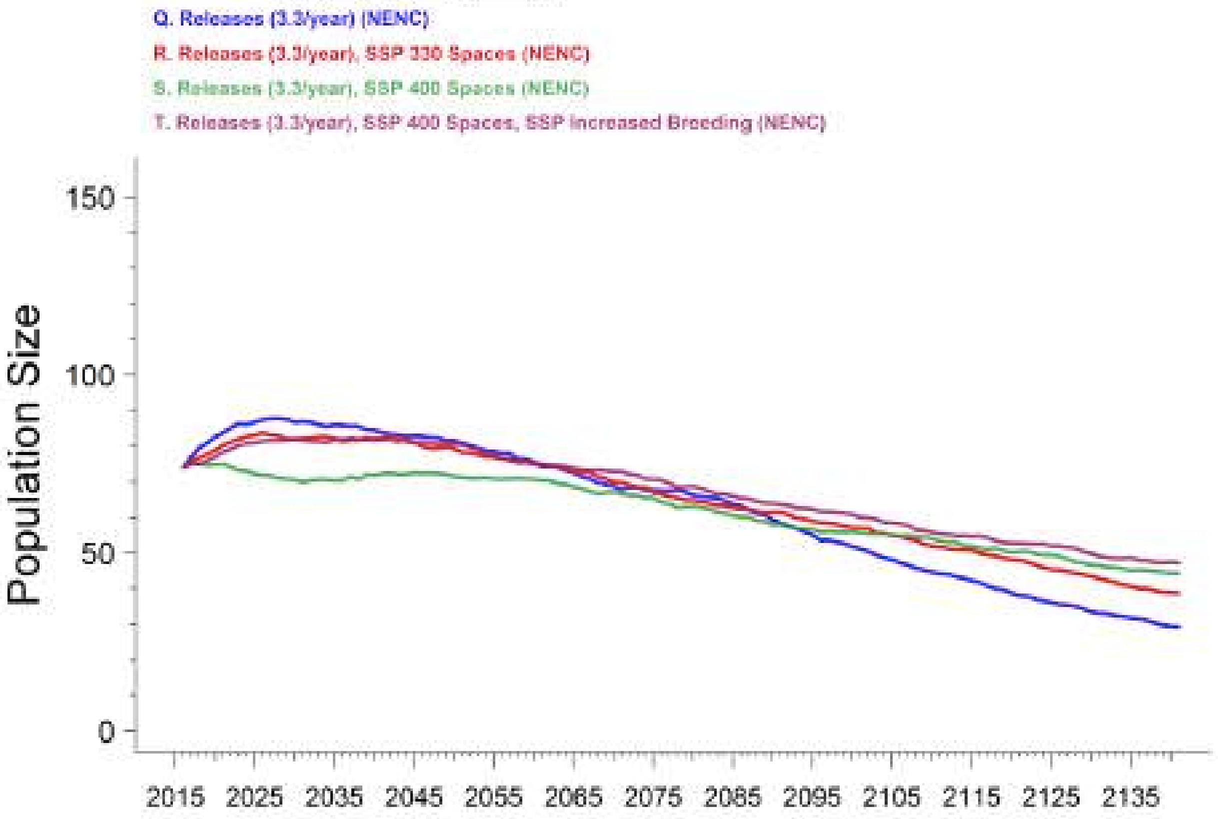

Figure 10. Mean final NENC population size for model scenarios with varying release strategies from the SSP to NENC population, and with additional space for the *SSP*. Mean size is calculated across all extant iterations. See Table 1 for scenario descriptions.

- ***Releases plus improvements to the NENC mortality and breeding (Scenarios U, V, W, also see 4H):***
  - Releases of 3.3 individuals for 125 years, in combination with improvements to NENC mortality, breeding, or both, would ultimately be able to create a sustainable NENC population (Fig. 11). Scenarios U-W, which included single or combined changes to NENC mortality and breeding rates, illustrate that a demographically stable NENC

population with a final N of ~100 or more individuals depending on the scenario (Fig. 6). Comparing scenarios U and V highlighting that changes in mortality have larger impacts than changes in breeding alone. These scenarios also result in a NENC population that was moderately genetically healthier, with P(80GD) ranging from 56.6% when only NENC breeding was improved (V) to as high as 66.7% when both breeding and mortality were improved (W).

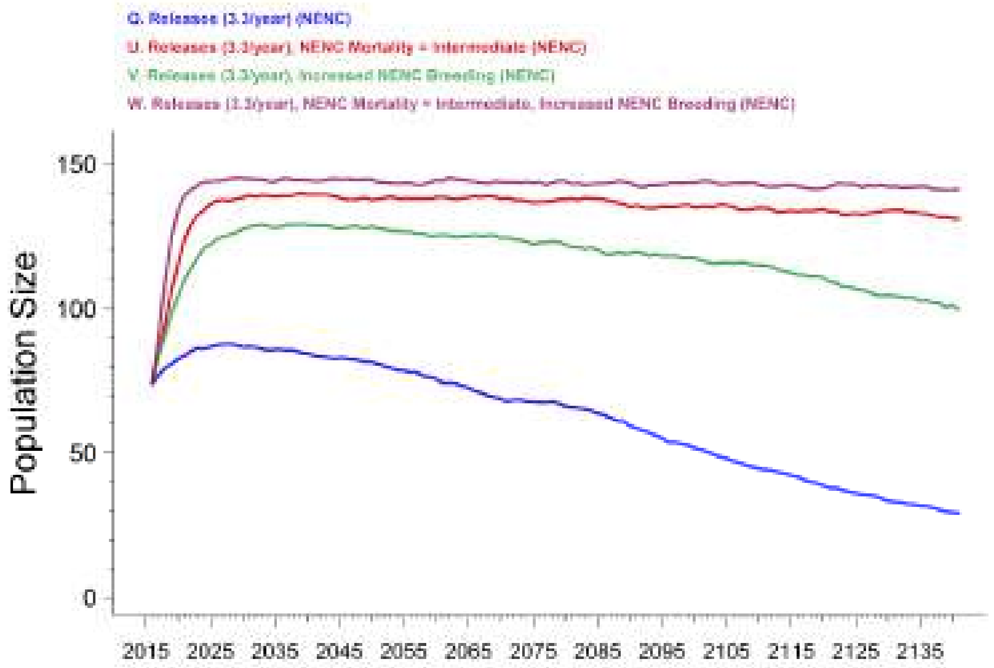

Figure 11. Projected mean population size for the NENC population for model scenarios with 3.3 releases for 125 years and varying improvements to NENC mortality or breeding rates. Population size is the mean size averaged across 1000 iterations.

- ***<u>Releases plus improvements to the NENC (mortality, breeding) and improvements to the SSP (space, breeding) (Scenarios AA, BB):</u>***
  - **If "best case" (i.e. most realistic but optimistic) changes are made to NENC vital rates and the SSP (400 spaces, 25% breeding), the NENC population can be substantially healthier and sustainable at 3.3 releases per year for 125 years. Improvements in NENC mortality (AA) or NENC mortality and breeding (BB) in combination with the previously modeled SSP changes from scenario T resulted in substantial demographic and genetic improvements to the NENC. It is able to maintain a stable population size (final NENC N for AA = 134.8 ± 26.0, for BB = 143.2 ± 18.5) and remain healthy genetically: P(80GD) for the NENC = 80.5% under AA and 81.5% under BB, much better than the 60.6% of Scenario T without the NENC demographic changes, or the P(80GD)s of 58-61% mentioned above for scenarios U-W (with NENC demographic changes only). Final inbreeding level in the NENC is comparable between T, AA, and BB, at F = 0.1577 ± 0.0879, 0.1577 ± 0.0584, and 0.1562 ± 0.0583, respectively (above that of half-siblings at**

0.125]. These rates are lower than those mentioned above for U-W where NENC demographic changes happened in isolation. These two scenarios (AA, BB) give the highest probability of <u>both</u> populations retaining over 80% GD in 125 years (Fig. 12).

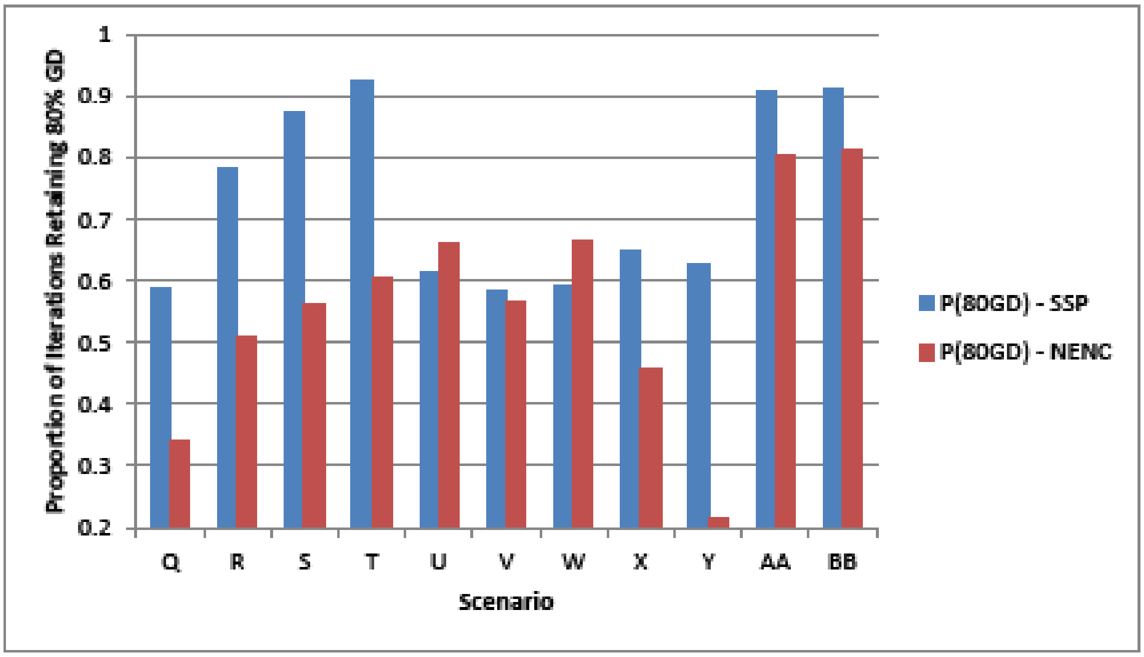

Figure 12. The P(80GD), or probability of the population maintaining 80% GD at 125 years, for the NENC and SSP populations for model scenarios varying release strategies, improvements to NENC mortality or breeding rates, and SSP changes. The results are calculated across all extant iterations for 1000 model runs.

- ***<u>Releases for shorter durations with varying long-term frequencies (Scenarios X, Y, also see 4I, 4J, 4K, 4L) with best case NENC demography</u>***
    - **These scenarios combine realistic but optimistic NENC demographic rates with alternate release strategies, exploring the impact of 15 (X, Y, 4I) or 25 (4J, 4K, 4L) years of annual releases, and then less frequent releases subsequently. Although the scenarios with 125 years of annual releases have very positive demographic and genetic results for the NENC, there are significant resource and logistical implications to sustaining a release program in perpetuity. A shorter term, intense level of releases can help boost the NENC population demographically, allowing it to maintain average population sizes between 110 – 140 at 125 years (compared to ~67 under scenario F without releases; Table 2) and virtually eliminating the chance of extinction (16.5% in scenario F versus rates between 0-1% for all scenarios included in Table 2). Short-term releases followed by periodic releases also improve genetic health, truly managing the population as a meta-population. Such management will likely be necessary because of the wolves' small founder base and the potential effects of inbreeding depression. For example, best case NENC demography alone results in P(80GD) of 6.6% (scenario F), but if releases were only carried out for 15 years and then once every 5 years, that P(80GD) increases to 46%; if carried out for 125 years, it increases to 66.7%. Mean final GD for**

those scenarios is 0.6568 ± 0.1382, 0.7794 ± 0.0689, and 0.8127 ± 0.051, respectively (Table 2). Specific modeling targeted at evaluation of realistic release strategies may be helpful in the future to evaluate tradeoffs for the species.

Table 2. Genetic and demographic results at 125 years for the NENC population related to scenarios with varying release strategies

		NENC Population Results						
		N - Mean	N – SD	GD – Mean	GD – SD	F – mean	F - SD	P(ex)
F	NENC mortality = intermediate, increased females breeding NENC	67.46	34.29	0.6568	0.1382	0.3096	0.1533	0.066
1P	Movement (3.3 every year), NENC mortality = intermediate, NENC increased breeding	141.38	20.21	0.8127	0.0510	0.1713	0.0623	0.667
1K	Movement (3.3 per year for 15 years then every 5 years), NENC mortality = intermediate, NENC increased breeding	132.23	29.36	0.7794	0.0689	0.2078	0.0730	0.460
1Y	Movement (3.3 per year for 15 years then every 20 years), NENC mortality = intermediate, NENC increased breeding	113.62	43.34	0.7281	0.0932	0.2310	0.1103	0.216
4J	Movement (3.3 per year for 25 years then every 5 years), NENC mortality = intermediate, NENC increased breeding	133.70	29.01	0.7769	0.0726	0.2117	0.0843	0.434
4K	Movement (3.3 per year for 25 years then every 10 years), NENC mortality = intermediate, NENC increased breeding	127.54	34.43	0.7563	0.0828	0.2324	0.094	0.344
4L	Movement (3.3 per year for 25 years then every 20 years), NENC mortality = intermediate, NENC increased breeding	111.40	40.63	0.7372	0.0929	0.2513	0.1052	0.262

PVA Results – Recovery on Federal Lands Only

Scenario Z, which simulates the hypothetical effects of only using federal lands for NENC recovery (see Table 1 for full scenario setup), has a severe demographic and genetic future – this approach would not result in a viable NENC population. After a severe bottleneck in the first 15 years of the model as the existing animals die off, any population survival is simply because the scenario includes releasing 1 animal every other year from the SSP (Fig. 13). Even with this, 67.1% of iterations ended with extinction. The scenario had a median TE of 14 years; this represents the time to first extinction, although some iterations that went extinct could be restarted by releases.

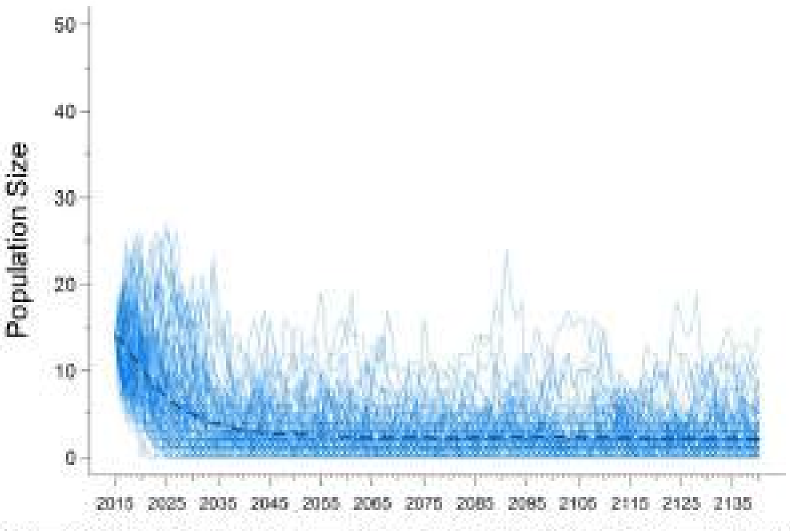

Figure 13. Scenario Z model results for NENC population for a sample of 100 model iterations.

PVA Conclusions

The overarching results from these modeling efforts indicate that:

1. Current conditions, without releases from the SSP or improvements to NENC vital rates, will result in extinction of the NENC population, typically within 37 years but in some iterations as soon as 8 years. The baseline NENC model is considered optimistic when compared to the current estimated population, which has already declined by an estimated 14-30 animals than our starting population taken as of 1 January 2015. Further, the model does not incorporate any requests to remove wolves from private land or more recent trends (2015 and 2016) in mortality and reproductive rates. These factors make it likely that 37 years is a high estimate of the time to extinction for the only remaining wild population of red wolves. This extinction would not just be about numbers, but would also represent the loss of behaviorally competent wild wolves on the landscape; creation of future populations at NENC or elsewhere would have to start from scratch and re-build that behavioral competence again, and would likely experience higher mortality and lower reproductive rates as it worked to re-build that competence.

2. The NENC population can avoid extinction and be viable, but requires assistance to do so:

    a. There were several scenarios in which the NENC had less than 10% probability of extinction:

C	NENC mortality = SSP mortality
D+	NENC mortality = Intermediate, no inbreeding depression
Q	Movement (3.3 every year)
R	Movement (3.3 every year), SSP 330 spaces
S	Movement (3.3 every year), SSP 400 spaces
T	Movement (3.3 every year), SSP 400 spaces, SSP 25% breeding
U	Movement (3.3 every year), NENC mortality = intermediate
V	Movement (3.3 every year), NENC increased breeding
W	Movement (3.3 every year), NENC mortality = intermediate, NENC increased breeding
X	Movement (3.3 per year for 15 years then every 5 years), NENC mortality = intermediate, NENC increased breeding
Y	Movement (3.3 per year for 15 years then every 20 years), NENC mortality = intermediate, NENC increased breeding
AA	Movement (3.3 every year), SSP 400 spaces, SSP 25% breeding, NENC mortality = intermediate
BB	Movement (3.3 every year), SSP 400 spaces, SSP 25% breeding, NENC mortality = intermediate, NENC increased breeding

    The most realistic of these are likely scenarios X or Y: a secure future with low extinction risk for the NENC can be created if the NENC can reduce its mortality closer to the modeled intermediate levels (which, when considered alone in scenario B, was a change from ~38 deaths to ~31 deaths in the first model year), increase breeding (by shifting mortality earlier in the year so its disruptive effect on breeding is reduced), and receive releases from the SSP for a short, intense period (15 years) followed by intermittent releases to maintain genetic health after that.

    b. It will be challenging for the NENC population to have a strong probability (>80% chance) of retaining greater than 80% GD (when considered alone, separate from the SSP). Only two scenarios, AA and BB, were able to achieve that, and required NENC demographic changes, annual releases for 125 years, and SSP improvements (400 spaces and 25% breeding). This benchmark will likely be challenging for the NENC population alone to meet (but will be easier for the species as a whole to meet).

3. To remain a strong supporting population for any recovery goals, the SSP population needs the following changes to increase its viability:

   a. Space: Model scenarios with growth to 330 or 400 spaces illustrate that the population could benefit substantially in its population genetics and ability to sustain releases from such a change – P(80GD) increases from 65.7% in the baseline to 80% at 330 wolves and 88.5% at 400 wolves. Currently, space limits population size and, because there are not enough spaces to place pups, fewer breeding recommendations are issued. This management results in the use of contraceptives, separating of pairs during the breeding season, and/or delayed or less frequent breeding opportunities for females. Evidence from other carnivore species suggests that all of these management actions can negatively impact female fertility and reproductive health (Penfold *et al.* 2014, Asa *et al.* 2014]. Because data on these effects do not exist for red wolves, we did not explicitly model any of these effects, although it is possible that the rate of recommendation success (19%) is being partially driven by females experiencing fertility problems. To increase from 225 to a population size of 330 or 400 wolves, new resources would need to be identified. Space within AZA institutions is limited and there is "competition" for space with other large canids managed within AZA (e.g. Mexican gray wolf, maned wolf, gray wolf, etc.) and potential wolf spaces are often associated with an institution's zoogeographic theme. The Red Wolf Species Survival Plan® (SSP) already has double the number of holding facilities (44) of similar AZA SSPs (median number of holding facilities is only 22 across all 324 "Yellow" SSPs; Yellow SSPs are populations with more than 50 animals that are not expected to retain 90% gene diversity for 100 years) and has long partnered with non-member facilities to expand beyond AZA institutions. Additional space to expand the captive population in facilities that exhibit animals to the public is limited. To hold 400 individual wolves, the SSP would likely need 100 more enclosures than now (Will Waddell, pers. comm.]. The recent Canid and Hyaenid Integrated Collection Assessment and Planning (ICAP) process, which considered wild and captive populations of all canids and prioritized captive populations, recommended that the red wolf SSP population be expanded and that facilities consider converting spaces held by coyotes (and gray wolves) to red wolves if possible.

   b. Reproductive improvements: Reproductive improvements are needed even if additional spaces aren't available if the SSP wants to avoid demographic decline – Scenario A and FF in combination illustrate that an increase in the number of pairs made will be important to avoiding that decline. Another route to reproductive improvements could be making each pairing more successful (e.g. focusing on younger pairs, minimize delayed breeding in females), rather than just making additional pairs; if the pair success rate increased to 25% and the SSP had more space, it would result in even better genetic results: P(80GD) = 88.3% at 330 wolves and 91.3% at 400 wolves.

4. Both populations are small and will face rising inbreeding levels, and in model scenarios including the inbreeding effects that have already been detected (Appendix 1), population declines in the NENC will occur without changes to the NENC population's demographic rates

and SSP releases. There is a possibility that some of these effects may lessen over time, if deleterious alleles are purged from the red wolf gene pool, but this amount of purging may be decreasing over time because the population's small size means that genetic drift will override selective forces to purge. More work is needed to better understand the impact. Therefore, it is likely that the population will continue to see these inbreeding impacts. Genetic theory suggests that continuing to manage the population in the long-term as a metapopulation, with migrants (either animals or sperm) in both directions (SSP to NENC and NENC to SSP) to maximize and manage gene diversity and inbreeding in both populations, will likely be the best strategy to maintain the species' long-term genetic health. In our model scenarios we did not include any genetic selection criteria for the releases that occurred, but in real time managers could plan breeding SSP pairs that would most benefit the NENC population genetically. The cross-fostering approach to releases is a promising management tool but has many logistical and timing constraints, which means that designed genetic selection is not predictable, but with additional space and increased breeding, the feasibility of this strategy is higher.

5. There are multiple ways to achieve the recovery goal of preserving at least 80% of the founding genetic diversity until 2140 when the species as a whole is considered (rather than the SSP and NENC considered separately). Scenarios which had greater than 80% chance of hitting that benchmark at the metapopulation level included:

C	NENC mortality = SSP mortality
D	NENC mortality = Intermediate, no inbreeding depression
F	NENC mortality = intermediate, Increased females breeding NENC
I	NENC mortality = intermediate, reduced coyote impact
L	SSP 400 spaces
M	SSP 330 spaces, SSP 25% breeding
N	SSP 400 spaces, SSP 25% breeding
P	Capturable wolves brought into SSP, SSP 330 spaces
S	Movement (3.3 every year), SSP 400 spaces
T	Movement (3.3 every year), SSP 400 spaces, SSP 25% breeding
X	Movement (3.3 per year for 15 years then every 5 years), NENC mortality = intermediate, NENC increased breeding
Y	Movement (3.3 per year for 15 years then every 20 years), NENC mortality = intermediate, NENC increased breeding
AA	Movement (3.3 every year), SSP 400 spaces, SSP 25% breeding, NENC mortality = intermediate
BB	Movement (3.3 every year), SSP 400 spaces, SSP 25% breeding, NENC mortality = intermediate, NENC increased breeding
4B	Capturable wolves brought into SSP, SSP 400 spaces
4E	Movement (young, 4.5 per year), SSP 330 spaces
4F	Movement (young, 4.5 per year), SSP 400 spaces
4G	Movement (young, 4.5 per year), SSP 400 spaces, SSP 25% breeding
4I	Movement (3.3 per year for 15 years then every 10 years), NENC mortality = intermediate, NENC increased breeding
4J	Movement (3.3 per year for 25 years then every 5 years), NENC mortality = intermediate, NENC increased breeding
4K	Movement (3.3 per year for 25 years then every 10 years), NENC mortality = intermediate, NENC increased breeding
4L	Movement (3.3 per year for 25 years then every 20 years), NENC mortality = intermediate, NENC increased breeding

These modeling scenarios highlight that red wolves will be a conservation-reliant species, requiring population management: all red wolves will need to be treated as a metapopulation, with occasional movement between the SSP and NENC, and perhaps other populations if they are established, to manage declining gene diversity given its small founding population (Goble *et al.* 2012). However, with NENC demographic changes and releases, maintaining a functioning wild NENC population is possible. This is a key example of a species that can be best preserved by the "One Plan" approach, where all populations, captive and wild, are considered under an integrated plan for species conservation (Byers et al. 2013).

Appendix 1: Vortex Model Setup Documentation & Supporting Analyses

This Appendix details the set-up of the metapopulation model of the red wolf (*Canis rufus*) constructed for the Red Wolf Feasibility Assessment. The model was constructed and evaluated using the program Vortex 10 (specific version: 10.1.4.0) (www.vortex.org). This model and supporting analyses were developed by Dr. Joseph (Josie) L. Simonis of DAPPER, LLC as a member of and in collaboration with the Red Wolf Population Viability Analysis Team. The full model file may be made available on request, and/or will be archived with later publication of this research.

