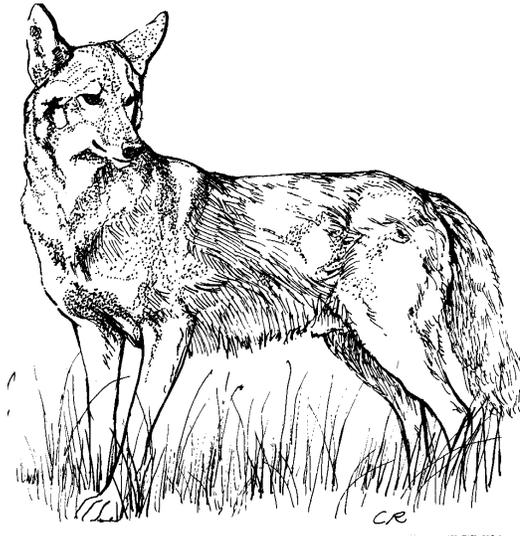


# *Red Wolf Adaptive Management Plan FY13-FY15*



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## PREFACE

The Red Wolf Adaptive Management Plan (RWAMP) specifies the framework and general goals in which the feasibility of controlling hybridization between red wolves (*Canis rufus*) and eastern coyotes (*C. latrans* var.) will be assessed while efforts to restore red wolves to northeastern North Carolina (NENC) continue. The RWAMP specifies core components designed to meet annual goals. However, the RWAMP retains the flexibility to adapt to new findings, either from the analysis of the data collected during implementation or from the findings of modeling efforts of research partners (see below I, II and III), or both. From this framework, the data it is designed to collect, and the modeling efforts and sensitivity analysis currently underway, the Red Wolf Recovery Program (RWRP) will be able to assess the RWAMP's progress and make recommendations regarding adaptations (changes), as necessary.

## PURPOSE AND BACKGROUND

The purpose of the RWAMP is to specify the goals and an implementation strategy using an adaptive framework to assess, control, and manage hybridization occurring between red wolves and eastern coyotes in the only extant population of red wolves in the United States. The U.S. Fish and Wildlife Service (Service) began restoring red wolves to the wild in 1987. Red wolves had been declared biologically extinct in the wild in 1980. The history of the red wolf reintroduction efforts prior to the temporal scope of the RWAMP is well documented (Gilbreath, 1998; Phillips et al., 1995, 2003).

During the week of April 12, 1999, at the request of the Service, a 3.5 day facilitated workshop was conducted by the Conservation Breeding Specialist Group (CBSG) of the IUCN's Species Survival Commission. The purpose of the workshop was to gather together experts who had studied wolves and coyotes, and that had expertise and experience in genetics, modeling, and canid population biology to discuss the biological and ecological issues facing red wolf recovery. Four subject areas were identified to be the focus of the workshop: (1) red wolf population monitoring; (2) red wolf hybridization with coyotes; (3) selection of additional release sites; and, (4) the role of the captive breeding program.

After reviewing data on the reproduction of red wolves in the wild, the attendees of this workshop concluded that the proportion of hybrid litters from red wolf/coyote interbreeding was alarmingly high, and recommended that the workshop focus solely on issues surrounding red

wolf/coyote hybridization, including: (1) how much hybridization could occur in the NENC population while still maintaining its genetic integrity; (2) how to assess the degree of hybridization in the NENC population; and, (3) how to limit hybridization to acceptable levels on a landscape scale. The RWAMP details an adaptive management approach (Holling, 1978; Walters, 1986) to these issues that is based on the recommendations from the CBSG workshop (Kelly et al., 1999).

## ORGANIZATION OF THIS DOCUMENT

The RWAMP is organized into three sections: (I) an overview of the adaptive management paradigm and a discussion of how the RWAMP is consistent with this paradigm; (II) a description of the experimental approach of the RWAMP; and, (III) goals of the RWAMP and measures by which adaptations should be based.