Sections

1. Data Sources
2. Conceptual Models for Baseline Scenario
3. Model Setup and Supporting Analyses
4. Figures
5. Tables

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1. Data Sources

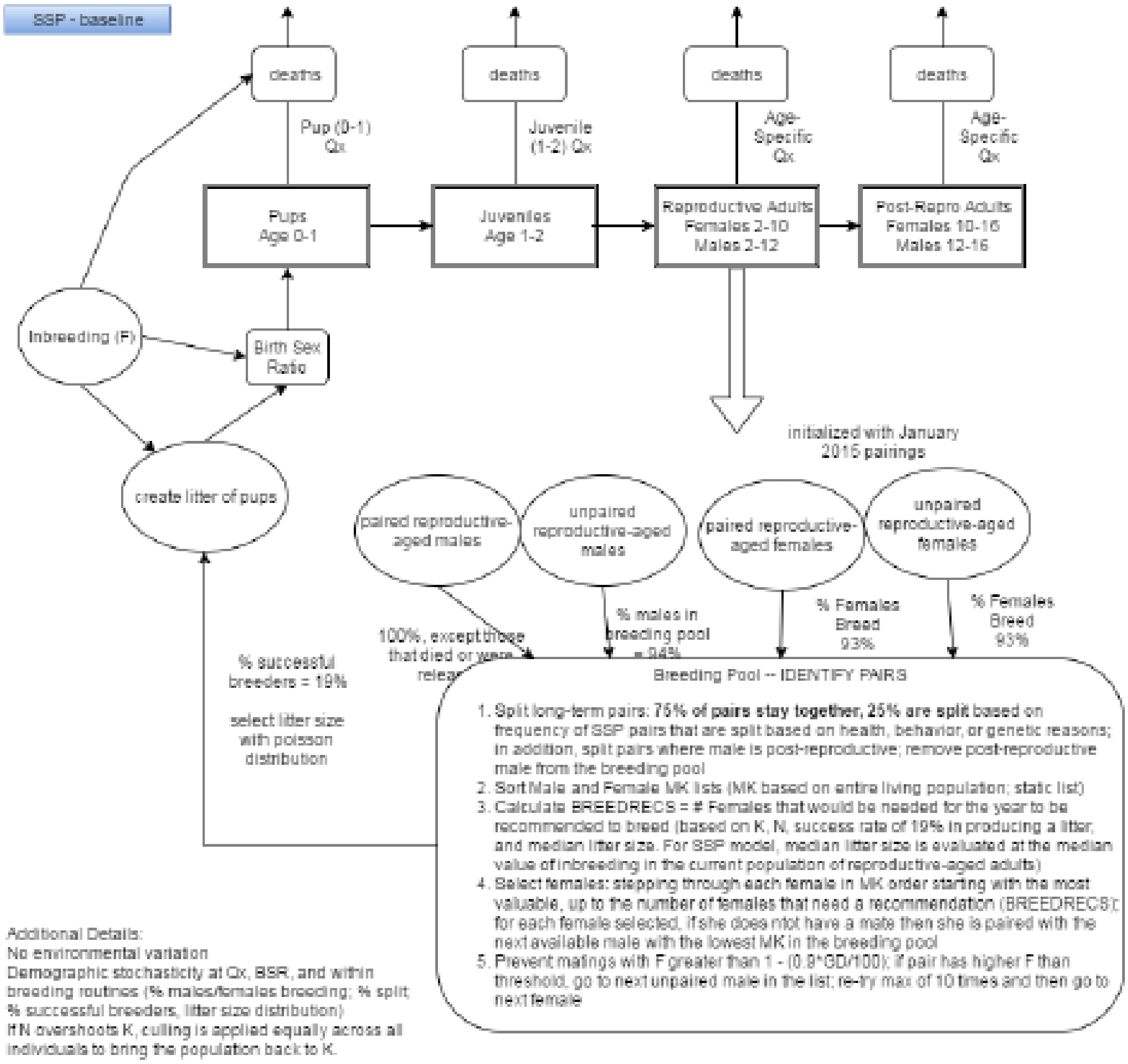
Data for the red wolf population and its management were collected from the SSP Studbook (Waddell 2015), the US Fish and Wildlife Red Wolf Population Database (USFWS, unpublished data), and PMCTrack (www.PMCTrack.org) (Faust *et al.* 2015).

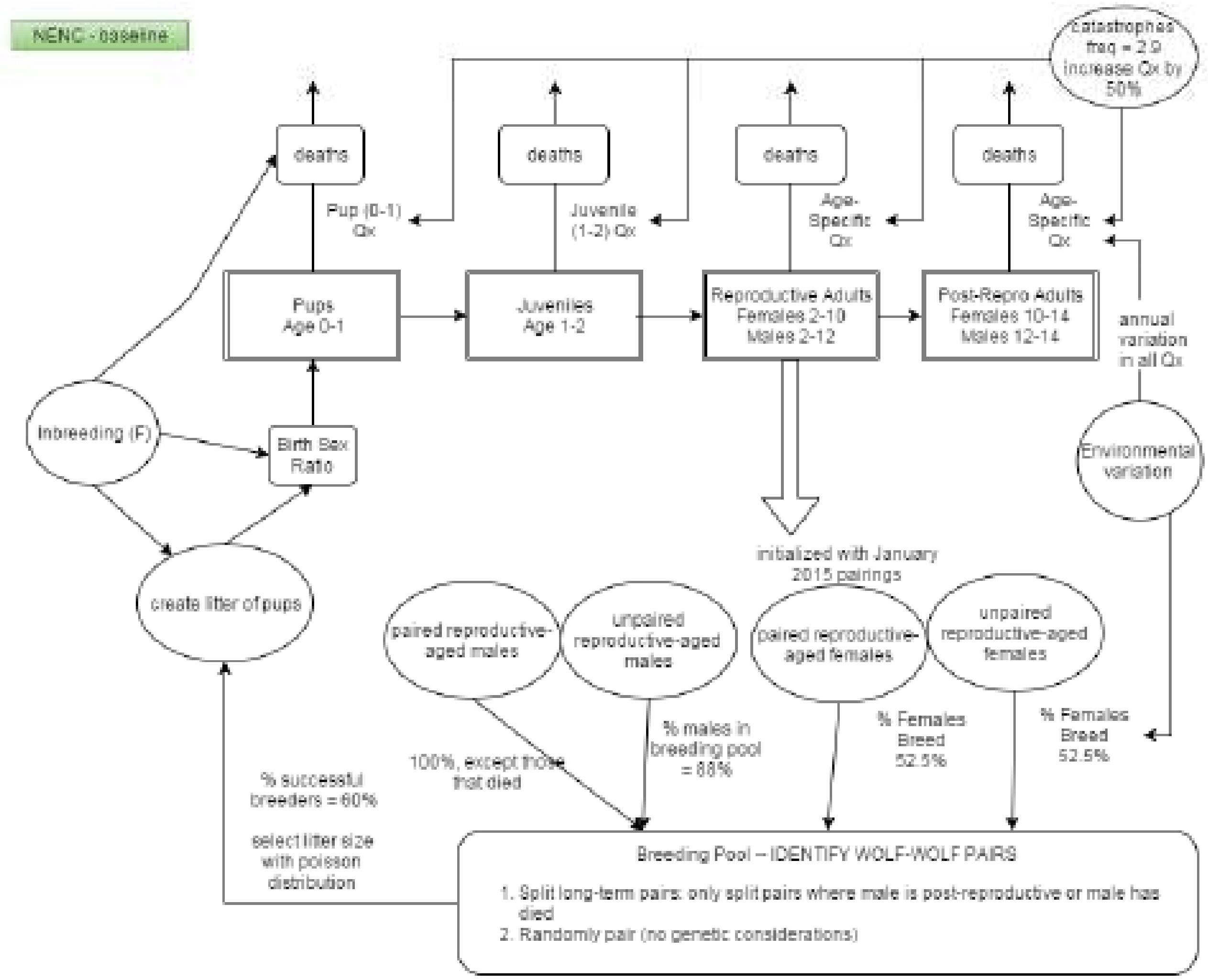
For the SSP population, following standard methodology, "modern management" was considered 1 January 1980 – 31 December 2014 (Simonis *et al.* 2015a). Thus, in general, that time frame was used for SSP data. However, more recent tracking of the SSP process has generated management data from 2001 onward (*e.g.*, Table A1). Thus, for some analyses, a restricted time window is used for the SSP.

For the NENC population, while the database goes all the way back to the initiation of the population, more intensive data collection was begun in 2000, allowing for much more rigorous data regarding, for example, mate pairs. A date window of 1 January 2000 – 31 December 2014 was used for all analyses unless otherwise noted.

2. Conceptual Models for Baseline Scenario

To better document and illustrate how we have used Vortex to model the dynamics of both the SSP and NENC populations, we created conceptual models of modeled dynamics for both populations:





Additional Details:
Demographic stochasticity at Qx, BSR, and within breeding routines (% males/females breeding; % successful breeders, litter size distribution)
If N > K at the end of the year, proportionally cull across all individuals to reduce N to K.

3. MODEL SETUP AND SUPPORTING ANALYSES

Minor Model Variables and Assumptions

- **We are assuming that there is concordance between environmental variation in reproduction and survival, such that "good years" and "bad years" for survival are directly correlated with good and bad years for reproduction.**
- **We are assuming that there is no correlation in environmental variation between the NENC and SSP populations (*i.e.*, a good year in the NENC does not necessarily translate to a good year in the SSP).**
- **We are assuming that reproduction is not density-dependent in either the SSP or NENC.**

- When animals move between the SSP and NENC via Vortex's Harvest and Supplementation routines, there is no additional mortality caused by the movement itself, and animals instantly take on the survival and reproductive rates of the NENC.
- Model order of events: our modeled order is different from the default in Vortex 10. In particular, Dispersal has been removed (not being used) and Harvest and Supplement have been moved ahead of Mortality and Age, which allows us to move pups between the populations in the way that wolves are actually managed (right after birth via fostering). First year mortality is delayed until all litters are produced (rather than directly after the creation of each litter), which allows very young pups to be moved (as is needed for pup fostering) before mortality occurs:

Event Type	Explanation
EV	Environmental Variation is imposed
Breed	Reproduction
Harvest	As translocation: removal from SSP
Supplement	As translocation: release to NENC
Mortality	Mortality (all age classes)
Age	Animals age +1 year
rCalc	Calculate population growth rate
Ktruncation	Enforce Carrying Capacity
UpdateVars	Update State Variables
Census	Census the population

Offspring Sex Ratio

Supporting Analysis:

We analyzed the impact of inbreeding on the birth sex ratio of captive and NENC red wolves. In total, we included 1765 total pups: 904 females (51.2%) and 861 males (48.8%). We removed unknown sex individuals. The inbreeding values of the individuals included ranged from 0 to 0.341, with median = 0.076, mean = 0.088, and standard deviation = 0.068. In total, 749 pups were from the NENC (42.4%), and 1016 were from SSP (57.6%). We used a logistic regression (generalized linear model with logit link), using the pup's inbreeding value and population to predict the sex. We also included blocking factors associated with dam and litter, but neither explained any variation in the sex ratio of offspring, and so they were excluded.

The birth sex ratio is significantly impacted by the inbreeding value of the pup, such that it is male biased with increasing inbreeding level ($p = 0.04$). There is no significant difference in the birth sex ratio between the SSP and NENC population ($p = 0.34$). See Fig. A1.

Using the general logistic relationship

$$BSR = \frac{e^{(b_0+b_1 \times I)}}{e^{(b_0+b_1 \times I)} + 1}$$

where BSR = Birth Sex Ratio (1.0 = Male, 0.0 = Female), I = inbreeding of the pup, and b_0 and b_1 are the intercept and slope (respectively), which are fitted statistically.

Coefficient	Estimate	SE(estimate)	p
Intercept (b_0)	-0.17462	0.07786	0.0249

Slope (b_1)	1.43362	0.70165	0.0410

Using the point estimates, the current population level median inbreeding (0.089) generates a BSR of 0.488 (48.8% males). A 50:50 sex ratio is achieved with an inbreeding value of ~0.12.

<u>Baseline Model Setup:</u>
The final model uses an equation of:

$$BSR = \frac{e^{(-0.176+1.434 \times I)}}{e^{(-0.176+1.434 \times I)} + 1}$$

where BSR = Birth Sex Ratio (1.0 = Male, 0.0 = Female) and I = inbreeding of the pup

<u>Alternate Scenario Setup:</u>
For the "no inbreeding impact" scenarios, we set the parameters equal to the inbreeding equation evaluated at the relevant population's current median inbreeding level (SSP: 0.075, NENC: 0.113, Total: 0.089).

Birth Sex Ratio (BSR; 1.0 = Male, 0.0 = Female):

$$BSR = \frac{e^{(-0.176+1.434 \times 0.089)}}{e^{(-0.176+1.434 \times 0.089)} + 1} = 0.488$$

Litter size

<u>Supporting Analysis:</u>
We analyzed the impact of inbreeding on litter size in captive and NENC red wolves. In total, our data set included 373 litters, 127 of which were NENC-born (2000-2015) and 246 of which were captive-born (1980-2015). Kinship between parents (*i.e.*, the inbreeding value of the pups) ranged from 0 to 0.341 (median = 0.075, mean = 0.090, standard deviation = 0.073).

We used a Poisson regression (generalized linear model with log link), and evaluated the impact of kinship between parents and population on the litter size. The data are well-approximated by a Poisson distribution, except from the lack of 0s. However, mean litter size is large enough (4.19) that the probability mass of 0 is only 0.015 (relatively infrequent). The data are slightly overdispersed, but not excessively so: as the variance (4.52) is only 1.08 times the mean (4.19).

Litter size decreases significantly with increasing kinship between parents ($p = 0.0001$) and is significantly larger in the NENC population ($p = 0.0005$) (Fig. A2, A10).

Using the general log relationship

$$LS = e^{b_0+b_1+b_2 \times KIN}$$

where LS = Litter Size, KIN = kinship between parents, and b_0, b_1, and b_2 are the general intercept, the population effect, and slope (respectively), which are fitted statistically.

Coefficient	Estimate	SE(estimate)	p
Intercept (b_0)	1.50637	0.04055	<0.0001
Population (b_1)	0.22105	0.06343	0.0005
Parent Kinship (b_2)	-1.70962	0.44443	0.0001

Baseline Model Setup:

The model contrasts were set up such that b_0 corresponds to the intercept value for the SSP population and $b_0 + b_1$ corresponds to the intercept value for the NENC population. Litter size was modeled as a Poisson random variable:

$$LS_{SSP} \sim Poisson\left(\lambda = e^{1.506-KIN\times 1.71}\right)$$
$$LS_{NENC} \sim Poisson\left(\lambda = e^{1.727-KIN\times 1.71}\right)$$

where LS = litter size and KIN = kinship between parents. However, given issues associated with the deterministic life table calculations (for Breed to K), we have to use a deterministic value for Year 1 in the SSP, so we used the logistic equation evaluated at the median value of inbreeding equation, which is the expected value of the Poisson distribution, but we take it to be a fixed value. Thus, in Year 1 for the SSP, the litter size is 3.97.

Alternate Scenario Setup:

For the "no inbreeding impact" scenarios, we set the parameters equal to the inbreeding equation evaluated at the relevant population's current median inbreeding level (SSP: 0.075, NENC: 0.113, Total: 0.089).

Litter Size (LS):

$$LS_{SSP} \sim Poisson(\lambda = e^{1.506-0.075\times 1.71}) = Poisson(\lambda = 3.97)$$
$$LS_{NENC} \sim Poisson(\lambda = e^{1.727-0.113\times 1.71}) = Poisson(\lambda = 4.64)$$

First-Year Mortality

Supporting Analysis:

We analyzed the impact of inbreeding on first-year mortality in red wolves. We only included individuals that stayed within one population for their entire first year (i.e. no translocated pups were included). In total, we analyzed the survivorship of 1628 pups (*i.e.*, they died before their first birthday or for sure lived beyond their first birthday), 747 of which were NENC-born (2000-2014) and 881 of which were captive (1980-2014). Inbreeding values of the pups ranged from 0 to 0.341 (median = 0.076, mean = 0.088, standard deviation = 0.070). We used logistic regression (generalized linear model with logit link), with population, pup F value, and the interaction between population and F value to predict the probability of mortality within the first year.

Infant mortality is significantly predicted by an interaction between population and inbreeding (p = 0.0031). Pup mortality increased with inbreeding in the NENC but decreased with inbreeding in the SSP (Fig. A3). We did also evaluate the impact of sex, but it was not a significant predictor of infant mortality (p = 0.69).

Using the general logistic relationship

$$m_0 = \frac{e^{(b_0+b_1+(b_2+b_3)\times I)}}{e^{(b_0+b_1+(b_2+b_3)\times I)}+1}$$

where m_0 = infant mortality, I = inbreeding of the pup, and b_0, b_1, b_2, and b_3 are the general intercept, the population effect on the intercept, the general slope, and the population effect on the slope (respectively), which are fitted statistically.

Coefficient	Estimate	SE[estimate]	p
Intercept (b_0)	-0.4667	0.1461	0.0014
Population Intercept (b_1)	0.2000	0.1895	0.2912
Slope (b_2)	3.1937	0.9729	0.0010
Population Slope (b_3)	-6.3132	2.1314	0.0031

The model contrasts were set up such that b_0 corresponds to the intercept for the SSP, $b_0 + b_1$ is the intercept for the NENC, b_2 corresponds to the slope for the SSP and $b_2 + b_3$ is the slope for the NENC.

Baseline Model Setup

With the point estimate parameter values, each population's probability of first-year mortality is related to pup inbreeding thusly:

$$m_{0_{SSP}} = \frac{e^{(-0.267-3.12\times I)}}{e^{(-0.267-3.12\times I)}+1}$$

$$m_{0_{NENC}} = \frac{e^{(-0.467+3.194\times I)}}{e^{(-0.467+3.194\times I)}+1}$$

where m_0 = first-year mortality and I = inbreeding of the pup.

Alternate Scenario Setup:

For the "no inbreeding impact" scenarios, we set the parameters equal to the inbreeding equation evaluated at the relevant population's current median inbreeding level (SSP: 0.075, NENC: 0.113, Total: 0.089).

First-year mortality (m_0):

$$m_{0_{SSP}} = \frac{e^{(-0.267-3.12\times 0.075)}}{e^{(-0.267-3.12\times 0.075)}+1} = 0.377$$

$$m_{0_{NENC}} = \frac{e^{(-0.467+3.194\times 0.113)}}{e^{(-0.467+3.194\times 0.113)}+1} = 0.474$$

Additional context on Inbreeding Analysis in comparison to other published studies: While previous analyses of red wolf inbreeding impacts have examined the SSP (Rabon and Waddell 2010) or the NENC (Brzeski *et al.* 2014) populations independently, no prior analyses have included both populations into a single synthethesized dataset. In addition to differences in the populations included, our treatment of the raw data differs from methods used by Rabon and Waddell (2010) and Brzeski *et al.* (2014). For example, in Brzeski *et al.*'s analysis, they considered all "Lost to Follow-up" (LTF) animals as censored, where we treated individuals that were LTF for more than one year as dead, because they were effectively removed from the population, whether they were a "true" mortality or not. Similarly, Rabon and Waddell (2010) considered the inbreeding value of pups as well as each parent, whereas we consider only the inbreeding value of the pups. In many cases, these differences in methodology do not lead to qualitatively different results between ours and previous studies - our results are consistent with patterns seen in the SSP population (Rabon and Waddell 2010). However, in some instances (for example detecting differences in the wild population parameters), we arrived at different conclusions regarding the impact of inbreeding than Brzeski *et al.* (2014). Considering this, it is important to recognize the impact of statistical analyses on the parameters underlying PVAs, and that future studies may refine, or change, our understanding of demographic rates of red wolves.

Overall Mortality

<u>Supporting Analyses:</u>

We analyzed overall mortality patterns in red wolves using a Cox proportional hazard model. We included both the SSP and NENC individuals in the analysis and assessed whether mortality rates differed between populations or sexes. Initial analyses showed that released wolves did not statistically significantly differ in their survival curves from the NENC-born wolves ($p = 0.26$), and so were combined with the NENC-born wolves, but treated as left-censored before their release dates. Wolves that were lost to follow-up for more than one year in the NENC population were considered dead. See Table A3 for the relevant data including sample sizes for both populations and age classes. In total, 1766 wolves were included, 1506 of which died.

Sexes did not differ significantly in their mortality curves ($p = 0.48$), nor was there an interaction between sex and population ($p = 0.60$). There was, however, a strong and significant impact of population on mortality, such that NENC wolves have a 2.38 times higher risk of mortality than captive wolves (hazard ratio: 0.4198, $p < 0.0001$; Fig. A4).

In addition, to inform alternate model scenarios on NENC changes in demographic rates, we looked at how per capita red wolf mortality has changed over time. For simplicity sake, we calculated the *per capita* mortality rate in NENC as the number of mortalities divided by the total population size. We analyzed the change in this rate over time by using a generalized linear model with an inverse link (assuming an exponential rate distribution) and with the regression weighted by the population size in each year. Our analysis indicates that the *per capita* mortality rate in the NENC has significantly ($p < 0.0001$) decreased over time, from ~23% in 1986 to ~14% in 2015 (Fig. A8).

We also looked at how the timing of mortality in comparison to the breeding season changed over time by treating each mortality as a binary variable, in that it could have occurred within the pre-breeding and breeding season (defined as 10/1 to 3/31) or not. We then used logistic regression to determine if the fraction of mortalities occurring during the pre-breeding/breeding season has changed over time.

Indeed, our analysis indicates there has been a significant ($p = 0.023$) increase in the fraction of mortalities that occur during this specific time window (Fig. A9).

Baseline Model Setup:
Age-specific mortality rates are called by Vortex via a lookup table, with rates corresponding to Table A3.

Alternate Scenario Model Setup:

In scenarios in which NENC mortality rates are altered to intermediate levels or SSP levels, pup mortality was not changed but age classes 1+ were altered to rates in Table A3.

NENC Generation Length (for use in Catastrophe model parameter)

We estimated the wild generation length using the following equations:

$$l_x = \frac{N_x}{N_0}$$

where N_0 is the number of females born, N_x is the number surviving from birth to age class x, and thus l_x is survivorship to age class x, and

$$T = \frac{\sum_{x=0}^{X} x l_x m_x}{\sum_{x=0}^{X} x l_x m_x}$$

where m_x is ½ the average number of offspring born to female parents of age x, X is the max age class, and T is the generation time. Using the survivorship and reproduction data in Table A6, we calculated an average generation length of 4.9 years in the NENC population.

Releases

We recognize that if releases of wolves to the NENC restart, they could vary with respect to overall rate (number of releases per year) as well as age distribution (Figs. A6 and A7, Table A5).

We consider two age distributions of releases ("wider" scenario results are included in Appendix 4):

1. "Young": 60.6% 0-year olds, 33.3% 1-year olds, and 6% 2-5-year olds
   This corresponds to releases from 2005-2014 and represents primarily pup fostering (Fig. A6).
2. "Wider" : 58.3% 0-year olds, 16.7% 1-year olds, and 25% 2-5-year olds
   This corresponds to releases from 1989-1993 and represents primarily population establishment (Fig. A6).

We consider three rates of releases corresponding to three historical time frames (Fig. A7, Table A5, Appendix 4):

2005-2014: 3.3 individuals/year
1986-2014: 4.5 individuals/year
1989-1993: 9.6 individuals/year

We assume that the releases are split evenly between the two sexes and that releases occur probabilistically via Poisson distributions.

4. FIGURES

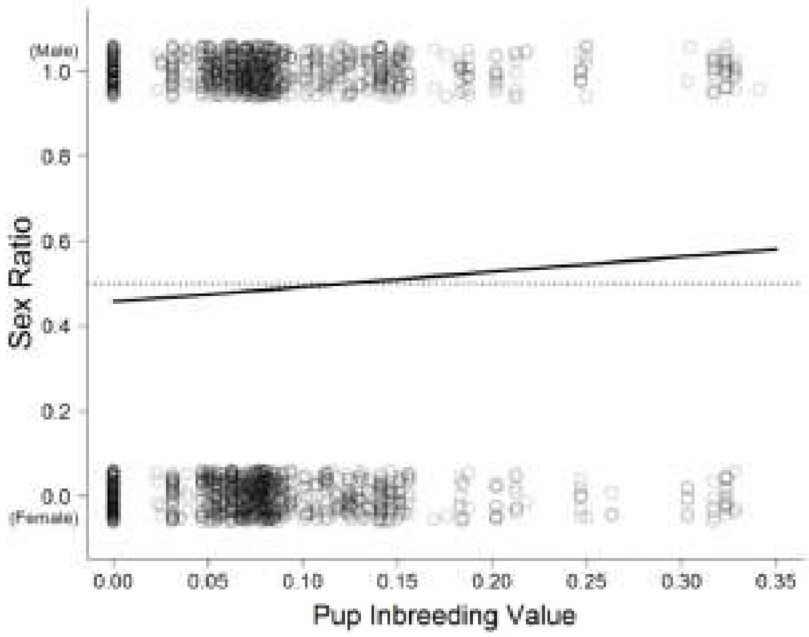


Figure A1. Impact of pup inbreeding level on sex ratio. Each point represents a single pup's sex in relation to their inbreeding value (as determined from the pedigree). The horizontal dashed line shows the 50:50 ratio and the solid line shows the results of the model fit, which predicts an increasing likelihood of a pup being male with increased inbreeding.

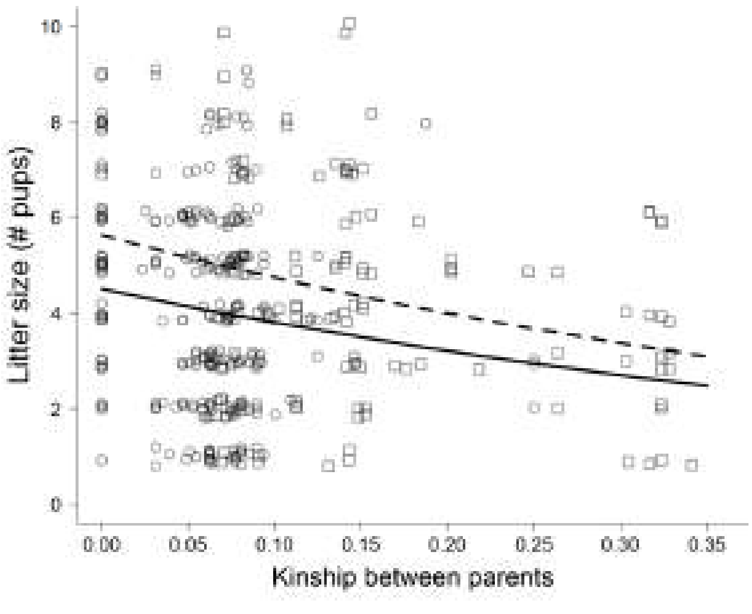


Figure A2. Impact of inbreeding (measured as kinship between parents) on litter size in red wolves. Boxes are NENC litters, circles are SSP litters. The dashed line is the model predicted mean litter size for the NENC population, and the solid line is that value for the SSP population.

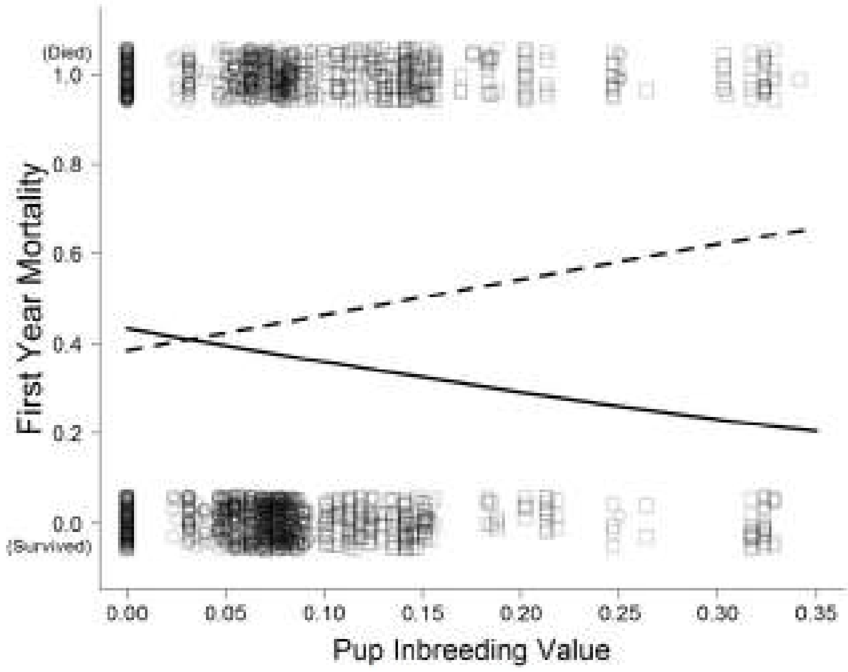


Figure A3. Impact of inbreeding on first year survival in red wolves. Boxes are NENC litters, circles are SSP litters. The dashed line is the model predicted probability of first year mortality for the NENC population, and the solid line is that value for the SSP population.

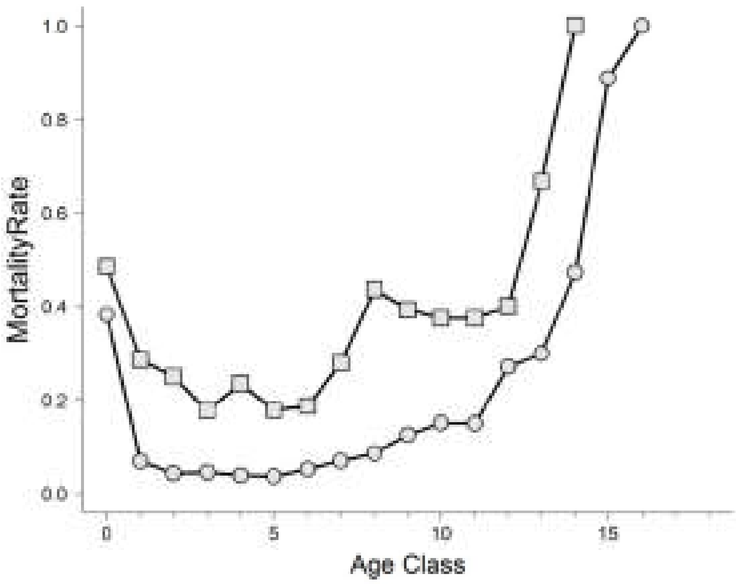


Figure A4. Age-specific mortality curves for the SSP (circles) and NENC (squares) populations. Data shown in Table A3.

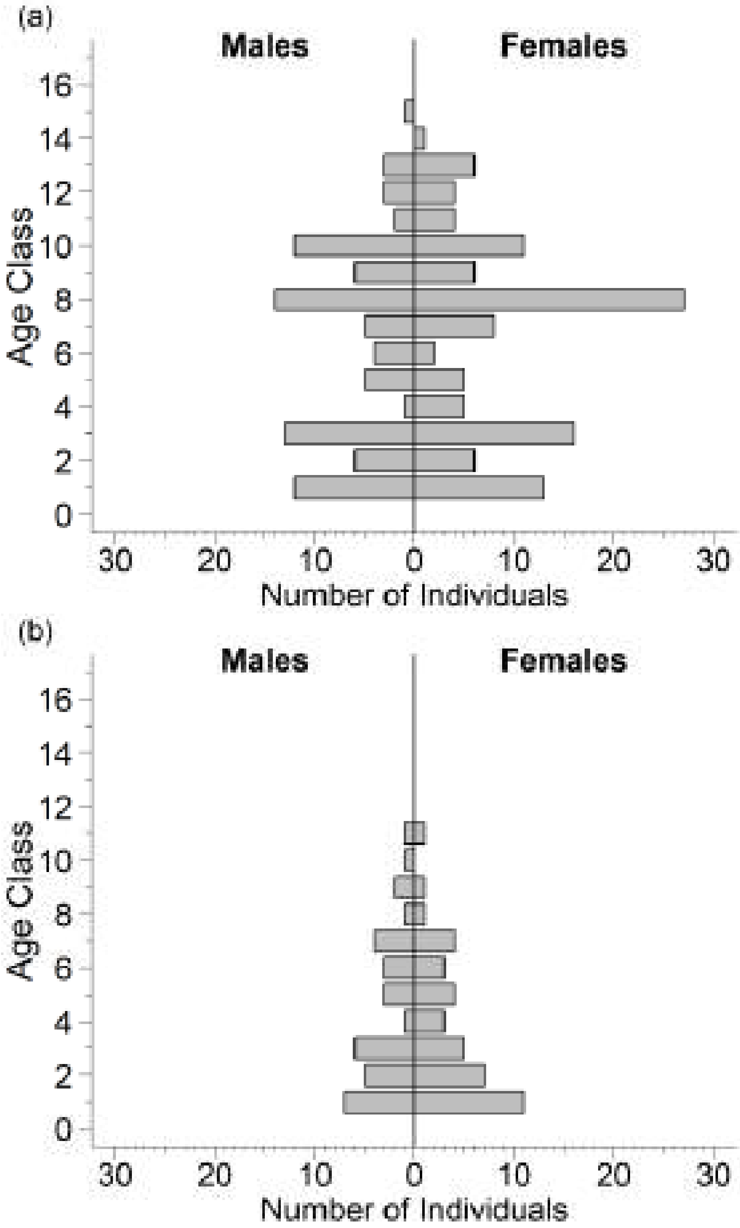


Figure A5. Age distributions for the SSP (a) and the NENC (b) initial populations.

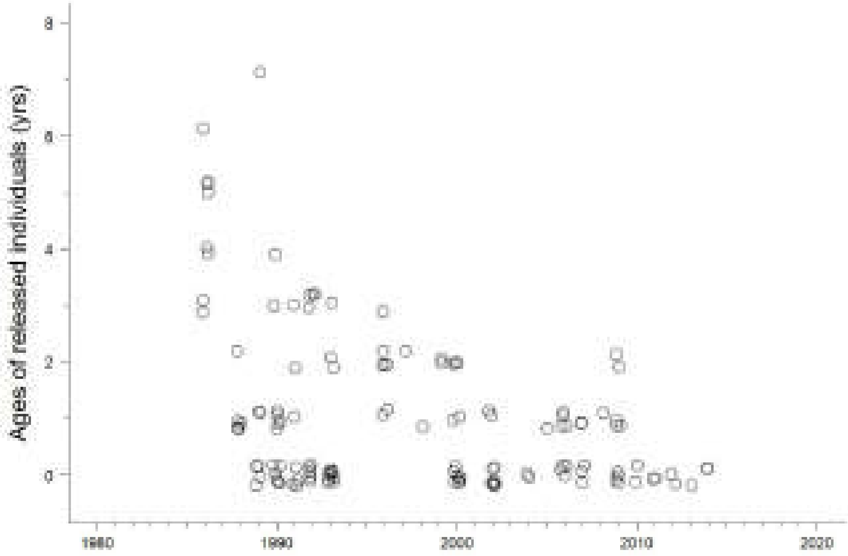


Figure A6. Ages of wolves released to the NENC population over time. Note that the data were jittered along the y-axis to show overlapping points.

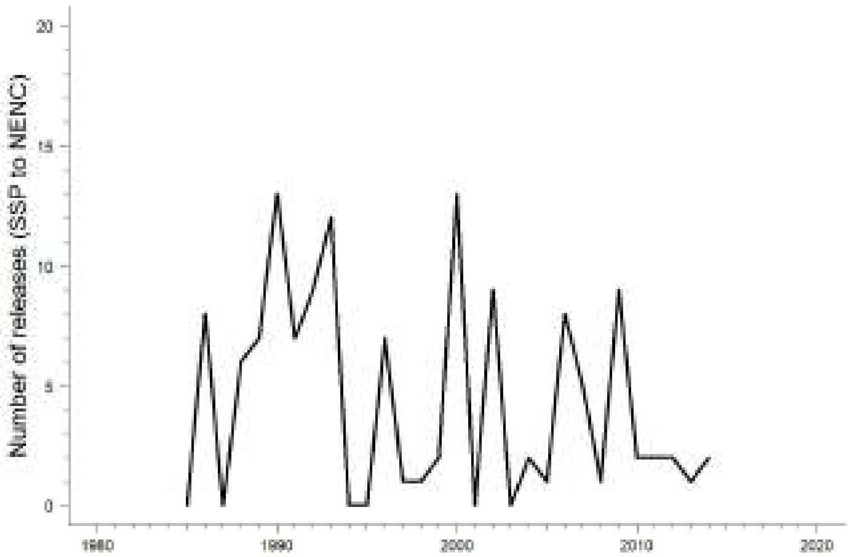


Figure A7. Annual number of releases from the SSP population to the NENC population over time. See also Table A5.

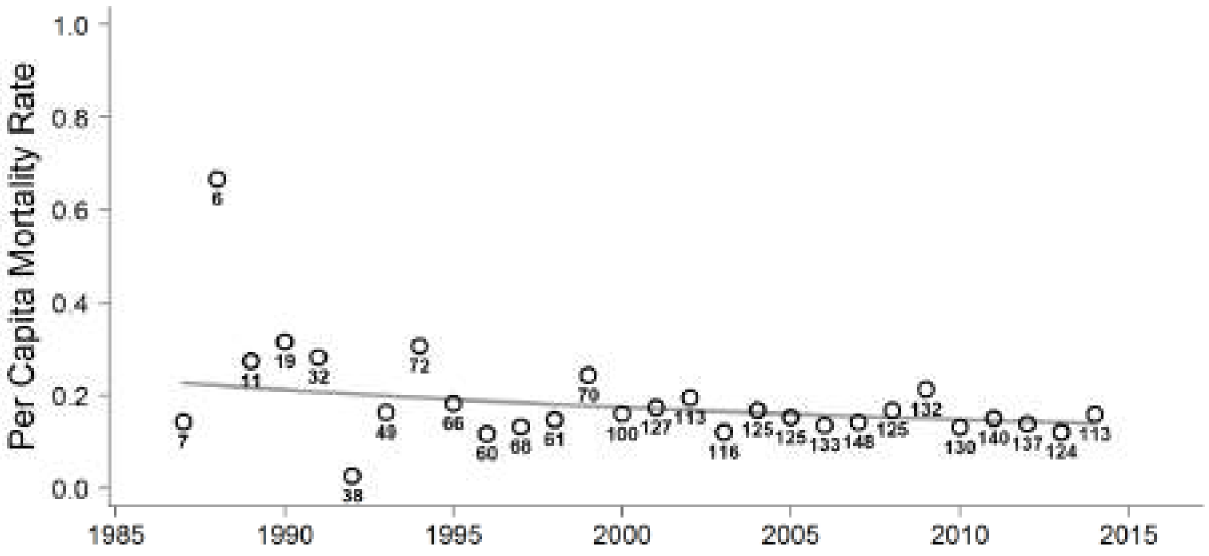


Figure A8. ***Per capita*** **mortality rate in the NENC population over time. Numbers next to points indicate the population size in the given year. Fitted line is the exponential, weighted regression, which shows a significant decrease in mortality over time.**

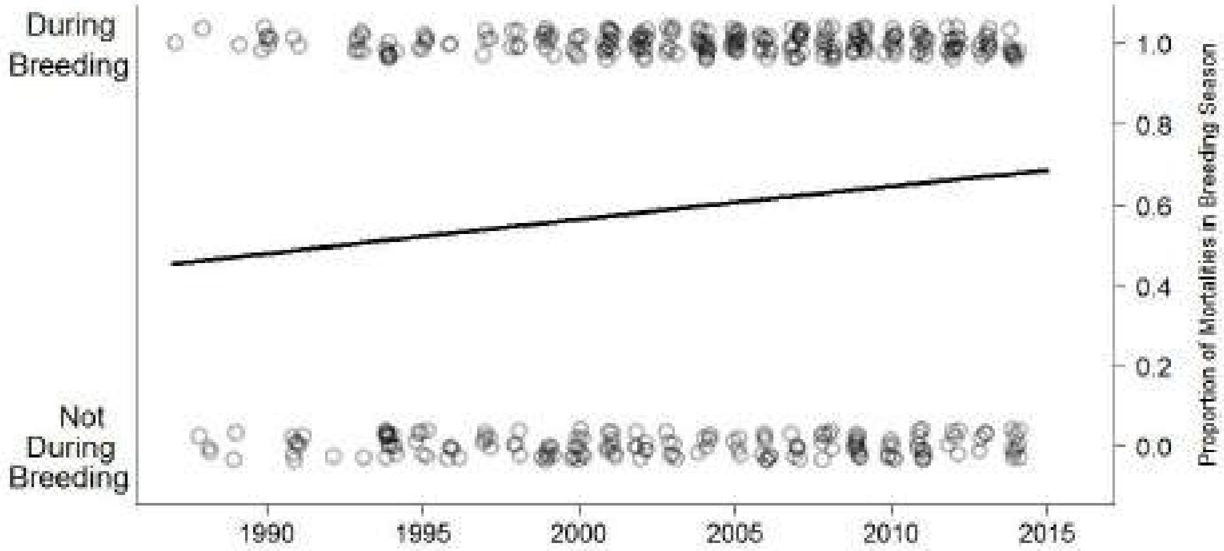


FIGURE A9. Mortalities in the NENC grouped by timing within the pre-breeding and breeding season (10/1 to 3/31) or not, as changing over time. The fitted line is the logistic regression, which shows a significant increase in the proportion of mortalities that occur during the pre-breeding and breeding season over time.

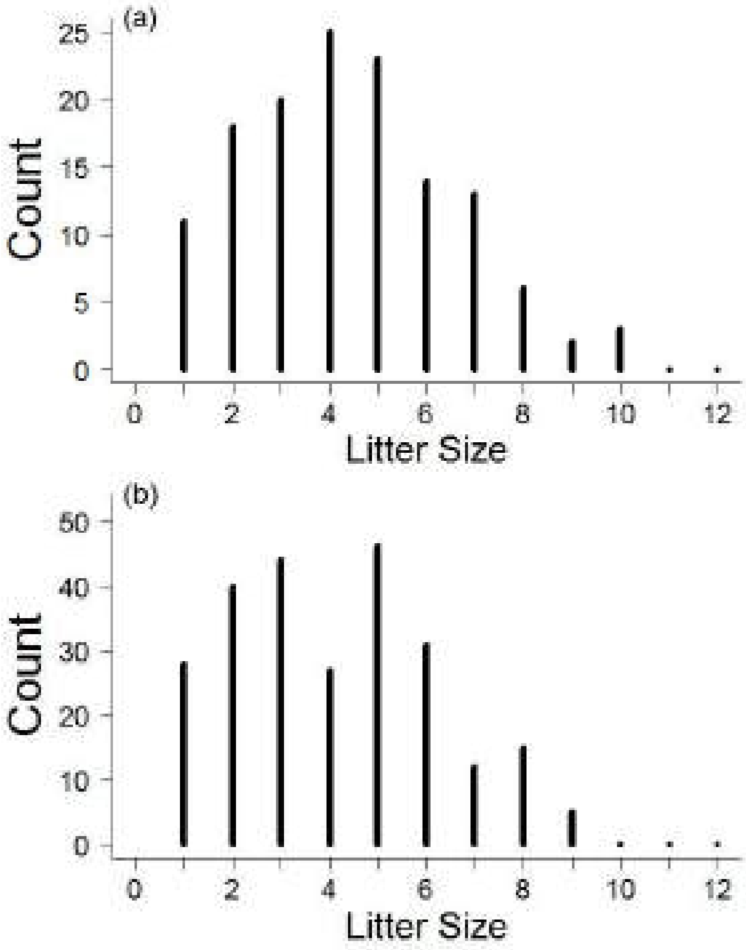


FIGURE A10. Litter size distributions for the NENC (a) and SSP (b) populations. These are the same data as shown in Figure A2.

5. TABLES

Table A1. History of breeding recommendation fulfillment (whether a breeding recommendation resulted in an offspring before the next year's plan) in the SSP population.

Year	# Recommendations (Scored)	Fulfilled Recommendations	% Fulfillment
2001	22	4	18.18
2002	34	7	20.59
2003	31	3	9.68
2004	32	7	21.88
2005	38	8	21.05
2006	33	7	21.21
2007	26	9	34.62
2008	13	2	15.38
2009	16	2	12.5
2010	28	6	21.43
2011	30	5	16.67
2012	32	7	21.88
2013	26	4	15.38
Average % Fulfillment (SSP Female Breeding Success)			19%

Table A2. Female wolf breeding in the NENC population.

Year	Females Aged 2-10	# Wolf-Wolf Pairs	% Females Paired Wolf-Wolf	**# Wolf-Wolf Pairs Successful**	**% Wolf-Wolf Pairs Successful**	**% Females Breeding Wolf-Wolf**
2000	24	7	29.2	**4**	**57.1**	**16.7**
2001	32	14	43.8	**9**	**64.3**	**28.1**
2002	28	11	39.3	**7**	**63.6**	**25.0**
2003	28	20	71.4	**9**	**45.0**	**32.1**
2004	28	20	71.4	**11**	**55.0**	**39.3**
2005	25	15	60.0	**9**	**60.0**	**36.0**
2006	27	15	55.6	**11**	**73.3**	**40.7**
2007	35	20	57.1	**11**	**55.0**	**31.4**
2008	29	18	62.1	**12**	**66.7**	**41.4**
2009	28	15	53.6	**11**	**73.3**	**39.3**
2010	27	15	55.6	**9**	**60.0**	**33.3**
2011	27	16	59.3	**11**	**68.8**	**40.7**
2012	31	16	51.6	**8**	**50.0**	**25.8**

2013	29	13	44.8	7	53.8	24.1
2014	24	8	33.3	4	50.0	16.7
Average % Wolf-Wolf Pairs Successful (Female Breeding Success)					59.7	

Table A3. Mortality rates in the SSP and NENC populations. Data are combined for both sexes.

Age	Captive				NENC				"Intermediate" NENC Mortality Rate (%)
	# At Risk	# Censored	# Mortalities	Mortality Rate (%)	# At Risk	# Censored	# Mortalities	Mortality Rate (%)	
0	906	25	347	38.30	820	3	398	48.54	
1	534	12	37	6.93	447	12	128	28.64	17.79
2	485	29	21	4.33	308	11	77	25.00	14.67
3	435	6	20	4.60	226	4	40	17.70	11.15
4	409	10	16	3.91	183	7	43	23.50	13.71
5	383	6	14	3.66	135	6	24	17.78	10.72
6	363	13	19	5.23	107	8	20	18.69	11.96
7	331	41	23	6.95	79	2	22	27.85	17.4
8	267	12	23	8.61	55	3	24	43.64	26.13
9	232	23	29	12.50	28	1	11	39.29	25.9
10	180	6	27	15.00	16	2	6	37.50	26.25
11	147	7	22	14.97	8	0	3	37.50	26.24
12	118	9	32	27.12	5	0	2	40.00	33.56
13	77	1	23	29.87	3	0	2	66.67	48.27
14	53	1	25	47.17	1	0	1	100.00	100
15	27	0	24	88.89					
16	3	0	3	100.00					

Table A4. Pairing of adult NENC wolves with other wolves and non-wolves (i.e. coyotes).

Year	**Males**					**Females**					
	# Breeding -Aged Wolves	# Wolf-Wolf Pairs	% Paired Wolf-Wolf	# Wolf-Non-Wolf Pairs	% Paired Wolf-Non-Wolf	# Breeding -Aged Wolves	# Wolf-Wolf Pairs	% Paired Wolf-Wolf	# Wolf-Non-Wolf Pairs	% Paired Wolf-Non-Wolf	**% Paired with Any Canid**
2000	23	7	30.4	4	17.4	24	7	**29.2**	7	**29.2**	**58.3**
2001	28	14	50	5	17.9	32	14	**43.8**	6	**18.8**	**62.5**
2002	33	11	33.3	8	24.2	28	11	**39.3**	4	**14.3**	**53.6**
2003	26	20	76.9	1	3.8	28	20	**71.4**	4	**14.3**	**85.7**
2004	31	20	64.5	1	3.2	28	20	**71.4**	2	**7.1**	**78.6**
2005	27	15	55.6	0	0	25	15	**60**	2	**8**	**68**
2006	28	15	53.6	1	3.6	27	15	**55.6**	6	**22.2**	**77.8**
2007	33	20	60.6	1	3	35	20	**57.1**	4	**11.4**	**68.6**
2008	35	18	51.4	3	8.6	29	18	**62.1**	4	**13.8**	**75.9**
2009	30	15	50	4	13.3	28	15	**53.6**	5	**17.9**	**71.4**
2010	36	15	41.7	6	16.7	27	15	**55.6**	2	**7.4**	**63**
2011	41	16	39	4	9.8	27	16	**59.3**	5	**18.5**	**77.8**
2012	37	16	43.2	6	16.2	31	16	**51.6**	5	**16.1**	**67.7**
2013	34	13	38.2	7	20.6	29	13	**44.8**	7	**24.1**	**69**
2014	32	8	25	7	21.9	24	8	**33.3**	5	**20.8**	**54.2**
2000-2014 Averages					12.0			**52.5**			

Table A5. Annual releases from the SSP to NENC.

Year	Number of Releases (SSP to NENC)
1986	8
1987	0
1988	6
1989	7
1990	13
1991	7
1992	9
1993	12
1994	0
1995	0
1996	7
1997	1
1998	1
1999	2
2000	13
2001	0
2002	9
2003	0
2004	2
2005	1
2006	8
2007	5
2008	1
2009	9
2010	2
2011	2
2012	2
2013	1
2014	2

Table A6. Survivorship and reproduction data for NENC population, used to calculate generation length.