### **(I) Adaptive Resource Management and the Red Wolf Recovery Program**

Adaptive resource management (ARM) is an approach derived from the need to blend research and management. To be effective resource stewards, wildlife managers should refrain from conducting research and management independently. Instead, sound scientific principles should be applied to solve problems. Adaptive management provides the paradigm by which this can be accomplished (Lancia et al., 1996).

Adaptive management is characterized by a 4-step process (Walters, 1986): (1) reach a consensus among stakeholders; (2) analyze existing data and model preliminary predictions regarding various management schemes; (3) assess how sensitive predictions are to changes in various assumptions and variables; and, (4) implement management in an experimental context. Adaptation of a management plan is effected via feedback from experimental results generated in step. Because the RWRP was seen as being in a crisis stage by the participants of the CBSG workshop, the RWRP did not adhere to the sequential implementation of this process. Instead, based on the results of the CBSG workshop (Kelly et al., 1999), several of the four steps outlined above were engaged simultaneously. Nonetheless, the Service's mission of working with others and basing decisions on sound science is consistent with the adaptive management paradigm and provided somewhat of a head-start on the four steps mentioned above. The current state of each step is detailed below.

### Reach a Consensus among Stakeholders (1)

In the ideal ARM paradigm, all stakeholders concede something to implement an adaptive management plan. In the context of the RWRP, red wolves are listed as endangered throughout their range, but a population was reintroduced under the non-essential experimental designation available in section 10(j) of the Endangered Species Act (Act). This designation allows for exceptions to the provisions of the Act that prohibit the take of an endangered species, specifically as it applies to the non-essential population (NEP) of red wolves. So in a broad sense, advocates of wolf introduction and restoration conceded absolute protection of wolves to accomplish restoration; and, by having greater flexibility to take wolves, opponents to wolf restoration were more amenable to wolves on the land. The rule-making process associated with an NEP designation provides the forum for reaching consensus. This process typically involves public meetings and written comment periods that result in the revision of a proposed rule to reflect consensus. The RWRP followed such a process to derive its current management rule (60 Federal Register 18941). However, the advent of a serious threat to recovery from hybridization precipitated the need to change the current red wolf rule. Prior to initiating the rule changing process, the RWRP pro-actively conducted open houses in the local communities to inform stakeholders of the need to change the rule and described conceptually the RWAMP. Although the rule package has not yet been published for public comment, the open houses have functioned to inform and begin the process of generating consensus. Additionally, RWRP personnel continue to present and discuss strategies of the RWAMP opportunistically with landowners and other members of the public, particularly when management activities are conducted on private or non-federal lands.

### Analyze Existing Data and Generate Models (2)

Prior to the CBSG workshop, no analysis had examined hybridization between red wolves and coyotes, and little empirical data existed on this topic. Participants of the CBSG workshop crafted a simple, theoretical, deterministic model of coyote genetic introgression into the NENC red wolf population. The model indicated that the restored red wolf population could sustain very little hybridization if it was to maintain its genetic identity. Because of the model, the workshop recommendations, and therefore much of the RWAMP, were largely based on

theoretical information, the Service and partners initiated research projects to address the dearth of data and to construct more applicable models to guide management decisions and actions.

A genetic test to distinguish pure red wolves from hybrids and a more substantial model of coyote introgression were projects that were deemed requisites to controlling hybridization. As more information has been gathered, additional models of social interactions between sympatric red wolves and eastern coyotes, and red wolf survival analysis were undertaken.

### Assess How Sensitive Predictions Are To Changes in Assumptions and Variables (3)

At the CBSG workshop, the need to assess the sensitivity of the models that would guide the RWAMP and future adaptations was evident. Field efforts would collect data on key variables or to test key assumptions, but collecting this data would not detract from affecting change in the population towards achieving recovery goals. The models would then be refined with empirical data from red wolves, eastern coyotes, and/or hybrids in the NENC population as these data became available and the models would serve to influence future management recommendations.