Age Class	Mortality Rate	l_x	Probability of Whelping	Litter Size	m_x
0	0.485	0.515	0.000	0.000	0.000
1	0.286	0.367	0.000	0.000	0.000
2	0.250	0.275	0.045	4.200	0.095
3	0.177	0.227	0.325	4.461	0.725
4	0.235	0.173	0.403	4.640	0.935
5	0.178	0.143	0.500	5.000	1.250
6	0.187	0.116	0.500	3.773	0.943
7	0.279	0.084	0.452	3.929	0.888
8	0.436	0.047	0.370	3.800	0.703
9	0.393	0.029	0.333	5.750	0.957
10	0.375	0.018	0.333	2.000	0.333
11	0.375	0.011	0.000	0.000	0.000
12	0.400	0.007	0.000	0.000	0.000
13	0.667	0.002	0.000	0.000	0.000
14	1.000	0.000	0.000	0.000	0.000

Appendix 2. Model Scenario Results Table

Abbreviation	Description
P(E)	Probability of extinction in 125 years (i.e. the # of extinct iterations/total # of iterations)
GD	Mean gene diversity in 125 years, calculated across surviving (non-extinct) model iterations
F	Mean inbreeding coefficient in 125 years, calculated across surviving (non-extinct) model iterations
N	Mean population size in 125 years, calculated across 1000 model iterations (extinct and extant)
TE	Median time to extinction for iterations that go extinct (only reported if the population went extinct in at least 50% of simulations)
P(80GD)	Probability of population maintaining 80% GD at 125 years, calculated across all surviving (non-extinct) model iterations

SSP RESULTS:

		SSP								
		N		P (E)	TE	GD		F		P
Label	Scenario Name	Mean	SD		Median	Mean	SD	Mean	SD	(80GD)
A	Baseline	207.93	11.44	0	–	0.8100	0.0536	0.1799	0.0648	0.657
B	NENC mortality = intermediate	208.20	11.27	0	–	0.8132	0.0509	0.1748	0.0583	0.690
C	NENC mortality = SSP mortality	207.82	12.09	0	–	0.8070	0.0545	0.1788	0.0638	0.615
D	NENC mortality = Intermediate, no inbreeding depression	208.98	10.20	0	–	0.8107	0.0522	0.1790	0.0627	0.656
E	Increased females breeding NENC	207.84	12.43	0	–	0.8092	0.0586	0.1803	0.0613	0.657
F	NENC mortality = intermediate, Increased females breeding NENC	207.79	11.50	0	–	0.8112	0.0526	0.1779	0.0623	0.685
G	Reduced coyote impact	208.18	11.86	0	–	0.8088	0.0543	0.1793	0.0674	0.654
H	Increased coyote impact	208.89	12.49	0	–	0.8096	0.0509	0.1788	0.0585	0.661
I	NENC mortality = intermediate, reduced coyote impact	207.41	11.65	0	–	0.8099	0.0530	0.1796	0.0640	0.676
J	NENC mortality = intermediate, Increased coyote impact	207.50	10.87	0	–	0.8074	0.0583	0.1820	0.0671	0.647
K	SSP 330 spaces	308.97	11.21	0	–	0.8334	0.0437	0.1577	0.0508	0.800
L	SSP 400 spaces	375.24	12.57	0	–	0.8437	0.039	0.1496	0.0452	0.885
M	SSP 330 spaces, SSP 25% breeding	330.47	10.82	0	–	0.8453	0.0387	0.1477	0.0459	0.883
N	SSP 400 spaces, SSP 25% breeding	376.89	11.69	0	–	0.8511	0.0382	0.1426	0.0423	0.913
O	Capturable wolves brought into SSP	209.31	10.40	0	–	0.8168	0.0535	0.1710	0.0629	0.714
P	Capturable wolves brought into SSP, SSP 330 spaces	309.86	11.86	0	–	0.8435	0.0418	0.1501	0.0487	0.871
Q	Movement (3.3 every year)	197.85	20.01	0	–	0.8007	0.0547	0.1869	0.0676	0.589
R	Movement (3.3 every year), SSP 330 spaces	304.55	14.44	0	–	0.8287	0.0463	0.1648	0.0538	0.781
S	Movement (3.3 every year), SSP 400 spaces	371.59	13.79	0	–	0.8421	0.0387	0.1509	0.0464	0.876
T	Movement (3.3 every year), SSP 400 spaces, SSP 25% breeding	374.23	12.37	0	–	0.8524	0.0356	0.1412	0.0412	0.928
U	Movement (3.3 every year), NENC mortality = intermediate	198.61	18.23	0	–	0.8025	0.0582	0.1846	0.0701	0.616
V	Movement (3.3 every year), NENC increased breeding	198.14	19.48	0	–	0.8003	0.0565	0.1880	0.0675	0.582
W	Movement (3.3 every year), NENC	197.70	19.52	0	–	0.8008	0.0571	0.1865	0.0678	0.594

Label	Scenario Name	SSP								
		N		P (E)	TE	GD		F		P
		Mean	SD		Median	Mean	SD	Mean	SD	(GD>0.90)
	mortality = intermediate, NENC increased breeding									
X	Movement (3.3 per year for 15 years then every 5 years), NENC mortality = intermediate, NENC increased breeding	205.81	12.49	0	–	0.8871	0.0536	0.1830	0.0629	0.647
Y	Movement (3.3 per year for 15 years then every 20 years), NENC mortality = intermediate, NENC increased breeding	207.76	11.53	0	–	0.8864	0.0580	0.1806	0.0685	0.625
Z	Recovery on federal lands only	205.87	14.38	0	–	0.8875	0.0560	0.1825	0.0661	0.651
AA	Movement (3.3 every year), SSP 400 spaces, SSP 25% breeding, NENC mortality = intermediate	374.71	12.23	0	–	0.8534	0.0364	0.1402	0.0421	0.910
BB	Movement (3.3 every year), SSP 400 spaces, SSP 25% breeding, NENC mortality = intermediate, NENC increased breeding	374.95	12.29	0	–	0.8523	0.0377	0.1423	0.0443	0.912
CC	No RSR bias	208.29	11	0	–	0.8873	0.0581	0.1811	0.0678	0.648
DD	No inbreeding	208.41	9.44	0	–	0.8882	0.0534	0.1807	0.0648	0.644
EE	No genetic management of SSP	202.36	17.46	0	–	0.7505	0.0834	0.2390	0.0887	0.300
FF	SSP Current Number of Pairs	118.59	25.17	0.005	–	0.7611	0.0785	0.2201	0.0947	0.351
GG	No Environmental Variation in any demographic parameters	208.28	11.12	0	–	0.8129	0.0586	0.1768	0.0605	0.682

NENC RESULTS:

Label	Scenario Name	NENC								
		N		P(E)	TE	GD		F		P(GD>0.90)
		Mean	SD		Median	Mean	SD	Mean	SD	
A	Baseline	0	0	1	–	0	0	1	0	0
B	NENC mortality = intermediate	4.19	13.34	0.822	–	0.5835	0.1826	0.3334	0.2310	0.046
C	NENC mortality = SSP mortality	116.85	42.11	0.016	–	0.6921	0.1112	0.2884	0.1226	0.131
D	NENC mortality = Intermediate, no inbreeding depression	138.57	24.82	0.083	–	0.6546	0.1244	0.3345	0.1328	0.055
E	Increased females breeding NENC	0.03	0.45	0.996	–	0.4211	0.1755	0.4347	0.2807	0
F	NENC mortality = intermediate, Increased females breeding NENC	67.46	54.29	0.165	–	0.6568	0.1382	0.3086	0.1535	0.066
G	Reduced coyote impact	0	0.04	1	66	0	0	1	0	0
H	Increased coyote impact	0	0	1	23	0	0	1	0	0
I	NENC mortality = intermediate, reduced coyote impact	61.58	50.34	0.162		0.6486	0.1352	0.3157	0.1555	0.051
J	NENC mortality = intermediate, Increased coyote impact	0	0	1	49	0	0	1	0	0
K	SSP 330 spaces	0	0	1	38	0	0	1	0	0
L	SSP 400 spaces	0	0	1	37	0	0	1	0	0
M	SSP 330 spaces, SSP 25% breeding	0	0	1	36	0	0	1	0	0
N	SSP 400 spaces, SSP 25% breeding	0	0	1	37	0	0	1	0	0
O	Capturable wolves brought into SSP	0	0	1	24	0	0	1	0	0

Label	Scenario Name	NENC								
		N		P(E)	TE	GD		F		P(NGD)
		Mean	SD		Median	Mean	SD	Mean	SD	
P	Capturable wolves brought into SSP, SSP 330 spaces	0	0	1	25	0	0	1	0	0
Q	Movement (3.3 every year)	29.32	22.87	0.022	–	0.757	0.0817	0.201	0.1253	0.343
R	Movement (3.3 every year), SSP 330 spaces	38.66	28.04	0.006	–	0.7855	0.0701	0.1750	0.1026	0.508
S	Movement (3.3 every year), SSP 400 spaces	44.45	31.78	0.003	–	0.7934	0.0682	0.1750	0.0994	0.561
T	Movement (3.3 every year), SSP 400 spaces, SSP 25% breeding	47.28	32.77	0.003	–	0.8037	0.0676	0.1577	0.0879	0.606
U	Movement (3.3 every year), NENC mortality = intermediate	131.17	28.86	0	–	0.8113	0.0548	0.1764	0.0658	0.661
V	Movement (3.3 every year), NENC increased breeding	98.80	42.53	0.001	–	0.7965	0.0586	0.1859	0.0779	0.566
W	Movement (3.3 every year), NENC mortality = intermediate, NENC increased breeding	141.38	20.21	0	–	0.8127	0.0580	0.1755	0.0625	0.667
X	Movement (3.3 per year for 15 years then every 5 years), NENC mortality = intermediate, NENC increased breeding	132.23	29.56	0	–	0.7794	0.0688	0.2076	0.079	0.460
Y	Movement (3.3 per year for 15 years then every 20 years), NENC mortality = intermediate, NENC increased breeding	113.62	43.54	0.022	–	0.7291	0.0852	0.251	0.1103	0.216
Z	Recovery on federal lands only	2.13	2.36	0.671	14	0.6427	0.1494	0.1745	0.2315	0.045
AA	Movement (3.3 every year), SSP 400 spaces, SSP 25% breeding, NENC mortality = intermediate	134.82	26.01	0	–	0.8314	0.0457	0.1577	0.0584	0.805
BB	Movement (3.3 every year), SSP 400 spaces, SSP 25% breeding, NENC mortality = intermediate, NENC increased breeding	143.17	18.48	0	–	0.8335	0.0448	0.1562	0.0583	0.815
CC	No BSR bias	0	0	1	38	0	0	1	0	0
DD	No inbreeding	31.54	48.17	0.589	103	0.4830	0.2122	0.4946	0.233	0.008
EE	No genetic management of SSP	0	0	1	37	0	0	1	0	0
FF	SSP Current Number of Pairs	0	0	1	38	0	0	1	0	0
GG	No Environmental Variation in any demographic parameters	0	0	1	38	0	0	1	0	0

METAPOPULATION RESULTS:

Label	Scenario Name	Metapopulation (SSP + NENC)								
		N		P(E)	TE	GD		F		P(NGD)
		Mean	SD		Median	Mean	SD	Mean	SD	
A	Baseline	287.93	11.44	0	–	0.810	0.0536	0.1798	0.0648	0.657
B	NENC mortality = intermediate	212.38	17.46	0	–	0.816	0.0504	0.1772	0.0599	0.711
C	NENC mortality = SSP mortality	324.67	44.50	0	–	0.8416	0.0422	0.2157	0.0597	0.873
D	NENC mortality = Intermediate, no inbreeding depression	347.55	27.19	0	–	0.8367	0.0449	0.2404	0.0655	0.840
E	Increased females breeding NENC	287.86	12.45	0	–	0.8092	0.0505	0.1804	0.0613	0.657

Label	Scenario Name	Metapopulation (SSP + NENC)								
		N		P(E)	TE	GD		F		P(IDGD)
		Mean	SD		Median	Mean	SD	Mean	SD	
F	NENC mortality = intermediate, Increased females breeding NENC	275.25	55.29	0	–	0.0351	0.0461	0.2037	0.0682	0.825
G	Reduced coyote impact	285.18	11.86	0	–	0.0085	0.0543	0.1793	0.0674	0.654
H	Increased coyote impact	285.08	12.49	0	–	0.0096	0.0508	0.1788	0.0595	0.661
I	NENC mortality = intermediate, reduced coyote impact	258.98	50.65	0	–	0.0332	0.0479	0.2058	0.0621	0.817
J	NENC mortality = intermediate, Increased coyote impact	287.90	10.87	0	–	0.0074	0.0583	0.1820	0.0671	0.647
K	SSP 330 spaces	305.97	11.21	0	–	0.0334	0.0437	0.1577	0.0505	0.800
L	SSP 400 spaces	375.24	12.57	0	–	0.0437	0.038	0.1496	0.0452	0.865
M	SSP 330 spaces, SSP 25% breeding	310.47	10.82	0	–	0.0453	0.0387	0.1477	0.0459	0.883
N	SSP 400 spaces, SSP 25% breeding	376.08	11.69	0	–	0.0511	0.0362	0.1426	0.0423	0.913
D	Capturable wolves brought into SSP	289.31	10.40	0	–	0.0165	0.0535	0.1710	0.0629	0.714
P	Capturable wolves brought into SSP, SSP 330 spaces	309.06	11.86	0	–	0.0435	0.0418	0.1501	0.0497	0.871
Q	Movement (3.3 every year)	227.17	31.39	0	–	0.0031	0.0542	0.1868	0.0653	0.604
R	Movement (3.3 every year), SSP 330 spaces	343.24	30.97	0	–	0.0348	0.0463	0.1660	0.0526	0.798
S	Movement (3.3 every year), SSP 400 spaces	416.44	35.00	0	–	0.0430	0.0395	0.1533	0.0459	0.883
T	Movement (3.3 every year), SSP 400 spaces, SSP 25% breeding	421.51	35.67	0	–	0.0532	0.0352	0.1432	0.0404	0.936
U	Movement (3.3 every year), NENC mortality = intermediate	329.77	34.49	0	–	0.0236	0.0498	0.1813	0.0574	0.744
V	Movement (3.3 every year), NENC increased breeding	257.94	47.19	0	–	0.0167	0.0492	0.1874	0.0573	0.686
W	Movement (3.3 every year), NENC mortality = intermediate, NENC increased breeding	339.08	28.67	0	–	0.0256	0.0456	0.1831	0.0535	0.764
X	Movement (3.3 per year for 15 years then every 5 years), NENC mortality = intermediate, NENC increased breeding	337.24	32.46	0	–	0.0402	0.0408	0.1913	0.0532	0.864
Y	Movement (3.3 per year for 15 years then every 20 years), NENC mortality = intermediate, NENC increased breeding	321.38	44.95	0	–	0.0349	0.0446	0.2038	0.0583	0.847
Z	Recovery on federal lands only	286	14.51	0	–	0.0075	0.0561	0.1827	0.0661	0.649
AA	Movement (3.3 every year), SSP 400 spaces, SSP 25% breeding, NENC mortality = intermediate	509.53	28.61	0	–	0.0549	0.0343	0.1448	0.0389	0.942
BB	Movement (3.3 every year), SSP 400 spaces, SSP 25% breeding, NENC mortality = intermediate, NENC increased breeding	518.11	22.07	0	–	0.0604	0.0335	0.1461	0.0387	0.937
CC	No RSR bias	289.29	11.00	0	–	0.0073	0.0591	0.1811	0.0678	0.649
DD	No inbreeding	240.95	48.60	0	–	0.0140	0.0527	0.2104	0.0868	0.676
EE	No genetic management of SSP	282.35	17.46	0	–	0.7546	0.0834	0.2390	0.0857	0.300
FF	SSP Current Number of Pairs	118.59	25.17	0.005	–	0.7611	0.0765	0.2201	0.0947	0.351
GG	No Environmental Variation in any demographic parameters	285.28	11.12	0	–	0.0129	0.0506	0.1768	0.0585	0.682

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Appendix 4. Additional Model Scenarios

These model scenarios were run for the initial draft report, but were not integral to explaining key model results and conclusions; the scenarios are presented here in case readers needed additional information.

Label	Scenario Name	Description
		NENC individuals brought into SSP
4A	Capturable wolves brought into SSP, SSP 233	Bring in the 32 individuals mentioned above + create new spaces for just these individuals, such that the carrying capacity for the SSP becomes the current population (201) plus the 32 individuals brought in (space = 233)
4B	Capturable wolves brought into SSP, SSP 400 spaces	Bring in the 32 individuals + increase SSP carrying capacity to 400
		Release scenarios - Releases Only
4C	Movement (young, 4.5 per year)	Release SSP animals into the NENC population via "young" strategy as described above. 4.5 animals per year is based on the average release rate from 1986-2014.
4D	Movement (wide, 9.6 per year)	Release young and older animals (ages 0 – 5) with these age frequencies: 58.3% 0-year olds, 16.7% 1-year olds, and 25% 2-5-year olds (matching age distributions of releases from 1988-1993, Fig. A6). 9.6 individuals per year is based on release rates from 1989-1993.
		Release scenarios - Releases + SSP changes
4E	Movement (young, 4.5 per year), SSP 330 spaces	Releases as in Scenario T + SSP carrying capacity is increased to 330.
4F	Movement (young, 4.5 per year), SSP 400 spaces	Releases as in Scenario T + SSP carrying capacity is increased to 400.
4G	Movement (young, 4.5 per year), SSP 400 spaces, SSP 25% breeding	Releases as in Scenario X + SSP K = 400 + % females producing a litter increased to 25% from 19%
		Release scenarios - Releases + NENC demographic rate changes
4H	Movement (young, 4.5 per year), NENC mortality = intermediate, NENC increased breeding	Release as in Scenario T + improved mortality + improved breeding in the NENC population as in Scenario F.
		Release scenarios - Releases + SSP + NENC changes
4I	Movement (3.3 per year for 15 years then every 10 years), NENC mortality = intermediate, NENC increased breeding	Release young animals, 3.3 per year for 15 years and then 3.3 every 10 years from year 16 – 125. NENC mortality = intermediate and increased females breeding as in Scenario F.
4J	Movement (3.3 per year for 25 years then every 5 years), NENC mortality = intermediate, NENC increased breeding	Release young animals, 3.3 per year for 25 years and then 3.3 every 5 years from year 26 – 125. NENC mortality = intermediate and increased females breeding as in Scenario F.
4K	Movement (3.3 per year for 25 years then every 10 years), NENC mortality = intermediate, NENC increased breeding	Release young animals, 3.3 per year for 25 years and then 3.3 every 10 years from year 26 – 125. NENC mortality = intermediate and increased females breeding as in Scenario F.
4L	Movement (3.3 per year for 25 years then every 20 years), NENC mortality =	Release young animals, 3.3 per year for 25 years and then 3.3 every 20 years from year 26 – 125. NENC mortality = intermediate and increased females breeding as in Scenario F.

Label	Scenario Name	Description
	intermediate, NENC increased breeding	

APPENDIX 4 EXTRA SCENARIO RESULTS

Abbreviation	Description
P(E)	Probability of extinction in 125 years (i.e. the # of extinct iterations/total # of iterations)
GD	Mean gene diversity in 125 years, calculated across surviving (non-extinct) model iterations
F	Mean inbreeding coefficient in 125 years, calculated across surviving (non-extinct) model iterations
N	Mean population size in 125 years, calculated across 1000 model iterations (extinct and extant)
TE	Median time to extinction for iterations that go extinct (only reported if the population went extinct in at least 50% of simulations)
P(80GD)	Probability of population maintaining 80% GD at 125 years, calculated across all surviving (non-extinct) model iterations

SSP RESULTS:

		SSP								
		N		P (E)	TE	GD		F		P (80GD)
Label	Scenario Name	Mean	SD		Median	Mean	SD	Mean	SD	
4A	Capturable wolves brought into SSP, SSP 233	215.59	10.52	0		0.8187	0.0516	0.1701	0.062	0.726
4B	Capturable wolves brought into SSP, SSP 400 spaces	375.42	12.56	0		0.852	0.0373	0.1408	0.0435	0.912
4C	Movement (young, 4.5 per year)	192.59	22.04	0		0.7999	0.0567	0.1865	0.0679	0.588
4D	Movement (wide, 9.6 per year)	167.6	26.85	0		0.7849	0.0656	0.2025	0.0789	0.486
4E	Movement (young, 4.5 per year), SSP 330 spaces	302.45	16.66	0		0.8306	0.0422	0.1617	0.0489	0.795
4F	Movement (young, 4.5 per year), SSP 400 spaces	370.73	14.57	0		0.8396	0.0404	0.1538	0.0471	0.86
4G	Movement (young, 4.5 per year), SSP 400 spaces, SSP 25% breeding	373.67	12.1	0		0.8502	0.0387	0.1451	0.0455	0.901
4H	Movement (young, 4.5 per year), NENC mortality = intermediate, NENC increased breeding	190.32	23.33	0		0.7991	0.0541	0.1893	0.0665	0.574
4I	Movement (3.3 per year for 15 years then every 10 years), NENC mortality = intermediate, NENC increased breeding	205.95	11.4	0		0.8102	0.0536	0.1771	0.0633	0.667
4J	Movement (3.3 per year for 25 years then every 5 years), NENC mortality = intermediate, NENC increased breeding	205.41	11.71	0		0.8053	0.0544	0.1848	0.0628	0.612

Label	Scenario Name	SSP								
		N		P (E)	TE	GD		F		P (80GD)
		Mean	SD		Median	Mean	SD	Mean	SD	
4K	Movement (3.3 per year for 25 years then every 10 years), NENC mortality = intermediate, NENC increased breeding	205.7	12.55	0		0.808	0.0538	0.1806	0.064	0.654
4L	Movement (3.3 per year for 25 years then every 20 years), NENC mortality = intermediate, NENC increased breeding	205.17	12.89	0		0.8059	0.0573	0.1841	0.0682	0.642

NENC RESULTS:

Label	Scenario Name	NENC								
		N		P(E)	TE	GD		F		P(80GD)
		Mean	SD		Median	Mean	SD	Mean	SD	
4A	Capturable wolves brought into SSP, SSP 233	0	•	1	24	0	•	1	0	0
4B	Capturable wolves brought into SSP, SSP 400 spaces	0	•	1	24	0	•	1	0	0
4C	Movement (young, 4.5 per year)	42.06	29.3	0.005		0.7789	0.0713	0.1992	0.1021	0.406
4D	Movement (wide, 9.6 per year)	48.16	33.17	0.032		0.7641	0.0807	0.2057	0.1079	0.373
4E	Movement (young, 4.5 per year), SSP 330 spaces	57.48	34.17	0.003		0.8	0.0579	0.1752	0.0845	0.594
4F	Movement (young, 4.5 per year), SSP 400 spaces	62.05	36.41	0		0.8073	0.0564	0.1657	0.0808	0.635
4G	Movement (young, 4.5 per year), SSP 400 spaces, SSP 25% breeding	69.06	38.01	0		0.8189	0.0507	0.1574	0.0771	0.731
4H	Movement (young, 4.5 per year), NENC mortality = intermediate, NENC increased breeding	141.39	20.18	0		0.8143	0.051	0.1757	0.063	0.682
4I	Movement (3.3 per year for 15 years then every 10 years), NENC mortality = intermediate, NENC increased breeding	125.1	36.97	0.007		0.7585	0.0907	0.2366	0.1026	0.314
4J	Movement (3.3 per year for 25 years then every 5 years), NENC mortality = intermediate, NENC increased breeding	133.7	29.01	0		0.776	0.0726	0.2117	0.0843	0.434
4K	Movement (3.3 per year for 25 years then every 10 years), NENC mortality = intermediate, NENC increased breeding	127.34	34.45	0.004		0.7563	0.0826	0.2324	0.094	0.344
4L	Movement (3.3 per year for 25 years then every 20 years), NENC mortality = intermediate, NENC increased breeding	115.4	40.68	0.009		0.7372	0.0929	0.2513	0.1092	0.262

METAPOPULATION RESULTS:

Label	Scenario Name	Metapopulation (SSP + NENC)								
		N		P(E)	TE	GD		F		P(90GD)
		Mean	SD		Median	Mean	SD	Mean	SD	
4A	Capturable wolves brought into SSP, SSP 233	215.89	10.52	0	0	0.8187	0.0516	0.1701	0.062	0.726
4B	Capturable wolves brought into SSP, SSP 400 spaces	375.42	12.56	0	0	0.852	0.0373	0.1408	0.0435	0.912
4C	Movement (young, 4.5 per year)	234.65	37.33	0	0	0.8029	0.0557	0.1884	0.0640	0.62
4D	Movement (wide, 9.6 per year)	216.76	47.15	0	0	0.7898	0.0628	0.2024	0.0739	0.509
4E	Movement (young, 4.5 per year), SSP 330 spaces	359.92	37.34	0	0	0.8328	0.0416	0.164	0.0481	0.814
4F	Movement (young, 4.5 per year), SSP 400 spaces	432.78	38.8	0	0	0.8411	0.0397	0.1555	0.0456	0.86
4G	Movement (young, 4.5 per year), SSP 400 spaces, SSP 25% breeding	442.72	38.92	0	0	0.8518	0.0383	0.1468	0.0436	0.906
4H	Movement (young, 4.5 per year), NENC mortality = intermediate, NENC increased breeding	331.7	31.58	0	0	0.8226	0.0445	0.1834	0.0532	0.753
4I	Movement (3.3 per year for 15 years then every 10 years), NENC mortality = intermediate, NENC increased breeding	331.85	38.71	0	0	0.8389	0.0438	0.1993	0.0571	0.856
4J	Movement (3.3 per year for 25 years then every 5 years), NENC mortality = intermediate, NENC increased breeding	338.11	31.19	0	0	0.8368	0.0425	0.1952	0.0539	0.837
4K	Movement (3.3 per year for 25 years then every 10 years), NENC mortality = intermediate, NENC increased breeding	333.64	37.06	0	0	0.8306	0.0449	0.1958	0.0545	0.856
4L	Movement (3.3 per year for 25 years then every 20 years), NENC mortality = intermediate, NENC increased breeding	320.57	42.29	0	0	0.8378	0.0436	0.2058	0.0596	0.844

APPENDIX G: TEAM COMMENTS

The Red Wolf Recovery Team was comprised of a diverse group of individuals representing many different levels of experience and perspective. Initially, group members included scientists; policy-makers; local, state, and federal government officials; academicians; private landowners; and non-governmental organization representatives (both proponents and opponents of the Red Wolf Program).

Many participants disagreed on various issues considered by the Team, in some cases vehemently. Appendix G is included to provide readers a first-hand account of comments made by individual members and which reflect the breadth and depth of concurrence and discord among members. Unvarnished comments are included as presented to the facilitators. While this approach may be viewed as atypical for reporting with a goal of value-added conservation planning, it provides participants the opportunity for individual expression. As importantly, it provides the reader a glimpse into the psychology of this group.

Readers not interested in these details can skip Appendix G.

Page	Section/Comment
1	**Introduction** Mike Phillips: *In my opinion we did a good job assessing the status of the existing recovery program with a focus on NENC project but we did not equally consider actions needed to achieve recovery of the red wolf in large part because recovery criteria (i.e., downlisting and delisting criteria) do not exist.* *Since no recovery criteria exist, this is the only outcome that was possible.* *The predominant threats are genetic introgression through hybridization with coyotes (Canis latrans) exacerbated by human-induced mortality. This is a very good and important statement and should be emphasized throughout the report.* *Restoring "the red wolf throughout its historic range" is not required for recovery. Indeed a strong argument can be made that recovery only requires that the species in question remain insecure (i.e., endangered or threatened) across no more than an insignificant portion of this historic range. Relatedly, the captive population does not need to be expanded unless the Service continues to list the red wolf under the ESA.* Jett Ferebee: *Only in a Government agency would you have to evaluate the feasibility of a program that had not succeeded after 30 years of efforts. Many of the efforts were even outside the legal parameters allowed.* **Addressing questions related to the taxonomic status of the red wolf;** *Our team was never allowed to discuss this topic other than to be told what some scientists said at a USGS conference. Our group did not concur that the red wolf was a listable taxon. My beliefs are now confirmed once again in this most recent scientific Genome Wide DNA study that confirms the red wolf is a hybrid (75% coyote and 25% grey wolf):* *http://advances.sciencemag.org/content/2/7/e1501714.full* *The team concludes that neither the red nor the eastern wolf is a species. Instead, they suggest that both are hybrid populations that arose after Europeans arrived in North America, when gray wolves that managed to survive hunting and habitat loss mixed with expanding populations of coyotes. “There’s nothing in their genome that’s not gray wolf or coyote,” says co-author Robert Wayne, an evolutionary biologist at the University of California, Los Angeles.* *“Wolf biologists and others have been waiting for this sort of definitive analysis for years,” says Susan Haig, a wildlife ecologist at the United States Geological Survey in Corvallis, Oregon.* *“It’s beautiful work and topflight science,” says Mike Phillips, a restoration ecologist with the Turner Endangered Species Fund in Bozeman, Montana. “But from a practical standpoint, to do what they’re asking [and consider the ecological benefits of hybrids], you’d have to amend the ESA.”* *http://www.sciencemag.org/news/2016/07/how-do-you-save-wolf-s-not-really-wolf* **Accurately representing the historic range of the species and supporting justification;** Jett Ferebee: *Again, our team was only told that USFWS had hired WMI to do this task. WMI, of course, said the red wolf was native to NC as WMI President Steve Williams was the USFWS Director while the non-native wolves were being illegally introduced into eastern NC.* ***Neither WMI nor USFWS in 30 years of trying has yet to come up with physical evidence that the red wolf selectively bred in a zoo in Tacoma Washington was ever in the State of NC.*** *The current facts show that as USFWS “restores” the refuges to their historic hydrology, the red wolf*

Page	Section/Comment
	cannot live there. Using common sense, how then was this so called "red wolf" ever native to this pocosin region??? *Finally, using the best and most recent scientific data available in this study (http://advances.sciencemag.org/content/2/7/e1501714.full), scientists have confirmed true red wolves never inhabited North Carolina or even the Southeast.*
1	**Recovery Feasibility** Eric Gese: I*f this was truly the purpose of our evaluation, it would have been really good to have known this up front; discussing shutting the program down does not fit within this purpose….nor listening to Jett whine about his past issues with the Service.* *Feasibility was examined by the PVA analysis only; the rest were just opinions from members of the recovery team. I think if we had brought in other scientific experts for a formal evaluation, we would not have been discussing closing the program down – that is the opinion of the non-scientific part of the team (i.e., the commission, farm bureau, and landowners). Essentially the division was along the lines of politics versus science.* Mike Phillips: *I disagree that these are the conclusions of the recovery team – specifically, that there is uncertainty around being able to manage the threats and that we concluded a more measured approach was advisable. Half the recovery team would not agree with these sentiments. Published research on the red wolf management practices and the projections of the PVA, have been shown the threats to be manageable.* *The recovery team pushed to include a "full recovery" scenario to be discussed and explored, indicating "a more measured approach" was not assumed to be a foregone conclusion by the recovery team. And the fact that this option was not on the original list for consideration by the recovery team indicates a bias against this option by USFWS leadership from the start of the feasibility assessment process.* *I think it is more accurate to say that it's the willingness of the USFWS to manage the threats that is uncertain. And it's fair that the USFWS needs to consider the feasibility or sustainability of managing these threats, as well as the social dimensions affecting the recovery, but the threats themselves are manageable by known and documented methods. Furthermore, we were not asked to and did not assess the option of "full restoring the red wolf throughout its historic range". We were only tasked with assessing the part of the recovery program and population that is in NENC.*
2	**Expanding Captive population to ensure long-term preservation of the red wolf genome** Mike Phillips*: I don't recall* ***this consensus*** *and do not necessarily support the use of federal funds to expand the captive program absent a full-blown recovery program going forward*
3	**Utilize wild wolves for populating new restoration sites;** Eric Gese: *This is counter to removing all the wild wolves from the NENC. Where will these wild wolves come from if there are no wolves in the wild?* Mike Phillips: *For myriad reasons, I see this as a wholly unreasonable assumption.* Pete Benjamin: *The idea, upon which I thought we reached agreement, was to retain wolves in the wild in NENC at least until another reintroduction site was established.*
3	Mike Phillips*: It is worth noting that this was an important part of the NENC project during the first few years. Indeed, a case can be made that the human dimensions work there was adequate until coyotes became an issue.* **Determining population viability (both captive and wild populations considering the effects of coyotes, management, and climate change);**

Page	Section/Comment
	Jett Ferebee: From my determination, this study failed to fully and accurately assess the impact of coyotes on the wild population in eastern NC. Somehow, the critical success factor of no coyotes as determined in 1999 became all but irrelevant in 2016. The group that did this study was very much vested in coming up with results to match their agenda. They relied on the false premise that hybridization with coyotes could be controlled via adaptive management. *They falsely blamed the drop in wolf numbers on poachers rather than the obvious explosion of the coyote population in eastern NC.* *The exact same scenario (hybrid swarm) that caused USFWS to remove the Texas "red wolves" from the wild in order to save them from extinction. Nowhere on the Peninsula had wolves kept coyotes at bay. There was no way possible biologists could sterilize every coyote that may breed with a wolf and there was certainly no way biologists could know who was breeding who or what across 1.7 million acres. In Zone 1 (full extent of adaptive management techniques used) trapping in February 2016 at XXXX resulted in 2 wolves, 4 hybrids and 10 coyotes. Hybrids outnumbered wolves 2/1. 87.5% of the canines trapped were nonwolf. 2/3s of the "wolf like" canines actually turned out to be hybrids. When confronted with this current data pulled from the heart of Zone 1 of adaptive management, Pete chose to ignore it and only look at a study by college students picking up scat in 2010… This is why we don't trust USFWS. The recent drastic drop in wolf numbers was precisely predicted by the 1999 PVA studies presented in the Va. Beach RWIT meeting, if hybridization could not be controlled.* *Further proof that coyotes, not poaching caused the wolf population collapse, is the fact that Alligator River National Wildlife Refuge was declared ideal red wolf habitat and started with 4 breeding pairs of wolves 30 years ago and was the site of almost half of the 132 wolf releases. Yet with virtually NO suspected illegal gun shot deaths on ARNWR, the refuge 30 years later is home for only one red wolf pair and countless coyotes. That is the inconvenient truth that will not be told by USFWS, RWC, DOW, and SELC.* *It turns out, USFWS does not count hybrids when it measures the influx of coyote genes into the wolf population. A hybrid is no longer a wolf so it is ignored when calculating the genetic diversity of the wolf population on the Albemarle Peninsula. Accordingly, USFWS can flood eastern NC with hybrids, but still claim to the public that they are controlling hybridization because there is no influx of coyote genes into their "known wolf" population. So as long as USFWS can capture known and pedigreed wolves and ignore hybrids, they will mischievously declare adaptive management a success. I know, it defies all logic but now we know how they spew forth that lie and quickly look the other way when presented the facts of what has truly ~~has~~ happened in eastern NC.* *So no, I do not concur with the wild population viability assessment, as it was agenda driven and based on incorrect and unattainable assumptions.*
4	**It is time to revise the red wolf recovery plan**. Mike Phillips *This is an essential and immediate step that should be taken if the red wolf remains listed under the ESA.* **Assessing Human Dimensions** Jett Ferebee: *I maintained from the beginning that this should have been an exercise to assess the legal dimension of this program. The ESA is based on laws, not a current popularity contest. USFWS intentionally violated Federal Rules at will and were never held accountable. This is why the private landowners have finally stood up and fought back. A survey of the human dimension had no place in our study.* *The Federal Rule for establishing an experimental population provides for agreement of rules by affected private landowners, not the general public.* *https://www.law.cornell.edu/cfr/text/50/17.81*

Page	Section/Comment
	Federal Rule 50 CFR 17.81 *(d) The Fish and Wildlife Service shall consult with appropriate State fish and wildlife agencies, local governmental entities, affected Federal agencies, and affected private landowners in developing and implementing experimental population rules.* *When appropriate, a public meeting will be conducted with interested members of the public. Any regulation promulgated pursuant to this section shall, to the maximum extent practicable, represent an agreement between the Fish and Wildlife Service, the affected State and Federal agencies and persons holding any interest in land, which may be affected by the establishment of an experimental population.* **This report presents the views and opinions of member's work of the Recovery Team.** Jett Ferebee: *No, item 1 was work by scientists at the USGS conference in Stone Mountain. Item 2 was hired out to WMI, who just paid someone to review the findings of- agenda driven USFWS biologists. Item 3, was performed by people whose jobs are directly impacted by the results of this study. The report itself was written exclusively by USFWS and reflects their opinions and views, certainly not those of this private landowner. My edits were completely ignored in this report. Only when I complained was this appendix G created. I do not agree with much of this report; however, I remained on the team in an effort to get certain facts into the public record.* **As discussed in detail herein, after careful consideration of all the available information, the Recovery Team was not able to reach consensus that recovery of the red wolf in the wild is "feasible". Work conducted in association with this evaluation (as discussed herein)** Jett Ferebee: *does not clearly identify the red wolf as a separate species, which was the finding of the WMI report as well (although one researcher was cited in the WMI report as saying the evidence points towards the red wolf being a separate species of canid). A recently published peer reviewed DNA research report by a number of wildlife biologists, which was published after the final team meeting, was funded in part by NIH grants as well as critical sequencing support provided by grants from the Morris Animal Foundation, the Turner Foundation, and the Wilburforce Foundation. This report used extensive DNA analysis to point to only one distinct wolf species in North America, the gray wolf. The report presented whole-genome sequenced data pointing to the likelihood of other wolf-like canids, such as the red wolf and eastern wolf, as **hybrids** of gray wolves and coyotes. Hybrid species are not protected under the ESA, and as such brings into question whether the red wolf should continue any classification of protection under the ESA, as well as suggests the captive program should, at a minimum, be addressed again.* *and USFWS's failure to operate the program in accordance with their very own Federal Rules, i.e. maintain the program on Federal land where the wolf is fully protected. .*
	Summary of Findings Herb Vandeberry: *The recent DNA research report noted on page 1 that brings into question the taxonomy of the red wolf changes the first item, "Red wolf is a listable entity under ESA." In fact, the 2nd item states….."Continued genetic investigation and willingness to incorporate new findings" supports including the new DNA findings in this report, even though we were not able to discuss the report during our last team meeting. The point of recognizing the recent research report is to draw on further, current science, or genetic investigation, to assess feasibility of the program as the team was charged to do.* *I do not feel there is consensus on this item as stated, that is, "Red wolf is a listable entity under ESA", if you interpret the ESA law as written. Either it needs to be removed, or preferably, revised to*

Page	Section/Comment
	read something like this: "Due to ongoing research by scientists to determine if the red wolf is a unique species, and no clear picture at this point that it is, the team cannot concur that the red wolf is a listable entity under ESA." *References about the SSP, including sustaining and expanding that population, need to be pulled back until there is more clarity on the taxonomy. That's not to say the captive program should be dismantled, but it must be recognized that the captive population was established under the ESA as well, and that certainly is in question at this point.* *The use of the words "significant retooling" is not a consensus item of the team – in fact, the consensus of team members present at the last meeting and even Mike Phillips, who was not able to attend the final meeting, was that the program in NENC should be WOUND DOWN AND TERMINATED.* *A strong majority of the team recommended winding down the program and ultimately terminating the wild program, with some possibility of a captive program remaining. But there certainly is no consensus for some alternative option to continue the program in NC.* *A measured, humane process to ensure the survivability of the existing animals in the wild while winding down the program in NC is supported by all team members, no doubt. But to be clear, the program needs to pull back and eventually remove the animals to another location suitable for their survival.* *As Mike Phillips stated, "situating some of the currently free-ranging red wolves that are excess to the viability of the captive breeding program in secure settings of federal land where separation from coyotes can be sufficiently assured thru management (e.g. mainland Dare County) or because coyotes are absent from the area (e.g. Bulls Island)."*
6	**Things We can Live With Red wolf is a listable entity under ESA** Jett Ferebee: *There was never consensus on this issue. It turns out the red wolf was a just a selectively bred hybrid and now Mike Phillips wants to bring it back into captivity to breed some more grey wolf genome into it! Read his comments at the end of this report.* ***Continued support to sustain and expand the SSP*** Jett Ferebee: *I can no longer support wasting even more taxpayer dollars on a non-protected hybrid that was "juiced up" by a USFWS selective breeding program in a zoo in Tacoma Washington and then illegally placed in North Carolina. This was not the intention of the ESA.~~!~~* ***Team Assumptions*** Jett Ferebee: *Transitioning to a new direction should be expedited in the very same manner as was done with the Smokey Mountain non-essential experimental population of wolves.* *Articulate what specifically we are going to do WITH the landowners see: and community as the program transitions; see Federal Rule 50 CFR 17.81*
7	**Taxonomy** Eric Geese: *How does the new paper by vonHoldt et al. effect this section?* **Lessons Learned and Implications for the future** Jett Ferebee: *Large carnivore reintroductions on private lands were carried out illegally by USFWS personnel in eastern NC~~.~~ 64 out of 132 wolves were illegally released onto private lands with no legal authorization. 120 of the 132 wolves were released without Section 7 authorization. This ultimately has bankrupted the captive breeding program. The good news is that with this new study confirming*

Page	Section/Comment
	that red wolves are hybrids (75 coyote/25 grey wolf), USFWS can always breed up some more at their wolf manufacturing facility at the Point Defiance Zoo. Grey wolves and coyotes are rather plentiful. The expectations and fears of the community are serious and were amplified by USFWS misconduct.. Despite best intentions, USFWS personnel illegally released wolves meant for their own from Federal lands onto private lands containing preferred habitat and then intentionally did not remove them as mandated by federal law. Jett Ferebee: *This was not a consensus item, in fact, not only are the landowner representatives on the team in disagreement with this,* ***it is not clear from the other team members that red wolves and coyotes can effectively be managed together.*** *Mike Phillips certainly points out the need to separate the two animals in order to maintain integrity of the bloodline, whatever that is, hybrid or otherwise at this point. So, while some team members might agree in theory with this bullet, it is by no means a consensus item. The statement "…given adequate resources and with sufficient community support hybridization between red wolves and coyotes can be effectively managed" does not align with the evidence over 30 years of experience to the contrary. Using a hypothetical, utopian scenario to defend this statement is not reality, nor feasible, keeping in mind the team was asked to assess the feasibility of red wolf recovery.* *There was/is no way possible biologists could sterilize every coyote that may breed with a wolf and there was certainly no way biologists could know who was breeding who or what across 1.7 million acres. In Zone 1 (full extent of adaptive management techniques used) trapping in February 2016 at Xxxxxxx resulted in 2 wolves, 4 hybrids and 10 coyotes. Hybrids outnumbered wolves 2/1. 87.5% of the canines trapped were nonwolf. 2/3s of the "wolf like" canines actually turned out to be hybrids. When confronted with this current data pulled from the heart of Zone 1 of adaptive management, Pete chose to ignore it and only look at a study by college students picking up scat in 2010… This is why we don't trust USFWS. The recent drastic drop in wolf numbers was precisely predicted by the 1999 PVA studies presented in the Va. Beach RWIT meeting, if hybridization could not be controlled.* *Further proof that coyotes and hybridization, not poaching caused the wolf population collapse, is the fact that Alligator River National Wildlife Refuge was declared ideal red wolf habitat and started with 4 breeding pairs of wolves 30 years ago and was the site of almost half of the 132 wolf releases. Yet with virtually NO suspected illegal gun shot deaths on ARNWR, the refuge 30 years later is home for only one red wolf pair and countless coyotes. That is the inconvenient truth that will not be told by USFWS, RWC, DOW, and SELC.* *It turns out USFWS does not count hybrids when it measures the influx of coyote genes into the wolf population. "A hybrid is no longer a wolf so it is ignored" when calculating the genetic diversity of the wolf population on the Albemarle Peninsula. Accordingly, USFWS can flood eastern NC with hybrids, but still claim to the public that they are controlling hybridization because there is no influx of coyote genes into their "known wolf" population. So as long as USFWS can capture known and pedigreed wolves and ignore hybrids, they will mischievously declare adaptive management a success. I know, it defies all logic but now we know how they spew forth that lie and quickly look the other way when presented the facts of what has truly has happened in eastern NC.* ***Balancing public trust and private landowner rights is tough was ignored by overzealous wildlife biologists.*** *The agreement to remove unwanted wolves from private lands created conflict with USFWS goals so the agreement was intentionally ignored and an unsustainable situation where some private landowners were tolerant of wolves while others demanded their removal. The Service was unwilling to keep original commitments to relocate undesired wolves to Federal lands and even went so far as to illegally release wolves onto private land. This increased friction. The rights of private landowners must be respected in future efforts, but the mere presence of an animal on their*

Page	Section/Comment
	property is not always seen as problem to USFWS so the 1995 Federal Rules specifically addressed the fact that private landowners could have wolves removed for any reason. This of course was completely ignored by USFWS Red Wolf personnel. ***Retooling or winding down the Terminating NENC NEP should not be used as a precedent to justify future landowner "vetoes" of trust species to better educate USFWS personnel that Federal Rules apply to them also.*** Jett Ferebee: *It is of paramount importance to note that USFWS personnel were actively releasing wolves onto private land as public hearings were being held for the 1995 Rules revision that said only 12 or so wolves would be released on Pocosin Lakes Refuge. If USFWS had any interest in telling the truth to the public, this would have been the ideal time to bring it to the attention of the public and cover it in the Federal rule. They chose to intentionally hide this salient fact from the public and that one calculated poor decision will likely impact all future recovery efforts involving private land. These are the wolves illegally released on private land as USFWS held public meetings and passed a Federal Rule telling us they only wanted to release a small number of wolves on Federal land:* *SPECIES ID # BIRTH DATE BL RELEASE DATE COUNTY LAND OWNERSHIP* *WOLF 10304 06-May-86 C 17-Sep-90 DARE PRIVATE* *WOLF 10327 12-May-87 C 17-Sep-90 DARE PRIVATE* *WOLF 10397 09-Apr-90 C 17-Sep-90 DARE PRIVATE* *WOLF 10398 09-Apr-90 C 17-Sep-90 DARE PRIVATE* *WOLF 10399 09-Apr-90 C 17-Sep-90 DARE PRIVATE* *WOLF 10426 02-May-90 C 03-Oct-90 HYDE PRIVATE* *WOLF 10427 02-May-90 C 03-Oct-90 HYDE PRIVATE* *WOLF 10430 02-May-90 C 03-Oct-90 HYDE PRIVATE* *WOLF 10464 26-Apr-91 C 23-Aug-91 DARE PRIVATE* *WOLF 10382 14-May-89 I 03-Aug-92 HYDE PRIVATE* *WOLF 10517 14-Apr-92 C 03-Aug-92 TYRRELL PRIVATE* *WOLF 10518 14-Apr-92 C 03-Aug-92 TYRRELL PRIVATE* *WOLF 10519 14-Apr-92 C 03-Aug-92 TYRRELL PRIVATE* *WOLF 10523 14-Apr-92 C 03-Aug-92 HYDE PRIVATE* *WOLF 10408 10-Apr-90 C 23-Aug-93 DARE PRIVATE* *WOLF 10586 18-Apr-93 C 23-Aug-93 DARE PRIVATE* *WOLF 10587 18-Apr-93 C 23-Aug-93 DARE PRIVATE* *WOLF 10588 18-Apr-93 C 23-Aug-93 DARE PRIVATE* *WOLF 10589 18-Apr-93 C 23-Aug-93 DARE PRIVATE* *WOLF 10590 18-Apr-93 C 23-Aug-93 DARE PRIVATE* *WOLF 10591 18-Apr-93 C 23-Aug-93 DARE PRIVATE* *WOLF 10383 14-May-89 I 15-Sep-93 TYRRELL PRIVATE* *WOLF 10445 24-Apr-91 C 15-Sep-93 TYRRELL PRIVATE* *WOLF 10633 02-May-93 C 15-Sep-93 TYRRELL PRIVATE* *WOLF 10634 02-May-93 C 15-Sep-93 TYRRELL PRIVATE* *WOLF 10448 24-Apr-91 C 02-Feb-94 TYRRELL PRIVATE* *WOLF 10465 26-Apr-91 C 02-Feb-94 TYRRELL PRIVATE* *WOLF 10593 18-Apr-93 S 06-Apr-95 TYRRELL PRIVATE*
10	**Communities expect a voice in decisions that affect them** Jett Ferebee: see *Federal Rule 50 CFR 17.81* *Much of the conflict in NENC can be traced to the violations of the 1986 and 1995 Federal Rules for*

Page	Section/Comment
	this NONESSENTIAL EXPERIMENTAL POPULATION by USFWS leaders and personnel. Residents and leaders of the five counties who ~~felt~~ were ignored, unheard, or saw little benefit of having wolves reestablished. Future programs need to obey the laws and honor commitments made to the communities they affect. Mike Phillips: *It is worth noting that this was an important part of the NENC project during the first few years. Indeed, a case can be made that the human dimensions work there was adequate until coyotes became an issue.* Jett Ferebee: *The Service should have an in-depth understanding of the beliefs, concerns and support of prospective communities, a means of communication between the Service and community leaders, and a governance structure that includes the affected community in management of the population. The North Carolina Wildlife Resources Commission's study of citizen attitudes toward canids in eastern North Carolina should have absolutely no impact on this controversy, as this problem is a matter of law and the violations of them by USFWS.* Jett Ferebee: *Fully understanding community interests and laws can be tough for USFWS.* ***Conditions can and do change rapidly**.* *Jett Ferebee: Sea level rise and USFWS intentionally flooding their "ideal red wolf habitat~~"~~ that was never part of the red wolf historic range once thought ideal for red wolf recovery. Also, our desire to illegally expand our red wolf program onto private land throughout eastern NC is altering our perception of ideal red wolf habitat. Future biological conditions on refuges do not appear adequate to support a sustainable wild population. Long-term habitat resilience must be ~~criterion~~ an important criterion for potential reintroduction sites.* ***Coyote arrival in eastern North Carolina changed everything.** Restrictions on coyote hunting, expectations of private landowners to be able to manage their land as they saw fit and the difficulty of distinguishing wolves from coyotes resulted in a an unsustainable situation and increased wolf mortality when wolves were not returned to Federal Land where they were fully protected. Very few wolf gun shot mortalities occurred on the Federal refuges over the 30 years of this program.* ***60 out of 64 suspected illegal gun shot mortalities occurred on private land*** *Jett Ferebee: Where USFWS was mandated by law to remove them. So, if USFWS had complied with their 1986 and 1995 Federal Rules, these 60 wolves would not have been accidentally taken. The unlawful take of these animals rests on the shoulders of USFWS personnel who failed to comply with their very own rules.* ***Restrictions on coyote hunting in the 5-county area bred resentment. and, in some cases, vigilante behavior.*** *Jett Ferebee: Prove this. Do not make a baseless claim like this against the people USFWS has trampled over in their illegal experiment. ~~.!!!~~* **Coyote arrival in eastern North Carolina changed everything.** Restrictions on coyote hunting, expectations of private landowners to be able to manage their land as they saw fit and the difficulty of distinguishing wolves from coyotes resulted in a an unsustainable situation and increased wolf mortality. Jett Ferebee: *Very few wolf gun shot mortalities occurred on the Federal refuges over the 30 years of this program. 60 out of 64 suspected illegal gun shot mortalities occurred on private land where USFWS was mandated by law to remove them. So, if USFWS had complied with their 1986 and*

Page	Section/Comment
	1995 Federal Rules, these 60 wolves would not have been accidentally taken. The unlawful take of these animals rests on the shoulders of USFWS personnel who failed to comply with their very own rules. **Federal rules did not keep pace with these changing circumstances. Restrictions on coyote hunting in the 5-county area bred resentment and, in some cases, vigilante behavior.** *Jett Ferebee: Prove this. Do not make a baseless claim like this against the people USFWS has trampled over in their illegal experiment.!!!* **Nature abhors a vacuum**. There is going to be a large canid on the landscape in North Carolina regardless of the management action and lawsuits. Jett Ferebee: *Landowners can manage canids just like USFWS does on the Pea Island Wildlife Refuge, Boddie Island, and Cape Hatteras National Seashore. If your statement here is true why does it not apply to your USFWS Refuge that you want to manage without a canine predator??? USFWS traps and kills all canids on the above-mentioned land.* **Seize the opportunity to broaden learning and apply lessons learned from similar challenges across the country**. This exercise underscores the limits of law and science in conservation management. Geneticists, managers, and policy-makers will continue to wrestle with the role of hybridization in species evolution and its implications for conservation programs for many species. The Endangered Species Act mandates species recovery but there is limited policy guidance regarding conservation of a growing list of conservation-reliant species that are unlikely to ever return to self-sustaining, free-ranging populations. New thinking is needed for addressing these issues more consistently within the Service. Now may be an opportune moment Jett Ferebee: *to recognize the red wolf is a hybrid that is not protected by the ESA and that the 30-year-old program has failed. No more taxpayer money should be spent on this nonessential experimental humanly constructed and selectively bred coywolf. There are plenty of other true species that deserve this kind effort. USFWS must learn that it is OK to say something does not and cannot work. You simply cannot justify spending hard earned money because you "must recover an animal in the wild". Dan Ashe even said the ESA only mandated saving a species from extinction not recovering it in the wild*
12	**Process** The Recovery Team met in person on two occasions and conducted most of the evaluation through a series of five teleconferences. teleconferences. Jett Ferebee: *Team members were never allowed the opportunity to see and approve minutes from any of the meetings, thus my longwinded editing of this document. Even at this time we have not been allowed to see several of the documents in the appendices that we supposedly used to make our decisions. After participating in this incredibly flawed process, I understand completely why the Red Wolf program has been so ineptly managed.* **Conservation Reliance** For the red wolf the recovery strategy (as described in the Recovery Plan; U.S. Fish and Wildlife Service 1990) has been two-pronged; a captive population comprised of at least 330 animals and 3 wild populations totaling at least 220 animals. The wild population forces us to confront the second issue – whether recovery is achievable. Mike Phillips: *It should be made very clear that no recovery criteria have ever been developed for the red wolf. The targets presented here represent no more than placeholders that once achieved would*