As an example of the sensitivity assessment of the introgression model, models were conducted where 75% of hybrids and mixed pairs were sterilized (Hedrick, unpublished data). This scenario had a large impact on the integrity of the red wolf genome with 30-year projections predicting greater than 90% retention. Simulation of simply removing hybrids was not nearly as effective. The introgression model to date would support the hypothesis that sterile hybrids are functioning as effective place holders, thereby reducing the rate of emigration of hybrids and potential introgression into the red wolf population.

Likewise, a red wolf/coyote/hybrid spatial use model was developed, based on empirical results derived from the field component of the RWRP in NENC (Roth et al., 2008). Results showed the model was highly sensitive to the estimates of the competitive impact of coyotes on red wolves, through declines in wolf productivity. Simulations of coyote management from either removal or surgical sterilization detected that both management strategies increased viability of red wolf populations, especially during initial colonization. Results suggested that coyotes can inhibit red wolf reintroduction success through competitive interactions, but that management of coyote populations can improve the probability of successful wolf recovery (Roth et al., 2008).

#### Implement Management in an Experimental Context (4)

See III below (Implementation of the RWAMP and Measures by Which Adaptions Should Be Based) for information on how the RWRP is implementing this component of the adaptive management paradigm.

#### **(II) Goals of the RWAMP and a Description of the Experimental Approach**

The goals of the RWAMP are to: (1) reduce interbreeding between red wolves and eastern coyotes to a level that does not threaten the long term genetic integrity of the red wolf in the wild; and (2) build and maintain the wild red wolf population from east to west in the NENC recovery area (see Figures 1 and 2). Achievement of the first of these goals is approached by eliminating the breeding potential of eastern coyotes within the study area through removing some eastern coyotes immediately upon capture, and by sterilizing, fitting them with a radio-telemetry collar, and releasing others. The adaptive approach allows for the second of the RWAMP's goals, namely increasing the red wolf population.

Man's inability to control coyotes is noteworthy (Lantz, 1905a; Balser, 1974a; 1974b). While wolves were rather easily exterminated from the U.S. during the predator control efforts of the early 20<sup>th</sup> century, the range of the coyote increased. Despite widespread efforts to suppress coyote populations within their historical range, coyotes have quickly colonized most of North America (Nowak, 2002; Bekoff and Gese, 2002). Decades of effort have been spent trying to remove coyotes to protect domestic livestock from predation. However, efforts to remove the offending individuals are often problematic and produce inconsistent results (Conner et al., 1998; Sacks et al., 1999b; Mitchell et al. 2004; Connor et al. 2008). Because coyotes are territorial and typically kill livestock to provision their pups (Till and Knowlton, 1983; Sacks et al., 1999a), researchers began testing whether surgically-sterilized but hormonally-intact coyotes could function to protect livestock by defending space against coyotes needing to provision pups (Bromley and Gese, 2001a; 2001b; Seidler and Gese, 2012). It is this concept of holding space that is being applied to manage hybridization between red wolves and coyotes by providing managers time, information, and a higher degree of control over the recovery landscape, while simultaneously providing reproductive advantage to the red wolf.

Initially the NENC recovery area was considered uninhabited by coyotes; individuals

were not observed until the early 1990s (Phillips et al. 2003). As a result, a management plan was needed that considered the probable continued expansion of the coyote population within the recovery area in its attempt to eliminate the threat of hybridization (Kelly 2000). This incremental process required the recovery area to be segregated into specifically defined management zones, each managed to reduce risk reduction (Stoskopf et al., 2005). Eliminating “zones of ignorance” is the primary component of the management process to ensure that all intact (breeding) pairs are wolves. These “zones of ignorance” are areas where no known canid is present, or where a nomadic (Crabtree, 1988) or transient (Windberg and Knowlton, 1988) red wolf is present but its status is unknown. Sterilization of coyotes (and hybrids) not only achieves one of the goals of the RWAMP by limiting eastern coyote genomic introgression, but it also provides a biological means by which zones of ignorance can be systematically assessed and eliminated, a critical intermediate step in the transition to a landscape occupied predominantly by red wolf breeding groups. Ultimately, sterilization is a method that allows territorial space to be held until that animal can be replaced naturally or by management actions (Bromley and Gese, 2001b; Seidler and Gese, 2012).

The underlying tenet of this approach is that space, and therefore territories, is limited on the recovery peninsula. Given a small, reintroduced red wolf population, that space is initially best occupied by breeding pairs of red wolves, non-breeding mixed (red wolf/coyote) pairs, and non-breeding eastern coyote pairs. In this way, introgression of non-wolf genes will be controlled and territories will be unavailable for colonization by intact eastern coyote or mixed pairs. As the red wolf population grows, having space available for dispersing red wolves becomes increasingly important, and this space is provided through natural interspecific behavior and/or management actions.

**(III) Implementation of the RWAMP and Measures by Which Adaptions Should Be Based**

The RWAMP is framed around the following biological seasons:

<u>Months</u>	<u>Biological Season</u>	<u>Associated Field Work</u>
October-March	Pair-bonding/Breeding	Trap red wolf groups to ID and fit with a radio-telemetry collar, and address partial zones of ignorance

February-March	Breeding	Address partial zones of ignorance
April-May	Whelping	Den work; transponder and ID pups
June-September	Pup-rearing	Survey zones of ignorance

Goals, by season, and general methods of the RWAMP are presented below. These goals generally are implemented in a priority order from Zone 1 through Zone 3, according to the three zones identified during CBSG workshop (Figure 1) and later modified (Figure 2). An outline of goals and tasks follow:

1. October - January (Pre-breeding/Pair Bonding):
  - a. Confirm and monitor the identification and disposition of individuals within known red wolf groups.
    - i. Capture and assess ID of wolves (pack members) not previously captured and/or identified. ID is determined by genetic analysis of blood samples, morphological measurements, and pedigree data.
    - ii. Confirm the presence, via recapture or survey, of previously identified and radio-telemetry collared wolves that have disappeared. Surveys methods can include identification of tracks, scat, or images from remote cameras, as well as visual observations of the wolves. The presence of a breeder may be confirmed from genetic assessment of the pups at time of their capture.
    - iii. Capture and fit with a radio-telemetry collar pups identified and implanted with transponders at the den the previous whelping season, as needed.
  - b. Provide space for dispersing or inserted wolves.
    - i. Remove sterile space-holders.
    - ii. Identify associates of previously suspected lone wolves, and remove non-wolf canids (see 2.b.i-iii.)
  - c. Conduct insertions of wolves into areas previously occupied by eastern coyotes or hybrids. This time of year is preferred when inserting island-reared wolves. The use of wild wolves that have recently dispersed from their natal home range will be opportunistic.

- d. Determine genomic identity of new associates of previously suspected lone wolves to prevent hybrid mating (i.e., address partial zones of ignorance).
    - i. Capture and assess genomic identity and decide disposition of every animal caught while trapping for suspected associates.
    - ii. Genomic identity is determined by genetic analysis of blood samples, morphological measurements, and pedigree data.
    - iii. Use survey methods (see 1.a.ii.) to focus capture efforts and address zones of ignorance. Additional survey methods appropriate for this objective include siren surveys and public reports.
2. February-March (Breeding):
- a. Continue with objective 1.a. through March 15<sup>th</sup> for areas not completed during the pre-breeding season.
  - b. Continue with objective 1.d. (address partial zones of ignorance)
  - c. When 2.a. and 2.b. are completed, focus can shift to addressing zones of ignorance.
  - d. Survey Zone 1 for presence of eastern coyotes or hybrids (e.g., scat surveys for genetic ID).
3. April-May (Whelping):
- a. Monitor all breeding-age canids (including sterilized individuals) to ascertain whether they exhibit localized movements.
    - i. If non-wolf females or female associates of non-wolf males localize movement, efforts should be made to determine whether she has a litter, and, if so, it should be removed.
    - ii. If red wolf females localize movements, try to locate the den beginning one week after the suspected whelping date. Blood samples should be taken from each pup for genetic analysis, and transponders inserted. Litters identified as non-wolf following genetic analysis should be removed.
  - b. Selectively cross-foster red wolf pups or litters from wild or captive litters.