Page	Section/Comment
	indicate significant process but not necessarily grounds for downlisting or delisting. Consequently, it was beyond the scope of this review effort to determine if recovery is achievable. To date the level of management has been intensive and the NENC population has declined over the past decade as human-related mortality has increased. Mike Phillips: *I was under the impression that over the last few years management had become much less intensive and this reduction of effort contributed to the population decline. Am I mistaken?*
13	**Conservation Reliance** Sarah Long: *"If" these are more efficient to manage?? This is an assumption, and may be incorrect. Typically smaller populations need to be managed more intensively (to avoid the hazards of demographic stochasticity, to avoid inbreeding, etc.).* Sarah Long: *I don't know that these statements could be supported by research or the recovery team. We don't know that several smaller populations would be more efficient than a single large population. Evidence from the eastern wolf (population size larger than red wolf NENC reached) and population biology theory would suggest that a larger population would need less intensive management, and we do not have enough information about certain elements of the red wolf system (e.g., the impact of coyotes or different management strategies over a wide variety of red wolf population sizes) to make a strong conclusion like this.* In truth, we currently do not know the extent to which the red wolf is a conservation-reliant species. Evidence suggests that red wolves and coyotes do not interbreed randomly (Bohling and Waits 2011, 2015) and that reproductive barriers do exist with the primary barrier being differential body size Mike Phillips: *I think this potential needs to be vigorously assessed. It is also consistent with the notion of minimizing the coyote-derived component of the red wolf genome and maximizing the gray wolf component thru selective breeding that would favor large body size.*
13	**Alternatively it may be necessary to directly test the assumption that a large population, properly managed to control human-related mortality, could sustain itself in the face of introgression as described by Bohling et al. (2016). In this case the recovery effort would focus on establishment of at least one large population (a step toward the Full Recovery Option).** Mike Phillips: *I don't necessarily agree with this view. Indeed, I'm rather confident that there do exist "management measures" that would lead to a red wolf population that would be an acceptable mimic of the Algonquin situation. Those measures would, however, probably be more involved that anything the Service has previously applied to advance red wolf recovery. It is worth noting that if recovery could be achieved with just one red wolf population, almost certainly it would need to include 500 to 1,000 wolves. That's probably a wildly unrealistic population target for the southeastern US.*
14	Returning to the first issue (eligibility for listing under the ESA), it is important to reiterate that there is scientific uncertainty here as well, as the taxonomic status of the red wolf is not a settled scientific matter. This uncertainty also argues for a more precautionary approach to red wolf conservation and against the large-scale commitment of resources that would be needed for a full recovery effort. Sarah Long: *I thought the taxonomy group convened in conjunction with this feasibility assessment made a conclusion about this already and declared it a listable entity? This paragraph doesn't acknowledge their conclusions and seems to allow the potential for future disagreement to perpetually keep the recovery as a small and weak effort.*

Page	Section/Comment
	As discussed further below, continuing uncertainty also lends support to taking a more measured approach to red wolf conservation efforts in the wild. These efforts should be narrowly focused and specifically designed to develop and evaluate means of sustainably managing hybridization and human-related mortality in a private-lands-dominated southeastern landscape. Mike Phillips: *This seems to be an important conclusion that should be emphasized throughout the document. This assumes, of course, that the narrow focus is broad enough to greatly clarify red wolf/coyote interactions. For my money the most important work in this regard to determining the usefulness of large size in red wolves as a governor on the frequency of hybridization with coyotes.*
14	**Taxonomy** Recent genetic data have cast doubt upon the hybrid origin hypothesis and the balance of evidence has tilted towards a North American canid assemblage composed of the eastern wolf, the red wolf, and the coyote as distinct taxa that are descended from a common ancestral canid of North American origin." Mike Phillips; *I thought the three species hypothesis was based on the belief that the large canids of the US arise from gray wolf, coyote, or eastern wolf/red wolf stock. Regardless, the significance of von Holdt et al. 2016 should be included in this report* **In fact, the preliminary results of the USGS investigation appear to strengthen the conclusion that the red wolf is a listable entity.** Mike Phillips: *On this point I am skeptical. Maybe written material from the meeting will change my mind, but with the red wolf genome greatly influenced by coyote introgression, it seems that the only path forward for the species to remain a listable entity is thru selective breeding that maximizes expression of the gray wolf component and minimizes expression of the coyote component. This assumes, of course, that the coyote component is not someday determined to be a lycaon component.* **Historic Range** *Jett Ferebee:. Most important here is that the Secretary can establish an experimental population outside of its current range* ***only if this effort*** *"furthers the conservation of the species".* *(b) Before authorizing the release as an experimental population of any population (including eggs, propagules, or individuals) of an endangered or threatened species, and before authorizing any necessary transportation to conduct the release, the Secretary must find by regulation that such release will further the conservation of the species. https://www.law.cornell.edu/cfr/text/50/17.81* *After 30 years, the eastern NC nonessential experimental population has failed. There are now either the same or fewer breeding pairs of wolves (four) than when the program was started in 1986. The release of 120 wolves without section 7 authorization has now bankrupted the captive breeding program. So absolutely, this experimental population has done nothing to further the conservation of the species. In fact it has done just the opposite. To continue artificially funding this population with wolves from captivity will only contribute to losing whatever red wolf genome may or may not exists. USFWS captured and "saved the red wolf from extinction in the wild due to hybridization" in Texas and Louisiana in the 70's. The history of this hybrid swarm is now reoccurring in eastern NC as the critical success factor of "no coyotes" no longer exist in our State.* *Jett Ferebee: Again, our team was only told that USFWS had hired WMI to do this task. WMI, of course, said the red wolf was native to NC as WMI President Steve Williams was the USFWS Director while the non-native wolves were being illegally introduced into eastern NC. Neither WMI nor USFWS in 30 years of trying has yet to come up with physical evidence that the red wolf selectively bred in a zoo in Tacoma Washington was ever in the State of NC. The current facts show that as USFWS "restores" the refuges to their historic hydrology, the red wolf cannot live there. Using*

Page	Section/Comment
	common sense, how then was this so called "red wolf" ever native to this pocosin region? Finally, using the best and most recent scientific data available in this study (http://advances.sciencemag.org/content/2/7/e1501714.full), scientists have confirmed true red wolves never inhabited North Carolina or even the Southeast.
17	**D. Captive Population** With a population size around 200, the SSP has a moderate chance of remaining above the 80% gene diversity goal of the Recovery Plan under the optimistic Baseline scenario (assuming 52 breeding pairs and 37.4 births per year). Mike Phillips: *A continued focus on maintaining genetic diversity is moving the genome in the direction of minimizing the gray wolf component and maximizing the coyote component, which seems wrongheaded. This inevitable shift was discussed in Atlanta. My concern is based on the assumption that the coyote component of the red wolf genome is not reassigned as a lycaon component different from latrans and lupus.* **Human Dimensions** Jett Ferebee: *Chris needs to understand that the Federal rules regarding nonessential experimental populations are quite different from true endangered species regulations. See below:* *Federal Rule 50 CFR 17.81* *(d) The Fish and Wildlife Service shall consult with appropriate State fish and wildlife agencies, local governmental entities, affected Federal agencies, and affected private landowners in developing and implementing experimental population rules.* *When appropriate, a public meeting will be conducted with interested members of the public. Any regulation promulgated pursuant to this section shall, to the maximum extent practicable, represent an agreement between the Fish and Wildlife Service, the affected State and Federal agencies **and persons holding any interest in land**, which may be affected by the establishment of an experimental population.* **Resource Commitments** Jett Ferebee: *These costs were never discussed with our group. The red wolf is rated a 5C status, meaning it has a low probability of recovery. After 30 years of unsuccessful efforts to create a self-sustaining population, USFWS must really consider any funding which continues to throw good money after bad. The ESA, NGO's, and scientists have really hijacked the taxpayer's pocket book if this is the case.*
19	**The scenarios with the largest number of releases per year to the NENC populations (9 animals) require an SSP population with 400 spaces and higher breeding rates in order to maintain demographic stability and genetic diversity of the SSP.** Mike Phillips: Nine releases per year is probably inadequate for properly launching a new restoration effort based on reintroductions. Jett Ferebee: *The below conclusion by 4 of our recovery team members must be weighed very heavily.* *Gese, Waites, Stoskopf, Waddell – 2015 3.2 Implications for future management of red wolves* *The U.S. Fish and Wildlife Service continues to actively promote recovery efforts of the red wolf in eastern North Carolina (USFWS, 2007; Hinton et al., 2013). These efforts are consistent with the conclusion that we should "protect the red wolf as a component of the evolutionary legacy of canids" (Allendorf et al., 2001), and recent analyses of North American canids indicating this species has a distinct genetic signature (VonHoldt et al., 2011;Rutledge et al, 2012b). We acknowledge that these efforts have required considerable financial and social investments each year (USFWS 2013), and the*

Page	Section/Comment
	population is not self-sustaining. In theory, efforts to remove or sterilize coyotes might be relaxed with time as red wolves fully occupy available habitat within the recovery area. Under such conditions, wolves dispersing within the recovery area would be successful in finding conspecific mates and coyotes immigrating to the area would be naturally excluded by resident wolves (Murray and Waits, 2007; Roth et al., 2008; Wheeldon et al., 2010). ***However, we believe this scenario is unlikely because wolf habitat is discontinuous within the recovery area and anthropogenic habitat changes will continue to favor coyotes because of their ability to more effectively colonize landscapes in closer proximity to human activity (Benson et al., 2012; Gese et al., 2012; Benson and Patterson, 2013).*** *Further, there is little evidence red wolves naturally control the coyote population through strife, which is a core prediction derived from the competitive exclusion hypothesis (Murray et al., 2015).*
20	**V. Options Considered** **The Recovery Team agreed that pursuing any of the options beyond the Status Quo would require a substantial amount of time and resources to properly implement.** Mike Phillips: *I don't agree with this but also find the cost estimates of the various options to be very high.* **A. Elements Common to All Options Beyond the Status Quo: Population Management** If the Service were to eliminate the NENC NEP population or refocus its management to Federal Lands there would need to be an effort to responsibly remove and/or relocate animals from or on the landscape. This would require that any animals captured be handled and housed humanely. As stated elsewhere in this report the current SSP facilities are at capacity. While the Recovery Team unanimously supports expansion of SSP capacity it is recognized that it would take time to add capacity sufficient to accommodate animals removed from the NENC NEP while meeting other SSP objectives. Mike Phillips: *Removals could be facilitated by improving the capacity of Sandy Ridge and using islands like Bulls Island.* If the Service were to set a future direction for red wolf recovery that included terminating or reducing the scope of the NENC NEP while attempting to establish one or more additional populations elsewhere it would be important to maintain wild wolves on the landscape for use in establishing new populations. Translocated wild wolves that are experienced in the wild have higher survival rates than captive-reared wolves. Mike Phillips: *I think it is highly unlikely that any of the current wild wolves could be used in other reintroduction project. And while I agree that wild stock is better suited for restoration purposes than captive stock, the latter is acceptable.* Currently the NENC NEP is widely scattered over the NENC NEP area. This sparse distribution increases the risk of hybridization as young animals dispersing from natal territories are far more likely to encounter coyotes than wolves. As such, should the Service decide to pursue the Fully Mike Phillips: *And hybrids.*
20	**Administrative Actions** Concurrent with the above described population management actions, a number of administrative actions would need to be implementing in conjunction with a major change in the direction of the Recovery Program. First, the Recovery Team agrees that the current version of the Red Wolf Recovery Plan is not an adequate guide for recovery efforts and needs updating and revision. Mike Phillips: *This agreement is of cardinal importance and should be emphasized to the Director.*

Page	Section/Comment
21	**Science** Much has been learned about red wolves throughout the history of the NENC NEP effort, yet key knowledge gaps persist. The transition period may afford opportunities for further learning, and the Recovery Team recommends that careful consideration be given to the design and implementation of studies aimed at providing further insight into red wolf and coyote management and inter-species interactions, predator-prey relationships, and human dimensions. Mike Phillips*: I doubt that the transition period will provide useful opportunities to conduct much research, especially concerning something as complex and context dependent as predator-prey relations.* The coyote population has dramatically increased in eastern NC and biologists can no longer sterilize every coyote that may come into contact with a breeding wolf. Mike Phillips*: I was under the impression that over the last few years management had become much less intensive and this reduction of effort contributed to the population decline. Am I mistaken?* Should we determine that the red wolf is and will likely remain a conservation-reliant species it would seem imprudent to continue to work toward establishing large wild populations that would need perpetual intensive federal management. Jett Ferebee: *The parameter to measure the success of this nonessential experimental population was to create a "self sustaining population of 220 wolves in 3 different locations. By all counts after 30 years of efforts, this has not and cannot occur. This is why the 5-year program evaluations have not been done as required. USFWS would have to admit the goals for the program could not be met.* Jett Ferebee: *Not now that it is documented as a hybrid. If the wolf is deemed conservation reliant, then it can never be fully recovered therefore not delistable. This is in conflict with the goals of the ESA.* *http://advances.sciencemag.org/content/2/7/e1501714.full* *This genome wide study shows the red wolf is a hybrid composed of 75% coyote and 25% grey wolf. Hybrids are clearly not granted protection by the ESA.* William Waddell: *Education and outreach focused at the REC were conducted primarily by the Red Wolf Coalition through an MOU with USFWS since Nov. 2012. The MOU was not renewed in 2015 and so these important education and outreach activities are currently not in place that I'm aware of.*
22	**Status Quo Management** **Description of the Status Quo Option** Mike Phillips: *I was under the impression that the current status quo included less robust field activities than described here. Am I wrong?* The Service works with a number of researchers on investigations designed to improve our understanding of red wolf taxonomy and ecology. The Service has conducted education and outreach activities focused mainly at the Columbia Red Wolf Education and Health Center (REC). William Waddell: *I hate to keep harping on this minor point but I'm not aware this is happening.*
22	**2. Evaluation of the Status Quo option** However, due to space (currently 44 facilities) and other constraints, the SSP has been producing

Page	Section/Comment
	approximately 31 births/year over the last ten years and only 29 breeding pairs for the past three breeding plans. Model results from these constraints (e.g., making only 29 breeding pairs per year) show that the SSP may not be able to sustain itself and would decline, producing an average of only 22.6 births/year over the first ten years. In this scenario, the population would decline to around 119 individuals, has a slight chance of extinction (P(E) = 0.5% and the probability of maintaining at or above a level of 80% gene diversity would decline to 76% and inbreeding would increase to F=0.2201 (approaching that of full siblings) over 125 years. Sarah Long: *The SSP population is actually projected to decline to 118.59 +/- 25.17); 208 is a typo in our report. See Scenario FF in SSP results table on p.53 of PVA report. I can send an updated PDF with the typo corrected.*
23	Sustaining a wild population within the NENC NEP area was deemed unlikely within the confines of the Status Quo option. Mike Phillips: *I think "uncertain" could be replaced with "impossible".* Regulatory Implications: Implementation of the Status Quo option would not require any additional regulatory compliance measures or rule-making. Mike Phillips: *I recall that we discussed some notable inconsistencies between the status quo fieldwork and that which was allowed by rule and regulation and that the two needed to be brought in line with each other. Am I wrong?* **Table 1. Estimated costs for the Status Quo Option,** including those associated with increasing trapping capacity to respond to removal requests. Annual costs are shown, as well as the one-time cost of additional fencing and repairs to the captive facility at Sandy Ridge. Total cost is calculated based on the first 5 years of implementation. Mike Phillips: *$7 M seems absolutely crazy to me as an amount of money needed to maintain the status quo. Moreover, the description of status quo activities on the bottom of page 19 and top of page 20 surely should not cost $1.3 M annually. Regardless, with a $1.3 M/year program it would seem unnecessary to set aside $750,000 for help with trapping.* **C. Historic Range** *Jett Ferebee: Again, our team was only told that USFWS had hired WMI to do this task. WMI ,of course, said the red wolf was native to NC as WMI President Steve Williams was the USFWS Director while the non native wolves were being illegally introduced into eastern NC. Neither WMI nor USFWS in 30 years of trying has yet to come up with physical evidence that the red wolf selectively bred in a zoo in Tacoma Washington was ever in the State of NC. The current facts show that as USFWS "restores" the refuges to their historic hydrology, the red wolf cannot live there. Using common sense, how then was this so called "red wolf" ever native to this pocosin region?* *The new vonHoldt study contradicts every bit of Xxxxxx's agenda driven and grossly flawed and assumption filled writings:* *http://advances.sciencemag.org/content/2/7/e1501714.full*
24	**3. Summary of Status Quo Option** The Recovery Team reached consensus that the Status Quo option was not an acceptable future direction for red wolf conservation. Mike Phillips: *Certainly not for $7.5M annually.*

Page	Section/Comment
	C. Suspend or Terminate the NENC NEP **A. Description of the Suspend or Terminate the NENC NEP Option** This option would suspend or terminate reintroduction efforts in the NENC NEP. Attempts would be made to remove as many red wolves as possible from the landscape. Captured wolves would be placed in SSP facilities to the extent possible; however, space is limited within the SSP and it is unclear how well wolves would transition to the captive program; as such if this option were implemented in the immediate future many if not most wolves removed from the NENC area would be euthanized. Mike Phillips: *It's reasonable to expect that they'd do fine. I strongly oppose euthanizing animals that are not causing problems that require lethal control as a solution. I strongly recommend finding some administrative approach that would allow as many animals as possible to live out their lives in a free-ranging state.* The PVA model results for this option show a small genetic benefit as a result of bringing the capturable NENC wolves into the SSP, which can be fully maximized if additional space is added to the SSP (Faust et al. 2016). The probability of achieving at or above 80% gene diversity under the current option with no additional space would be 71.4%, an increase from the baseline of 65.7%, but that probability could be increased to 87.1% with the expansion of the SSP Sarah Long: *Actual average GD at 125 years increases from 0.8100 in the baseline to 0.8168 if the capturable wolves are brought in. If the SSP space increases to 330, GD = 0.8334, compared to K=330 plus capturable wolves GD = 0.8435.* The some members of the Recovery Team agreed with the findings of the WMI, whereas other Recovery Team members did not. Jett Ferebee: *Please state the facts that no physical evidence has ever been presented that proved a red wolf ever existed in the State of NC. Merely reading 30 years of flawed assumptions does not cut it for me and many others. Even the new Princeton study says Xxxxx's assumptions are wrong. Pete, give reasons when we disagree. Don't just present your facts and then say we disagree.* ***D. The Captive Population*** The Recovery Team agreed that sustaining and growing the captive red wolf population should be a priority component of any path forward for the Service, provided that the best available scientific information continues to indicate that the red wolf is a valid taxon suitable for protection under the ESA. Jett Ferebee: *Based on the new Princeton study I can no longer support to continue wasting money breeding a hybrid coywolf. Our woods are full of them.* *http://advances.sciencemag.org/content/2/7/e1501714.full*
25	Wild Population Viability: Although efforts would be made to remove as many wolves as possible from the NENC NEP area, it is highly unlikely that it would be possible to capture all animals. The PVA work group estimated that approximately 20 animals would remain in the NENC NEP area despite removal efforts. Mike Philips: *See MP comment #33 – AS MANY ANIMALS AS POSSIBLE SHOULD BE ALLOWED TO LIVE OUT THEIR LIVES IN A FREE-RANGING STATE!*

Page	Section/Comment
	On the one hand, pursuit of this option could be viewed as a step backward in terms of red wolf recovery. This option would again extirpate the species from the wild and would appear on its face to be contrary to the ESA's mandate to "provide a program for the conservation of … endangered species". On the other hand, if the Service were to conclude that the red wolf is a conservation reliant species that is incapable of sustaining itself against the threat of genetic introgression with coyotes without perpetual intensive federal management, then it could perhaps be argued that continued efforts to maintain a large free-ranging population is placing the red wolf genome (and the species) at risk, which is also contrary to the purposes of the ESA. Mike Phillips: *This is a very important point and one that should greatly influence the direction of the red wolf recovery program. As accommodating as section 10(j) is, even it has limits to its application – it must advance recovery.*
27	Table 2. Estimated costs to suspend or terminate the NEP, including those associated with rule changes, program management, and increasing the capacity of the SSP for housing wolves removed from the wild. Annual costs are shown, as well as total costs, based upon the estimated time to completion of approximately 2-5 years, depending upon activity. Eric Geese: *Do you also need to consider the costs of lawsuits and litigation if terminating the program is implemented? Lawsuits will definitely be coming should shutting down the program be proposed.* Mike Phillips: *This seems like a crazy amount of money to suspend or terminate the NENC project.*
27	**D. Federal Lands-Focused NEP** **1. Description of the Federal Lands-Focused NEP** In addition to the measures described under the Status Quo the Service would augment the population with releases from the SSP to manage inbreeding and offset losses. Mike Phillips: *DOI islands could be very useful at least for a few wolves.* Eric Geese: *1 to 2 packs with <30 animals? Sorry, but red wolf packs do not get that big…do you mean 30 animals consisting of 1-2 packs and several lone animals?* Mike Phillips: *Actually, I'd fully expect that the Service would have to manage of flow of animals in both directions between federal lands and SSP facilities.*
28	**2. Evaluation of the Federal Lands Option** Captive Population Viability: Maintaining a small isolated group of red wolves on the limited federal land base of the NENC for any length of time would necessitate augmentation from the captive population. The PVA modeled the release of approximately one wolf every other year (on average) into he refugial population. The effect of the release of 1 animal every other year associated with the Federal Lands only scenario (Faust *et al. 2016)* was very slight: the probability of remaining above 80% (GD?) decreases from the baseline of 65.7% to 65.1%. With the removal of 3.3 animals/year from the SSP outside of the Federal Lands only context, the probability of remaining above 80% decreases to 58.965.1% Sarah Long: *Actually, this rate of release (1/yr.) was not determined to be what was needed (i.e., wasn't what was 'solved for'), it was pre-determined in the model setup (p. 11) "Scenario Z: Hypothetical effects of only using federal lands for NENC recovery, scenario includes: Increased coyote impact on reproduction as in Scenario H; NENC K reduced to 25 based on estimates of numbers of territories available on federal land; Release 1 animal every other year from the SSP; Initial NENC population reduced to 14 animals (8 adults, 4 pups, 2 juveniles)". I'd have to check our notes and consult with others to be sure but I think* Even with this release, 67.1% of iterations ended with extinction (Faust et al. 2016). Mike Phillips: *Of course, actual extinction would be avoided thru active management, which would be the only logical foundation for the federal lands option.*

Page	Section/Comment
	These include preserving the wolf's intrinsic value, as well as conducting education and outreach programs. Chris Serenari: *I wouldn't write this since it may be just as difficult to see them on a smaller scale as they are now. What this option does is uphold the spirit of the ESA and the preferences of many wolf supporters living in NENC who prioritized the intrinsic of wolves' value over consumptive (indirect or direct) value.* Jett Ferebee: *I seriously question the validity of a model such as this that has no proven track record of success with this species. It is basically like a spreadsheet of variables, where inputs and equations can be manipulated to produce the desire results. Tweak this, tweak that and voila. The scenario I desire works. Is there scientific integrity and validity to back up this model as well as the assumptions and variables input into it?* *In 1999, the red wolf team revealed the red wolf population had already sustained a hybridization rate 900 times more than allowed in order to maintain its genetic diversity goals required by the recovery program. The PVA model from the RWIT in 1999 predicted the exact population drop we are seeing currently, if hybridization with coyotes could not be controlled. Now that the results match that model, USFWS wants to blame the drop on human caused mortality, not the hybridization with countless coyotes that is in fact occurring in eastern NC.* *Public perception, desires of wolf activist groups, NGO's and lawyers profiteering on the back of tax payers via the ESA are not mentioned in this regulation!!!* *As mentioned before, the legal dimension surrounding this conflict has been shamefully and intentionally left out of this critical assessment of the feasibility of this red wolf program.*
29	**Table 3. Estimated costs to support the Federally-focused NENC NEP Option,** Mike Phillips: *Even though I think research into the influence of red wolf size on the frequency of hybridization should be a focus of this option, I still find the cost estimates to be very high.* **3. Summary of the Federal Lands Option** This intensive management would compromise efforts to conduct the kinds of research that would be a primary purpose of maintaining such an NEP. These difficulties would be multiplied if other such small NEPs were established. In terms of experimental design, working with one or more small groups of animals would present challenges in terms of sample size. Mike Phillips: *Not necessarily, even if active research was included in the option, which should be the case – see MP comment #42.* In terms of experimental design, working with one or more small groups of animals would present challenges in terms of sample size. Mike Phillips: *There probably is no way to avoid this problem.* Rather, this option is most defensible as an intermediate step toward terminating the NENC NEP all together, moving to another site or sites, or ultimately renewing efforts to establish a large population in NENC. Mike Phillips: *I like this notion.*

Page	Section/Comment
	Options Considered The Recovery Team agreed that pursuing any of the options beyond the Status Quo would require a substantial amount of time and resources to properly implement. Mike Phillips: *I don't agree with this but also find the cost estimates of the various options to be very high.* Jett Ferebee: *Terminating NENC NEP as was done in the Smoky Mountain Park will not take a substantial amount of time and resources. The costs will be one time costs, not recurring.* As such, it is the view of the Recovery Team that an emphasis should be placed on expanding capacity within the SSP and that efforts to remove animals from the landscape should be done expeditiously contingent on availability of space and resources to properly care for them must be made a priority. Jett Ferebee: *At this point, the number of red wolves on the landscape is minimal and the ability to catch them all is questionable, so I do not believe there is as big of a spatial and facilities* issue as Pete wants to make of it.
30	**The Recovery Team agreed with the findings of WMI that these objectives need to be revisited as several of the Recovery Team members believe that achieving these objectives would be insufficient to justify removal of the red wolf from the endangered species list.** In particular, there is considerable doubt among several Recovery Team members that three wild populations totaling 220 animals would be sufficient to withstand the threats faced by the species. Also, in consideration of the discussion above regarding conservation reliance the specific criteria for what would constitute 'recovery' of the red wolf remains unclear. Revising the Recovery Plan was determined to be beyond the scope of this evaluation, but should be a high priority following a decision by the Service regarding the future direction of the program. Mike Phillips: *Bravo!* Jett Ferebee: "*If the Service were to set a future direction for red wolf recovery that included terminating or reducing the scope of the NENC NEP while attempting to establish one or more additional populations elsewhere it would be important to maintain wild wolves on the landscape outside of eastern NC for use in establishing new populations." The private landowners have already been lied to about having a small population of wolves located on the Dare County ARNWR. It was our original trust that USFWS would restrict wolves to this land as promised in 1986 that has now led us to this cross road. DO NOT ASK US TO BELIEVE THIS LIE AGAIN, 30 YEARS LATER.* Mike Phillips: *I think it is highly unlikely that any of the current wild wolves could be used in other reintroduction project. And while I agree that wild stock is better suited for restoration purposes than captive stock, the latter is acceptable.* Jett Ferebee: *The termination of the Smoky Mountain NEP was basically an expeditious nonevent. Terminating just the EN NEP should be handled the same way.* **3. Public Engagement** The Recovery Team agrees with the findings of WMI (Wildlife Management Institute, 2014) that red wolf conservation efforts have suffered from the lack of a sustained public engagement process.

Page	Section/Comment
	Jett Ferebee: *How dare you say this.? We never agreed on this. I still maintain that 99.9% of the problems you are having is due to USFWS not properly managing this program according to the published Federal Rules. You will never gain the trust of people in our State if you keep avoiding taking responsibility. The arrogant attitude of you thinking we lack information about this program is coming back to get you now. So NO, do not think your issues are because the public is not educated enough or engaged enough.* *Even in the middle of this team project, USFWS and DOJ attorneys thru you and your office have continued to lie to me. USFWS DOJ attorneys told Judge Boyle there were no outstanding wolf take permit requests. When I made public my ongoing take request to USFWS and DOJ attorneys, they proceeded to ignore it. When opposition attorneys found out and reported it to the Judge, you sent me a bogus word document saying my request "had not been active since whelping season". You and I both know this was a lie, yet you played their game. I have the proof that this is a lie, but have been too busy to push the issue.* *USFWS must take responsibility for this failure and not because the private landowners of eastern NC aren't educated enough to love this non-native invasive coywolf USFWS dumped in our back yard.* *Oh boy, "adaptive governance"! I hope it works better than "adaptive management". To us less educated folks "adaptive governance" means just what you said…"a more robust governance structure". Go buy your own land!!! And fence your human engineered dogs in it!* **4. Science** Much has been learned about red wolves throughout the history of the NENC NEP effort, yet key knowledge gaps persist. The transition period may afford opportunities for further learning, and the Recovery Team recommends that careful consideration be given to the design and implementation of studies aimed at providing further insight into red wolf and coyote management and inter-species interactions, predator-prey relationships, and human dimensions. Mike Phillips: I *doubt that the transition period will provide useful opportunities to conduct much research, especially concerning something as complex and context dependent as predator-prey relations.* Jett Ferebee: *NO, we did not agree on this. After 30 years of milking this program what more can you possibly study! It was the grant hungry scientists in our group that wanted more studies. The landowners that house the bogus science project have had enough of their studying a made up wolf that was just a hybrid all along.*
32	**Table 4. Key Ecological Criteria for identifying potential red wolf reintroduction sites.** Mike Phillips: *It's worth noting that these criteria allow one to imagine a site much like NENC. Even if the current restoration effort is terminated, NENC may be well suited for another, albeit modified, reintroduction effort to restore a population that counts toward recovery.*
33	**Table 5. Key social conditions that should exist or be possible to create in order to sustain public support for efforts to establish a red wolf NEP.** Mike Phillips: *Most of this table seems excessively abstruse. Rewording with an eye to simplification would improve the usefulness of the table.* Consider population supplementation in areas where hunters are prevalent Eric Geese: This is everywhere in the US and not practical… Avoid recovery efforts in areas that are sensitive to economic hardships and how their tax dollars are

Page	Section/Comment
	spent, unless recovery provides a measurable economic benefit to communities Eric Geese: *This is not practical….how is hardship defined?* Avoid recovery areas where livestock is abundant unless novel deterrent methods are employed; carefully consider a compensation program in areas with smaller numbers of livestock Eric Geese: *Again, this is an opinion – what is the livestock density that is acceptable?*
33	If implementation of this option were to include establishment of one or more populations in addition to or in lieu of the NENC NEP it would require a multi-year effort to identify a potentially suitable location or locations, conduct the necessary site specific ecological analyses (e.g., prey base, coyote densities) and properly engage relevant stakeholders in development of an appropriate management and communications framework. The details of these analyses will vary depending on the location, but this work would be time and resource intensive and would need to precede the necessary regulatory and administrative compliance actions. Mike Phillips: *Good.* **Wild Population Viability** These may be designed such that releases occur annually for the first 15 or 25 years and then less frequently thereafter. Developing a program with short-term releases followed by periodic releases will help improve genetic health. The PVA model run for the NENC with intermediate mortality and increased female breeding showed that the probability of attaining 80% or higher gene diversity without releases was only 6.6%. Just by conducting releases every year for 15 years and then scaling back to releases once every 5 years, this would increase the probability to 46%. If carried out annually for 125 years, the probability would jump to 66.7%. Although significantly higher probability is achieved with the 125-year release plan, this may not be logistically feasible, especially when managing more than one NEP. Mike Phillips: *Releases over 15 to 25 years, to say nothing of 125 years seems crazy me and may represent PVA runs gone amuck.* Alternative release strategies provide additional options for consideration. In the future, more specific modeling can be conducted to evaluate release options and how those scenarios might help inform release strategies. In addition, integrated management, that is managing the NEP population(s) and SSP as a single population, will be essential for achieving the best results under this option. Mike Phillips: *This is essential and has been seen as such since 1990 when the Service's "recovery planning" effort was combined with the AZA species survival planning effort. It was the first time that those two types of planning efforts/documents were combined.*
35	**Our experience with the NENC NEP to date and the available evidence has not shown the population to be sustainable without intensive management.** The compounding effects of hybridization and human-related mortality have prevented the NENC NEP population from achieving a stable state that could persist in absence of intensive management. If management actions to improve reproduction and reduce mortality are successfully applied, the rate that the NENC NEP is projected to decline could be reduced (Faust et al. 2016). However, significant changes, especially in combination, are needed to ensure persistence of the NENC NEP into the future. Even if the higher reproductive rates documented in 2003-2004 were sustainable, the NENC NEP would still be at risk over the long term without additional changes. Likewise, short-term population increases may be realized if coyote impacts could be reduced to the

Page	Section/Comment
	extent that wolves only mated with other wolves, but modeling results still show a population trajectory that leads to extirpation. Reducing human-caused mortality rates has the greatest effect on the NENC NEP over these other management changes considered, but reducing mortality rates alone will not ensure a sustainable NENC NEP because of the effects of inbreeding depression on a closed population. If made in combination, improvements to reproduction and mortality can be expected to produce a healthier NENC NEP with a moderate risk of extinction (16.5%), but the probability of maintaining at or above 80% gene diversity would still decline over time to only 65.6% and inbreeding would increase to F=0.3086 (higher than matings at full-sibling level). However, despite these changes to the demographic rates, the NENC NEP would still not be a genetically healthy population. It is expected that other populations established within the historic range of the species, if isolated from one and other, would experience similar challenges. Eric Geese: *But this is only a hypothesis has not really been answered nor a study designed to answer it…* Mike Phillips: *Nor would reducing mortality rates necessarily obviate the importance of hybridization.* Eric Gese: *I would caution that much of what was just stated is from a MODEL….so couch these carefully as none of this is actually known but simply a result of the model…models are not findings but good for suggesting hypotheses that can then be tested.* These challenges are not easily overcome. Indeed a few Recovery Team members expressed the view that they were insurmountable in NENC and perhaps anywhere. Mike Phillips: *Please note that I am not one of the skeptics.*
36	**Landowner incentives or other measures needed to support community engagement** Chris Serenari: *To change people you need to change the Service's language (discourse). Incentives, Outreach, Education = status quo => dissent. See next comment. Financial? I hope not. I'd focus on cost to research and design mutually beneficial relationships.* It is the view of the Recovery Team that it would be imprudent to establish additional populations without a clearer understanding of the long-term commitment that will likely be needed to sustain them. Mike Phillips: *While I agree with this sentiment, almost surely the future of red wolf recovery will be decidedly incremental. Consequently, I doubt that there will ever be a case where the Service would be in the position of considering concomitantly the future of more than one population.*
37	The fact of the matter is that we currently do not know whether a population of red wolves can obtain a size and configuration that would enable it to persist with only modest management input. This uncertainty argues against pursuit of intensive efforts to establish multiple such populations. Eric Gese: *Actually it could be argued "for" establishing multiple populations to protect against extinction in the wild.* Instead, conservation efforts in the wild should be designed around research needed to test assumptions regarding conservation reliance. Establishment of one or more small populations would be advisable if we can learn what we need to learn about interactions between red wolves and coyotes through the study of such populations. Eric Gese: *Not sure where the advice came from? Or is this strictly an opinion? I'm not trying to be difficult, just pointing out where the Service could be open to lawsuits….* Sample size could be an issue. Conversely, establishment of a single large population would be

Page	Section/Comment
	prudent if it were determined that the conservation-reliance hypothesis can only be evaluated by testing it directly. Eric Gese: *Very good point and possibly this option would prevent lawsuits.* In either case, the effort must be accompanied by a robust and explicit plan that includes specific metrics and timeframes for determining success and a detailed study design with explicit testable hypothesis and data collection and analysis plans. Eric Gese: *Very good point, but perhaps this needs to be also a part of all the options discussed, not just the full recovery?* Jett Ferebee: *This estimated is grossly overstated and the cost to terminate the Smoky Mountain population should be examined. It is foolish to think that USFWS should even entertain the idea of spending 1.3 million per year to trap and remove 20 or so wolves. Amazing…truly amazing..* Mike Phillips: This seems like a crazy amount of money to suspend or terminate the NENC project. *Jett Ferebee: For less than $500,000, a private enterprise could shut this program down in eastern NC vs. your original inflated estimate of $10,810,000 over five years to round up 20 remaining wolves.*
38	On-going research by the NCWRC suggests that "partial solutions", such as outreach, education, or financial incentives, would be largely ineffective by themselves to achieve region-wide red wolf recovery because they do not address deeper issues underscoring historical recovery efforts. The NEP designation offers flexibility in designing a recovery program that could better achieve red wolf conservation while alleviating security, liberty, and equity concerns for many citizens, build trust among stakeholders, and overcome bureaucratic politics contributing to stakeholder divisions. A more robust system is needed that better differentiates red wolves from coyotes, formulates mutually beneficial relationships for landowners and other interest groups, and/or employs a management system based on developing clear goals, flexible and innovative rulemaking, information sharing, addressing uncertainty, and shared decision making and authority. Eric Gese: *But in the absence of hybridization issues, gray wolves in the northern Rockies are doing great despite the social problems – that is, wolves don't care about the social problems, people do. Think we need to make that distinction more clear.* Mike Phillips: *Good* Jett Ferebee: *The private landowners have already been lied to repeatedly by USFWS about having a small population of wolves located on the Dare County ARNWR. It was our original trust that USFWS would restrict wolves to this land as promised in 1986 that has now led us to this cross road. DO NOT ASK US TO BELIEVE THIS LIE AGAIN, 30 YEARS LATER!!!!! You promised to keep them on the refuge last time and laughed at us for thinking they would stay there. You promised to keep the wolves on Federal land, but at the very same time you were releasing them on private land. You had Federal rules requiring private land removal, while you wrote an internal policy saying not to honor removal request.* *You just re-released a trapped wolf XXXXXX that left the Alligator River refuge immediately and returned to the private land, where it was trapped, in a matter of days. Now the landowner is asking for this wolf's removal again and is being told the request must be written in a certain manner. At*

Page	Section/Comment
	this very same time you have your DOJ attorneys telling Judge Boyle that USFWS has no intention of removing any wolves from private land and they have no pending requests to do so. You also took a trapped coyote and put it on ARNWR. It too returned ~~e~~ to the private land where it was trapped in a matter of days. What a grossly mismanaged and fraudulent taxpayer scam. Are you really foolish enough to ask us to believe you will keep your animals on ARNWR? Even more absurd is that you would ask the American taxpayer to fund this revolving door scam. *You selectively bred a robust coywolf in a zoo in Tacoma Washington, called it an endangered species, and then falsified historic range maps to meet your needs of Federal lands with no coyotes, all so you could establish a wolf population on the east coast under the false guise of the ESA. Oh no USFWS, fool us, once shame on you. Fool us twice, shame on us. This will not happen again. This is the price you must pay for your wayward ways of the past. Take this opportunity to do the right thing and potentially regain the trust of your needed private land partner. There is a right way and a wrong way to treat others. The right way begins with integrity.*
39	**Wild Population Viability:** Jett Ferebee: *A group of red wolves managed under this option would be artificially constrained to the federal land base. Yea right. You just re released a trapped wolf from Xxxxxxxx- that left the Alligator River refuge and returned to private land in a matter of days. Now the landowner is asking for this wolf's removal and is being told the request must be written in a certain manner. You also took a trapped coyote and put it on ARNWR. It too returned to the private land where it was trapped in a matter of days. Are you really foolish enough to ask us to believe you will keep your animals on ARNWR? Even more absurd is that you would ask the American tax payer to fund this revolving door scam* **Human Dimensions** There would be some benefits to maintaining a small group of wolves on the Federal lands. These include preserving the wolf's intrinsic value, as well as conducting *Jett Ferebee: This is so bogus. Kim Wheeler, the Red Wolf Coalition Executive Director for over 10 years? and lives in the heart of the red wolf recovery area proclaimed in a court affidavit that she had only seen a red wolf in the wild twice in her life! So no it is highly doubtful the public will enjoy anything more than the howling of penned up wolves as they have for years, often being mislead into thinking they were hearing wild wolves. The whole mess is a fraud especially the part about the public experiencing wild wolves. Even Kim could probably not confirm if she had actually seen a wolf, hybrid, or coyote on her 2 lifetime sightings of a "wolf"* *Federal Rule 50 CFR 17.81* *(d) The Fish and Wildlife Service shall consult with appropriate State fish and wildlife agencies, local governmental entities, affected Federal agencies,* ***and <u>affected private landowners</u> in developing and implementing experimental population rules****. When appropriate, a public meeting will be conducted with interested members of the public. Any regulation promulgated pursuant to this section shall, to the maximum extent practicable,* ***represent an agreement between the Fish and Wildlife Service, the affected State and Federal agencies and <u>persons holding any interest in land which may be affected by the establishment of an experimental population</u>.***
41	Jett Ferebee: *I believe this is the option that USFWS has been tasked with accomplishing for the last 30 years and now has fewer or the same number of breeding pairs (4) that they originally started with in 1987. After 30 years, USFWS has failed to accomplish their original goals for either the wild population or the captive population. The goal was 220 wild animals and they now have maybe 40 and have released at least 132 animals to get this 40…* *To me, this is feasibility study enough, but then my paycheck is not tied to the continuation of this*

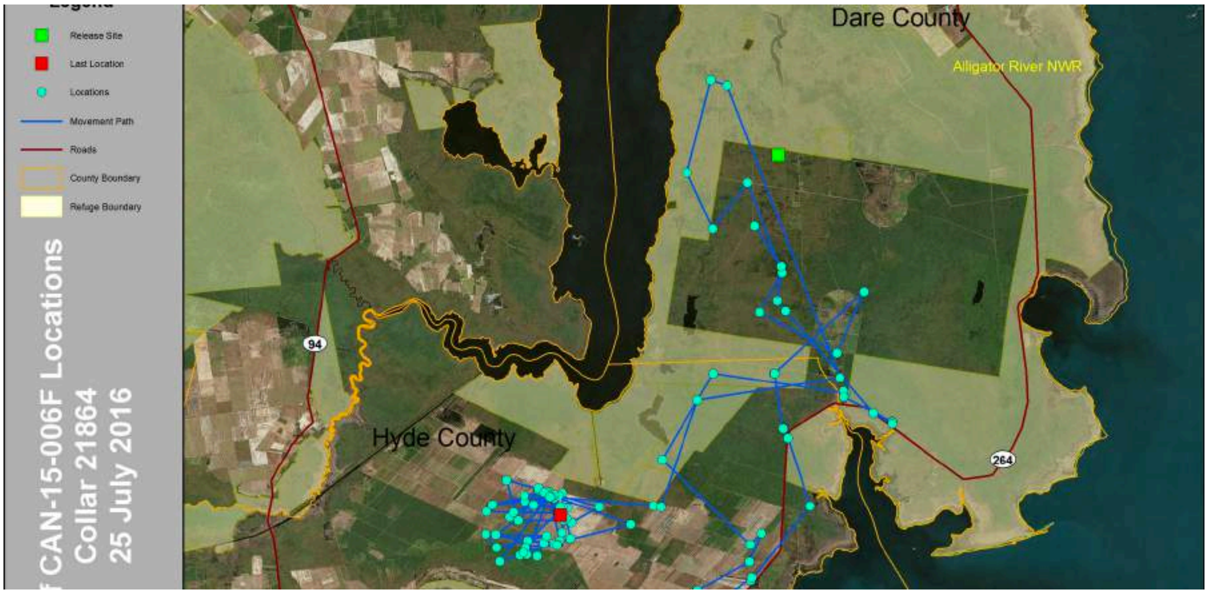
Page	Section/Comment
	farce and its associated studies.
48	We have seen in the NENC NEP that coyote hunting, trapping and control leads to levels of mortality in red wolves that are not sustainable. Jett Ferebee: *USFWS personnel not keeping wolves on Federal land as promised leads to levels of mortality that are not sustainable. USFWS flooding red wolf habitat for carbon credits and not managing their land for their own invented endangered species leads to levels of mortality that are not sustainable* Even with this effort there has been no systematic effort to analyze its effects on wolves, coyotes or human attitudes. Additional measures could include an outright prohibition on coyote hunting or other modifications to coyote hunting seasons and bag limits. Jett Ferebee: *Don't even think about it* These include the coexistence council for the Mexican grey wolf (Mexican Wolf/Livestock Coexistence Council, 2014) which includes a pay-for-presence program, and recovery efforts for jaguars in northern Mexico (Northern Jaguar Project). Jett Ferebee: *Yep sure, I believe the Mexican wolf program is in just as much of a mess as this red wolf program. The red wolf is a NONESSENTIAL EXPERIMENTAL POPULATION and has its own set of regulations that are specifically set up to protect private landowner rights NOT other interest groups maybe you guys need to review the 10j rules*
50	Utilize wild wolves for planning new restoration sites Mike Phillips: *It seems highly unlikely this will be possible*
51	**Lessons Learned** First we must take a moment to recognize the successes. We successfully established a captive breeding program to ensure the survival of the species. We achieved the first successful re-introduction of a large carnivore that had been declared extinct in the wild. Mike Phillips*: The truthfulness of this statement depends on how one defines "successful".* To ranchers in the area around Yellowstone the wolf is a threat to livestock and an economic liability. Mike Phillips: *More of a perceived threat and perceived liability. Most wolves don't make a whit of difference to most ranchers.*
52	The fact that we did not immediately and publicly acknowledge and correct our error created problems that persist to this day. Mike Phillips: This is not true. As evinced by signed agreements and our celebration of those agreements we certainly acknowledged the importance of private land. Hindsight is of course 20-20 and it is not fair to criticize the work of program staff, who were undoubtedly doing great work to deal with a very complicated, challenging and unprecedented reintroduction effort. We know now that as soon as wolves began leaving the Refuge we should have made a public statement of our changed understanding of red wolf habitat and space needs, and should have engaged the community in a dialogue of the meaning of this new information to the recovery effort and its relationship to the community Mike Phillips This is not true. As evinced by signed agreements and our celebration of those agreements we certainly acknowledged the importance of private land.
53	Second, being wrong about these fundamental early assertions regarding red wolf ecology undermined our scientific credibility early in the recovery effort in the minds of many in the

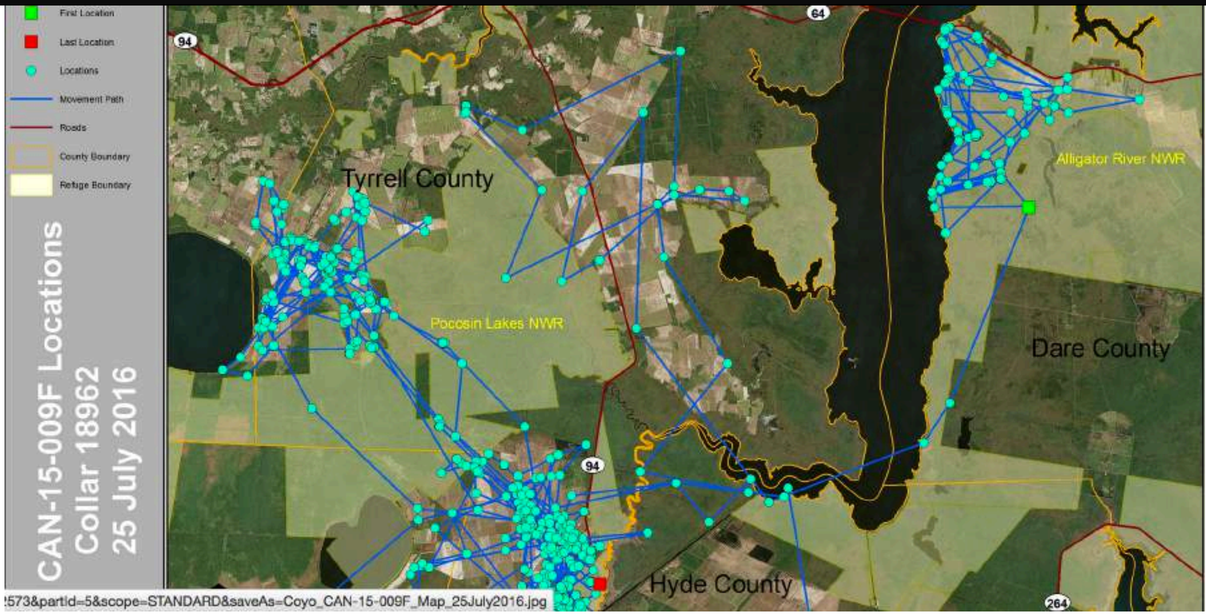
Page	Section/Comment
	community. If we could be this wrong about such fundamental aspects of red wolf ecology, how could the community be expected to put faith in our findings regarding more complicated aspects of red wolf conservation including taxonomy, management of hybridization, and predator-prey relationships? This could have been addressed had we been more forth coming about what we were learning about red wolf ecology and engaged the community is a dialogue regarding the consequences of this new information. Mike Phillips: *I think this paragraph conflates current circumstances that are intertwined with concerns about coyotes with very different circumstances that existed from 1986 through the mid-1990s.*
54	Things I Can Live With Jett Ferebee: *The NENC population needs to be terminated after 30 years of unsuccessfully meeting the program objectives and violating several key Federal Rules designed to protect private landowner rights. Winding down this process should be expeditious and used as an opportunity to learn and increase credibility between FWS and private landowners.* *In light of the new Princeton/UCLA genome wide DNA study that determined the red wolf to be a hybrid of 75% coyote and 25% grey wolf, I cannot support spending any more taxpayer money on either the wild population or even the captive population of red wolves. Hybrid animals are not protected by the ESA.* *Recognition that absolutely no physical evidence has ever been produced by USFWS to prove the red wolves selectively bred in a zoo in Tacoma, Washington were ever native to the State of NC.*
54	**Things I Oppose** Jett Ferebee: *Further spending of taxpayer resources on an animal of such questionable origins and the continued trampling of private landowner rights by USFWS and NGOs.* *Forcing this on people who don't want it. USFWS not managing their Federal land for the red wolf and then expecting private landowners to host their wolf program (biologists and all).* *USFWS not honoring the original commitments made to the citizens of North Carolina in Federal Rules and public meetings. The 1986 and 1995 Federal Rules governing this non-essential experimental species program were specifically established to protect private landowner rights including the ability to have unwanted wolves removed from their land.* *Thinking that adaptive management has controlled hybridization of wolves with coyotes in eastern NC.* *USFWS blaming hunters and landowners for the NC program failing rather accepting that the same conditions of coyote infiltration and hybrid swarm that lead to red wolves being removed from the wild in Texas by USFWS have now occurred in eastern NC.*
55	**"Recent genetic data have cast doubt upon the hybrid origin hypothesis and the balance of evidence has tilted towards a North American canid assemblage composed of the eastern wolf, the red wolf, and the coyote as distinct taxa that are descended from a common ancestral canid of North American origin."** Mike Phillips: *See my previous comments on this issue. It would seem appropriate to integrate van Holdt et al. 2016 into this report.*
56	**3. Can a wild population of red wolves be self-sustaining without active management for hybridization?** The honest answer is we do not know. The goals laid out in the Red Wolf Recovery Plan (establishing three wild populations with approximately 220 animals) are based on the premise that a red wolf population that is large enough and stable enough would be able to sustain itself against

Page	Section/Comment
	introgression with coyotes. This appears to be the case with the eastern wolf (*C. lycaon*) of eastern Canada. It too is intermediate in size between grey wolves and coyotes and hybridizes with both species. Yet, within Algonquin Provincial Park it is able to sustain a core population that appears stable. It is an open question whether the red wolf can do the same. It can certainly be said that such a situation has not been observed to date. The Service believes that in the period around 2005 the NENC NEP population was approaching a size and configuration (approximately 130 animals in about 20 packs) that may have been sustainable; though this was never demonstrated. Since that time the population has been in decline due primarily to increased loss of breeding animals to anthropogenic sources (primarily gunshot). The increased loss of breeders causes instability in the social structure of wolf packs that facilitates hybridization. So the question remains whether there is any set of conditions that would enable a large stable red wolf population to sustain itself against hybridization with coyotes or whether the red wolf is a conservation-reliant species that will perpetually require intensive management in the wild. Mike Phillips: Good
58	**9. Why are wolves are not being maintained on Federal lands as promised in the Federal rules?** **514 landowners have now demanded to not have wolves on their land, many of these had signed "partner agreements" and received compensation from the Service. Large tracts have pulled all support for this recovery program based upon unkept promises and commitments.** During the summer of 2014 we received a surge in requests to remove wolves from private lands. Our records indicate that we received 405 such requests. We followed up on each and every one. Our records indicate that 24 of the requests represented duplicate requests from the same address (e.g., husband and wife submitting identical requests on or about the same date). Forty-three requests contained no contact information and we were unable to identify the senders. We received no response to repeated attempts to contact 282 requestors. Fourteen requestors contacted indicated that they thought they were signing a petition to protest the NCWRC coyote hunting rules, but had no wolf issues on their lands. An additional 25 requestors reported no problems with wolves on their lands at the time but would contact us if the situation changed. Our staff conducted surveys of 21 properties at the landowner's requests and found no evidence of wolf presence. Those landowners requested no further action. We received no further response from 5 landowners following our original contact with them. Two landowners would not allow access to their property so we could follow-up on their requests. We ended up working with 13 landowners to address concerns regarding wolves using their property. We are working diligently to uphold our commitments to landowners and work within our 1995 regulations. Mike Phillips: *Good* *Jett Ferebee:* Pete, I have told you repeatedly that USFWS is misrepresenting these requests. These requests were for the removal of any wolves that were present or may become present on their land. Since USFWS would not even provide wolf locations to our NCWRC, no one knows if and when a wolf is occupying their land. These requests made it clear that if USFWS, who was mandated by Federal Rule to monitor their wolves, knew their wolf was on any one of these people's land; then they were to be notified and the wolf removed. Some even requested that USFWS not go on their private land as people were complaining of USFWS trespassing on their property. So all this bogus data you present here is meant to do nothing but discredit the integrity of private landowners in the red wolf recovery area. I have spent over 15 years trying to get USFWS to remove wolves as promised. Only now have I achieved any results. As a result of my success, USFWS and DOW will likely fabricate a sue and settlement arrangement in their current law suit and do away with our