- c. Continue with objective 2.c. if not yet complete.
4. June-September (Pup-rearing): Continue surveying zones of ignorance.
  5. Year-round efforts; to the extent possible:
    - a. Locate each radio-telemetry collared red wolf, via ground and aerial telemetry and/or by using satellite- or GPS-telemetry collars, a minimum of 10 or more usable locations sampled per biological season.
    - b. Gather data relevant to assessing dispersal patterns of red wolves, eastern coyotes, and red wolf-coyote hybrids.
    - c. Gather data essential to assess demographic parameters of the red wolf population necessary to assess viability of the red wolf population.

Seasonal variation in behavior dictates the timing for implementation of these goals. Focusing on known breeding groups of wolves during the pre-breeding season not only insures the ability to capture and begin tracking wolves that will serve as dispersers into the population, but also avoids exposing known red wolf groups to activities (e.g., trapping and handling) during the breeding season that may compromise their ability to breed and produce a litter. In contrast, the focus on zones of ignorance during pre-breeding identifies vacant areas for dispersing wolves, while the focus during breeding and whelping seasons maximizes control of hybrid production. See Knowlton (1972) for a discussion of the temporal effectiveness of coyote control and why control during the breeding season is effective.

The approach outlined above will simultaneously reduce known introgression, reduce zones of ignorance, provide data to test key hypotheses, and allow for the determination of the RWAMP's overall effectiveness. The following predictions can be used to test and evaluate the RWAMP:

- P1: Red wolves are territorial to the exclusion of pairs or groups of eastern coyotes.
- P2: The number of known red wolf breeding units increases over time.
- P3: The percent of coyote-free land occupied by red wolves increases over time.
- P4: Number of known "breeding" pairs or groups (sterilized pairs, and red wolf pairs) increases asymptotically with time.

- P5: The number of sterilized animals needed decreases over time.
- P6: The number of mixed pairs that change to red wolf pairs is greater than the number of red wolf pairs that change to mixed pairs.
- P7: The fraction of the known reproduction (red wolf and hybrid) that is hybrid decreases overtime.
- P8: The percent hybrid litters is on a trajectory to a value that is consistent with maintaining 90% of the founding genetic diversity for 100 years (1-2% of the red wolf reproduction is hybrid).

Statistically, testing some of these predictions may be problematic. Many are cast as time series data and a lack of independence of observations or pseudo-replication may be an issue, especially for analysis of variance and linear regression techniques. However, many can be cast as null models that should enhance their test-ability. Nonetheless, the most appropriate means by which these predictions are tested is evolving over time with guidance from researchers and collaborators. Table 1 below summarizes the current status regarding available data and future needs regarding these hypotheses.

Table 1. RWAMP predictions and data needs.

Prediction	Data Currently being collected?	If No, Does RWAMP Address?
P1*	No	Yes, n>10 locations/animal/season
P2	Yes, baseline established	
P3*	No	Yes, n>10 locations/animal/season
P4	Yes, baseline established	
P5	Yes, baseline established	
P6	Yes	
P7	Yes	
P8	Yes	

\* P1 and P3 are critical in validating the underlying tenet of the RWAMP - that space is limiting and red wolves will exclude eastern coyotes. Data with regard to these predictions is critical to assess the feasibility of managing hybridization, and thus whether red wolves can coexist with eastern coyotes. These predictions are not being tested because few eastern coyotes are monitored in areas of red wolf establishment.

Figure 1. Map of the NENC red wolf recovery area showing CBSG identified management zones.



Figure 2. Map of the NENC red wolf recovery area showing the modified management zones.



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