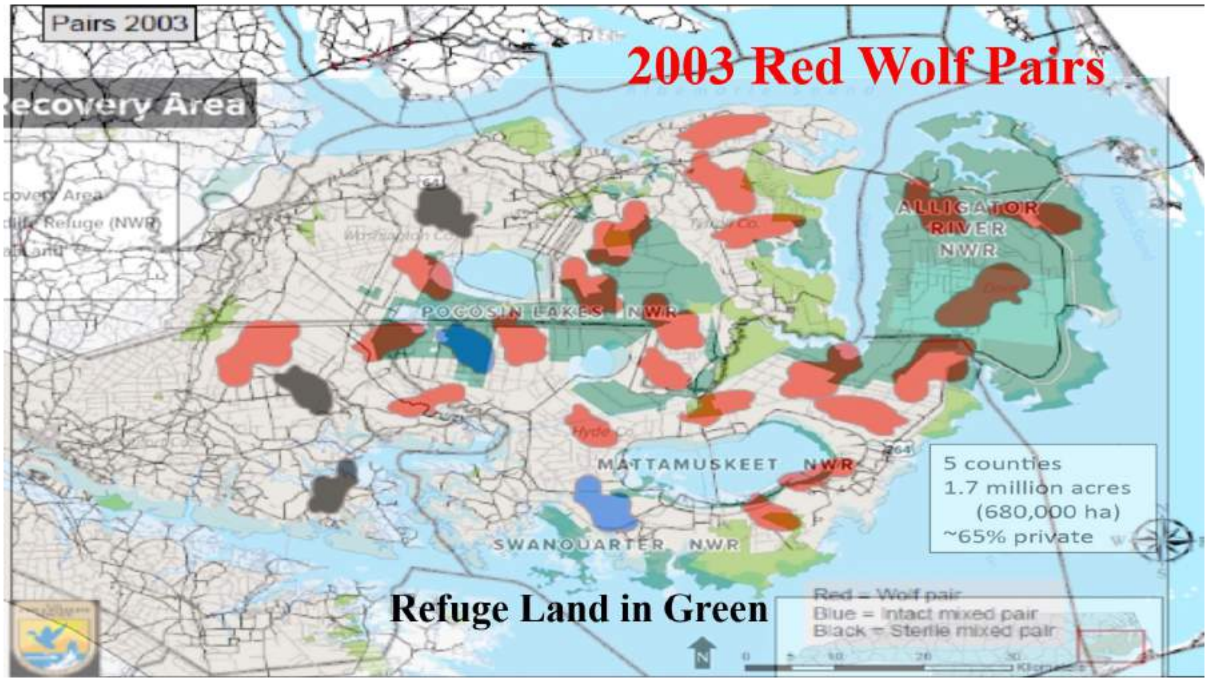
Page	Section/Comment
	ability to have wolves removed. In fact just last month, DOJ attorneys have already told Judge Boyle and SELC that they had NO INTENTIONS of removing any wolves. .
63	**Lessons Learned** First we must take a moment to recognize the successes. We successfully established a captive breeding program to ensure the survival of the species. We achieved the first successful re-introduction of a large carnivore that had been declared extinct in the wild. Mike Phillips: *The truthfulness of this statement depends on how one defines successful.* Jett Ferebee: *I disagree when it comes to experimental populations: see Federal Rule 50 CFR 17.81*
64	**This is important because the nature of the red wolf recovery program in eastern NC has changed repeatedly over the years as our scientific understanding of red wolves has evolved. This led to several important decision points and forks in the road where the Service acted unilaterally.** *Jett Ferebee: USFWS must admit the violations of Federal Rules – illegal private land releases, nonremoval of wolves, selectively breeding an animal to fit their needs, manipulating data to somehow make NC become historic range of the red wolf, falsifying take request information to a Federal Judge, conspiring with NGO's to sue and settle with our NCWRC… the list could go on and on. You can't continue to just say the community was not engaged or that USFWS should have educated them more.* Henry and Lucash (2000) summarized lessons learned through the first 12 years of the red wolf reintroduction efforts in eastern NC and the Great Smoky Mountains National Park. These lessons included recognizing the importance of private lands, taking steps to minimize conflicts with other land uses and practices, the need for public outreach and state agency involvement, and the need for transparency and consistency in our actions. While these lessons have been acknowledged it is clear that the Service has not taken these lessons sufficiently to heart to produce a lasting change in the relationship between the agency, the community and other key partners. Jett Ferebee: *This is epitomized by the last letter that your DOJ attorneys made you send me saying that my take permit request had not been active since "whelping season". This was a lie to cover up the lie that your DOJ attorneys told a Federal Judge. I cannot express how that galvanized my belief that USFWS has no intent to be truthful to anyone, including a Federal Judge. The ends never justify the means in any situation. I am not done with this "little issue" either.*
65	**A. Communication of Government Intent** When the northeastern North Carolina red wolf non-essential experimental population (NENC NEP) was first established in 1986 the Service said that the wolves would be managed on federal lands (Alligator River National Wildlife Refuge and Dare County Bombing Range) and would pose no threat to, and place no encumbrances upon, private lands. This commitment was based on our understanding at the time of red wolf ecology, which was based on limited observations of the habitat use, movements, and diets of the few wolves that existed in southwestern Louisiana and southeastern Texas. Our assumptions quickly proved unfounded as wolves soon left the Refuge and we discovered that their habitat preferences and space needs were much different than we originally believed. Jett Ferebee: *This is where you should state that you only had Section 7 authority to release 12 wolves from the captive population but released 132, which likely bankrupted your captive breeding program. This is where you should state you only had Federal Authority to release wolves on Federal land where the wolf was fully protected, but you released 64 out of 132 wolves onto private land. They did not simply "wander onto" private land or even "soon left the refuge".* ***<u>Your personnel put</u>***

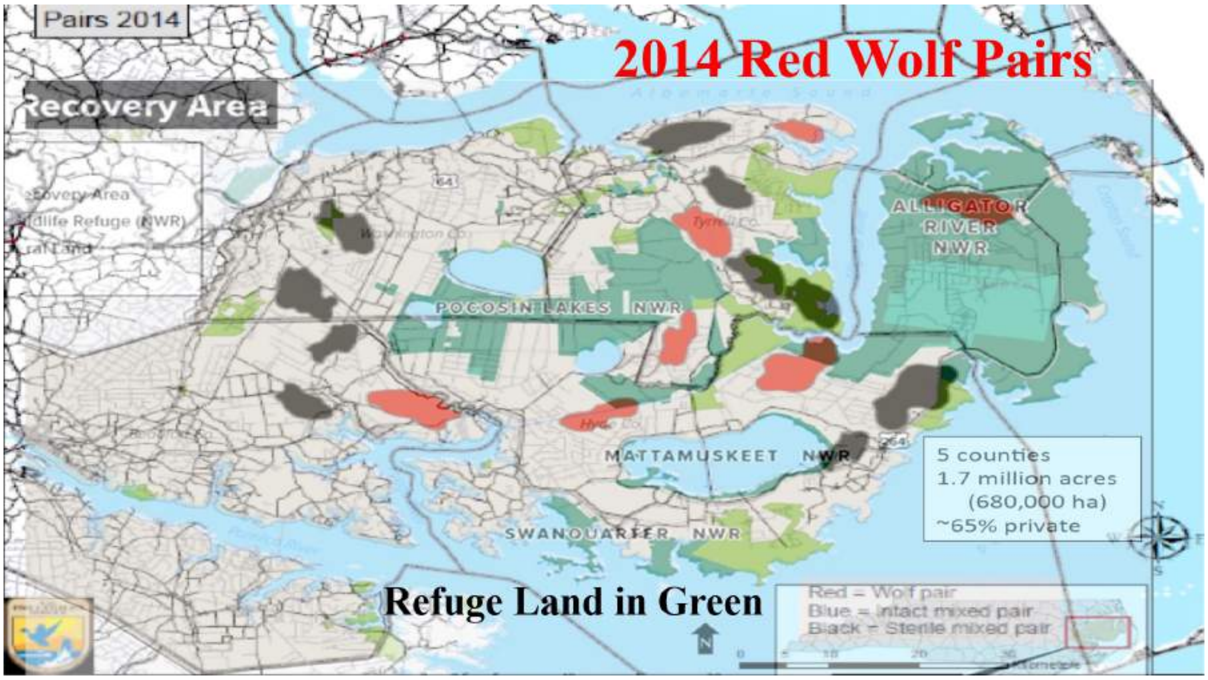
Page	Section/Comment
	<u>them in a crate and took them to private land, while they were having public meetings for the 1995 Rules revision that stated you were only going to be releasing a few wolves on the Federal lands of PLNWR.</u> *Now would be a good place to show a little humility and integrity.* This created two problems. First, as we altered our management practices in response to our rapidly changing knowledge of red wolf ecology we fundamentally altered the premise upon which the relationship between the red wolf and the community was founded. Wolves that were supposed to be confined to the Refuge were now routinely, even predominantly, occupying private lands. The fact that we did not immediately and publicly acknowledge and correct our error created problems that persist to this day. Mike Phillips: *This is not true. As evinced by signed agreements and our celebration of those agreements we certainly acknowledged the importance of private land.* Jett Ferebee: *It took a FOIA request from me almost three decades later for USFWS to finally admit to doing this with no legal authority. It took a called meeting with the NCWRC to expose that USFWS had an internal policy that stated they would not remove wolves from private land. This policy was in direct conflict with the 1995 Federal Rules, which state that ALL unwanted wolves would be removed from private lands.*
66	Jett Ferebee: *These people are sick and tired of USFWS saying they will be engaged and made aware of USFWS actions. This is being seen right now as Howard Phillips is flooding the refuge, which is now flooding wolf habitat and adjoining farmland. We do not want to ~~be~~ simply "be engaged". To date this is a one sided public stunt. We demand to be heard, especially when USFWS activities impact our private land! To date USFWS, as many Government agencies do, simply plays the old "rope a dope" technique and hopes the complainer goes away.*
67	**Transparency** When people do not know what a federal agency is doing they tend to speculate, and they almost never speculate positively. The absence of clear timely information from the Service provides a breeding ground for suspicion and mis-information that if left untreated (as has been the case with the red wolf reintroduction effort) leads to distrust and loss of confidence. Today, certain segments of the community believe we are determined to expand the range of the red wolf throughout North Carolina and beyond while other stakeholders believe we are managing the wild population to extinction. Neither is accurate, but how is anyone to know given the lack of accurate and timely information from the Service? Jett Ferebee: *What is accurate? The Federal Rules stated that you were going to establish a* ***<u>Nonessential Experimental Population</u>*** *(term you conveniently omitted from this report) on Federal lands. That is around 275,000 acres, yet now somehow USFWS has taken the recovery area size up to 1.7 million acres including all Federal, State and private land in five counties! What are we supposed to believe? Will the 1.7 million acres now grow to include all of NC next or even the entire Southeast? This is certainly what is being communicated by the NGOs and wolf scientists. Bait and switch is the private sector term for this*
68	**What evidence supports historic red wolf presence in NENC?** Jett Ferebee *The bottom line here is the fact that absolutely no physical evidence has ever been produced by anyone in 30 years of trying, that proves a red wolf was ever native to our State of NC. Absolutely the red wolf, that Michael Phillips described as being a human construct which was*

Page	Section/Comment
	selectively bred in a zoo in Tacoma Washington, was NEVER native to NC. To Mr. Phillips credit, I have found him to be very open in his assessment of the red wolf program from beginning to end. To build on Mr. Phillips's above description (see peer review WMI report), he now even states in this report he supports: *"An effort to modify the red wolf captive breeding program to promote greater expression of the gray wolf component of the red wolf genome as manifest by a substantial increase in the average body size of red wolves."* *This is the honest information that USFWS must communicate!* *If the "scientific community" thinks the Southeast needs a wolf, be honest about it. Be honest like Mike Phillips and just say you are going to breed something that may serve your purpose, but don't falsely hide behind the guise of the ESA*
72	**Why aren't wolves staying on Service refuge lands?** Here is GPS data on the wolf that Xxxxxxx trapped, gave to you, and in days it left your refuge and returned to Xxxxxxx:  Even one of your "placeholder" coyotes would not stay on your refuge for more than a couple of days. It too immediately found a way off your refuge and back to where it was trapped. Maybe you need to write a job description for your "Service animals".

Page	Section/Comment
	
73	**Why are wolf populations failing to keep coyotes from encroaching into new areas?** Jett Ferebee: *I have yet to see an area that had more wolves than coyotes and hybrids. Xxxxxxx in the heart of Zone 1 of your highest adaptive management regimen just produced this:* *2 wolves, 4 hybrids and 10 coyotes. The landowners demanded your wolves be removed because USFWS told them the wolves would keep the coyotes away. Read their removal request letter. Your statement "Wolves, being larger, predominate when the two species compete directly" is simply not correct. 87.5% of the canids trapped in 30 days were non wolf in your Zone 1.* *Trapping on my farm, yes the one USFWS said had "no wolves", produced similar results when trapped for 30 days:* *4 wolves and 13 coyotes and hybrids. 76% of the canids were nonwolf.* *Now this is the data you need to examine. I can't believe none of your grant driven scientist have never studied the negative correlation between wolf numbers and coyotes. I bet they have, but all of you would much prefer to blame the wolf population plummet on hunters. I'm not going to let that happen. The simple fact of the matter is the critical success factor of "NO COYOTES" no longer exists in eastern NC. USFWS can not sterilize coyotes across 1.7 million acres. Wolves are wrapped up in breedable coyotes and you can't stop it! It is time for USFWS to fold the cards in our State.*
74	**Why have Alligator River National Wildlife Refuge and the Pocosin Lakes National Wildlife Refuge been rehydrated? It appears to have made this habitat unsuitable to support red wolves.** The Service has been working to restore a more natural hydrologic regime to Pocosin Lakes and Alligator River NWRs in order improve habitat quality, reduce the risks of catastrophic wildfires, and enable the ecosystem to adapt to stresses caused by climate change. Landowners adjacent to Pocosin Lakes NWR have expressed concern that on-going wetland restoration work on the Refuge has increased water levels and thereby rendered the area too wet to be suitable red wolf habitat. This, they allege, has caused wolves to move onto private lands. These allegations are unfounded are supported by these maps from 2003 to 2014 and show that as the refuge was saturated, the wolves departed:

Page	Section/Comment

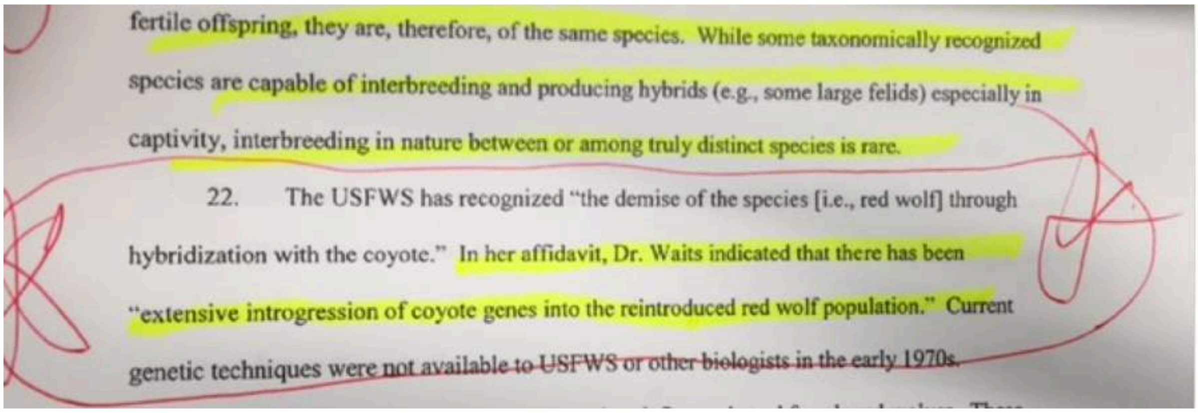


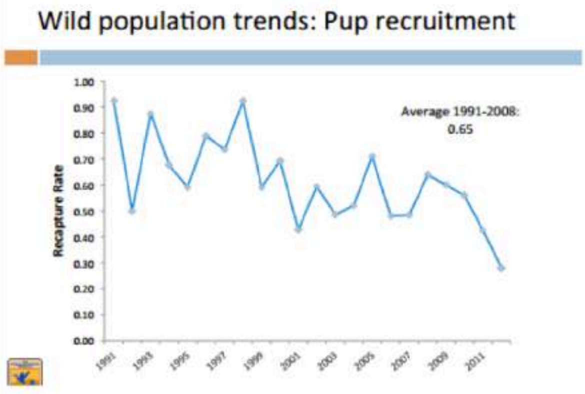
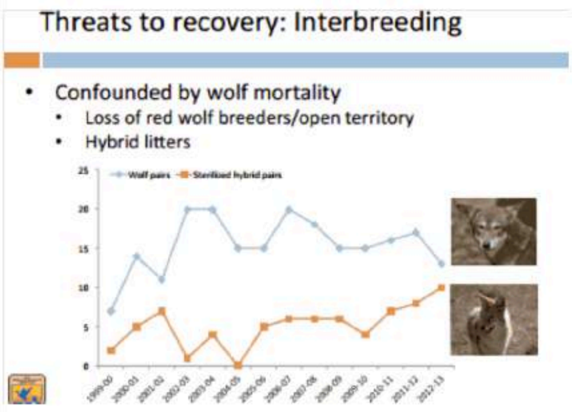


Yes, you see this correctly, only one red wolf pair is located on Federal land by 2014.

. The Refuge consists of 110,000 acres. To date the Service has restored approximately 20,000 acres of wetlands on the Refuge and the overall project calls for restoration of approximately 30,000 acres. Even assuming that all restored wetlands would be unsuitable wolf habitat there would be approximately 80,000 acres of unaltered habitat available to red wolves. I disagree with those acreage numbers, but at any rate where is any degradation of critical habitat of an endangered

Page	Section/Comment
	species allowed? "Additionally, because the goal of the restoration project is to recreate seasonally saturated soil conditions (not inundation) the majority of the restored wetland areas remain accessible and suitable for terrestrial wildlife including wolves." My maps just do not reflect any accuracy of your statement. "Our data indicate that the proportion of the overall red wolf population using Refuge lands has remained approximately unchanged as the hydrology restoration work has progressed." Again, I disagree and I have used your own maps to prove it. Only one red wolf pack~~s~~ has at least a portion of their territories on Refuge lands. This is not the same proportion that used Refuge lands prior to the hydrology restoration activities. There are in fact fewer wolves using Refuge lands today than there were 10 years ago because the overall size of the red wolf population has declined from a peak of about 130 wolves to a present size of about 45 to 60 wolves because of the burgeoning coyote population. There are more wolves on private lands because USFWS illegally placed them there and then would not remove them. The mix of forest and agriculture on these lands is more attractive to red wolf prey species.
75	**What evidence supports Adaptive Management and Placeholder Theory? Why isn't it working better?** Jett Ferebee: The Adaptive Management Plan (Rabon et al., 2013) was developed for the expressed purpose of managing coyote genetic introgression into the red wolf population. Its components include careful monitoring of the population to identify hybrid animals and either removing them from the population *I've been meaning to FOIA this information, but exactly how many canids have USFWS personnel killed in their effort to manufacture and put in place this nonessential experimental wolf population ~~wolf~~? Does DOW, AWI, RWC, Coyotes Forever, Humane Society, etc. realize that you guys are killing animals and puppies just because they don't measure up to or meet your needs. I was thinking about it the other day. I guess the original 400+ animals trapped were killed because they did not look woofy enough. The next realization was that USFWS must have killed hundreds of puppies that they raised up to adult size while doing their "selective" breeding process. USFWS bred animals back and forth to see what pairs would consistently produce wolf like offspring. So what did ya'll do raise them up to adults, measure their ears, tails, etc. and then ones that did not measure up were killed? How were they killed and why?* *After this I know the adaptive management plan called for den hunting for wolf and hybrid litters after pups were whelped in the spring. Then when your biologists found what they thought were coyote or hybrid pups, they would kill them. How did they kill these puppies that did not fit their needs? I have heard by drowning and then I have heard by "wacking them up beside the head". Either way it must have been an awful experience for the biologist and of course the puppy.* *I know in my readings of studies conducted by our team members that USFWS actually killed 30 hybrid litters. Wow, 30 times say 5 pups per litter, so 150 puppies killed because they didn't meet your needs. This wolf manufacturing process is sort of an ugly venue when you get past that stuff you read on the DOW and RWC website.* *Oh boy I almost forgot, my readings also detailed that USFWS mistakenly sterilized 3 red wolves. Now that's not the bad part. USFWS mistakenly killed 7 entire red wolf litters in this obscene adaptive management pipe dream that has failed to produce any positive results for the wolf population in eastern NC.* ***How did USFWS killing 7 entire red wolf litters factor into the population decline that was conveniently blamed on NC sportsmen and ultimately our NCWRC commissioners?*** *It seems like a whole lot of killing of innocent puppies as USFWS attempts to play God and decides*

Page	Section/Comment
	who lives and who does not.
76	*Jett Ferebee: I found this statement about our team member Lissette Waites and her affidavit for the Coyote suit against our NCWRC concerning that introgression issue:*  fertile offspring, they are, therefore, of the same species. While some taxonomically recognized species are capable of interbreeding and producing hybrids (e.g., some large felids) especially in captivity, interbreeding in nature between or among truly distinct species is rare. 22. The USFWS has recognized "the demise of the species [i.e., red wolf] through hybridization with the coyote." In her affidavit, Dr. Waits indicated that there has been "extensive introgression of coyote genes into the reintroduced red wolf population." Current genetic techniques were not available to USFWS or other biologists in the early 1970s. *When I asked why we were seeing so many hybrids yet USFWS claimed they were successfully managing hybridization it turns out, Pete said USFWS does not count hybrids when it measures the influx of coyote genes into the wolf population. A hybrid is no longer a wolf so it is ignored when calculating the genetic diversity of the wolf population on the Albemarle Peninsula. Accordingly, USFWS can flood eastern NC with hybrids, but still claim to the public that they are controlling hybridization because there is no influx of coyote genes into their "known wolf" population. So as long as USFWS can capture known and pedigreed wolves and ignore hybrids, they will mischievously declare adaptive management a success. I know, it defies all logic but now we know how they spew forth that lie and quickly look the other way when presented the facts of what has truly has happened in eastern NC.* *Lisette: Waits: Mr. Ferebee's point is presented out of context. I did make that statement in my affidavit in relation to the 1993 hybridization event that went undetected until we had improved genetic testing. However, it does not accurately reflect the genetic composition of the animals that USFWS was managing in the wild at the time of that court case. Thru adaptive management that included removal of hybrids and introgressed individuals we had maintained a wild red wolf population with < 5% recent coyote gene introgression*
77	*Jett Ferebee: Here are two graphs that show that as adaptive management increases, wolf numbers and pup recruitment decrease:*

Page	Section/Comment
	Adaptive Management by the numbers:  Pup recruitment is at an all time low of less than .30 from a high of .93. That is a 67% decrease.  It sure looks to me that as sterilized pairs increase (adaptive management), wolf pairs decrease! I believe these two lines on the graph have now intersected! *In fact in 2003, there were 21 breeding pairs of wolves in the recovery area and in 2016 there are only 3 or 4 breeding pairs remaining. Again, we see an 85% decrease in breeding pairs as the adaptive management plan enters its sixteenth year and the red wolf recovery "experiment" enters its 30th year!!!! At least 40% of all wolf packs in the recovery area are now mixed packs with coyotes.* *The facts do not lie…*
78	Why **Why are wolves are not being maintained on Federal lands as promised in the Federal rules?** *Jett Ferebee:* *Because in 1999 USFWS adopted an internal policy to not remove wolves from private land. This was in direct conflict with the 1995 Federal Rules (agreed to 4 years prior) mandating that all unwanted wolves would be removed.* *I have told you repeatedly that USFWS is misrepresenting these requests. These requests were for the removal of any wolves that were present or may become present on their land. Since USFWS would not even provide wolf locations to our NCWRC, no one knows if and when a wolf is occupying*

Page	Section/Comment
	their land. These requests made it clear that if USFWS, who was mandated by Federal Rule to monitor their wolves, knew their wolf was on any one of these people's land, then they were to be notified and the wolf removed. Some even requested that USFWS not go on their private land as people were complaining of USFWS trespassing on their property. So all this bogus data you present here is meant to do nothing but discredit the integrity of private landowners in the red wolf recovery area. I have spent over 15 years trying to get USFWS to remove wolves as promised. Only now have I achieved any results. As a result of my success, USFWS and DOW will likely fabricate a sue and settlement arrangement in their current law suit and do away with our ability to have wolves removed. In fact just last month, DOJ attorneys have already told Judge Boyle and SELC that they had NO INTENTIONS of removing any wolves.
80	**13. Why was NCWRC been denied access to wolf location maps?** As mentioned above we are actively sharing information with the NCWRC and are collectively working on ways to make more information more readily available to the public. *Jett Ferebee: Up until 2 months ago NCWRC has demanded to know where your wolves were and USFWS refused to give them the information. David Rabon specifically denied this information to our NCWRC. Had USFWS been forthright from the beginning about where their wolves were, the current events may have been different.* *Here is a place you need to own up to what happened and let it be a "lesson learned".* *By the way, why did you quit sending me the GPS updates on the wolf I returned to you that you then released????* 14. The USGS workshop group was in agreement that the red wolf is listable, but that this consensus is considered tentative until their findings are published. If there is unanimous consensus that red wolf is not a listable taxonomic entity and the Service moves to delist, what is the Service's plan for the animals managed in the RWSSP if this unfolds?

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