Red Wolf
(Canis rufus)

5-Year Status Review: Summary and Evaluation

U.S. Fish and Wildlife Service
Southeast Region
Red Wolf Recovery Program Office
Alligator River National Wildlife Refuge
Manteo, North Carolina

September 28, 2007

5-Year Status Review
Red Wolf (*Canis rufus*)

Table of Contents

5-YEAR STATUS REVIEW

Red Wolf (*Canis rufus*)

1. GENERAL INFORMATION

1.1. Reviewers

Lead Region:	Kelly Bibb, Endangered Species, Southeast Region, USFWS, (404) 679-7132
Lead Field Office:	Bud Fazio, Team Leader Red Wolf Recovery Program, Manteo, North Carolina (NC), (252) 473-1131, ext. 241
Cooperating Offices:	Will Waddell, Coordinator Red Wolf Species Survival Plan / Point Defiance Zoo and Aquarium (PDZA), Tacoma, WA (NWR = National Wildlife Refuge) St. Vincent NWR, Florida Cape Romain NWR, South Carolina Alligator River NWR, NC Pocosin Lakes NWR, NC Mattamuskeet NWR, NC Ecological Services Field Office, Raleigh, NC
Peer Reviewers:	Tim Langer, Ph.D, Bear Biologist, Appointed Commissioner, North Carolina Wildlife Resources Commission, Raleigh, NC Rolf O. Peterson, Ph.D, Wolf Ecology, Michigan Technological University, Houghton, MI Michael R. Vaughan, Ph.D, Population Dynamics and Ecology, Virginia Polytechnic Institute and State University. USGS-BRD Coop. Wildl. Res. Unit, Blacksburg, VA. See Appendix A for a complete list of peer reviewers and more details about their comments and the peer review process.

1.2 Methodology used to complete the review

This review was completed by Bud Fazio, Team Leader of the Red Wolf Recovery Program. The review was completed with assistance from field biologists of the Program, from other U.S. Fish and Wildlife Service (Service or USFWS) field stations, and from the Red Wolf Species Survival Plan Coordinator listed in Section 1.1 above. In addition to in-house reviews by Service experts, this document was peer reviewed. Peer reviewers provided individual, written responses that addressed scientific aspects of the 5-year review, but did not include review of the recommendation on status (refer to Appendix A). No part of this review was contracted to outside parties. All documents and literature used for this review are on file in the Red Wolf Recovery Program office located at Alligator River NWR headquarters in northeastern NC. Information used in constructing this review includes the recovery plan, species survival plan, and adaptive management work plan guiding red wolf field activities. Additional information used includes peer-reviewed manuscripts, symposium proceedings, technical reports, Service reports, published papers and notes and communications from other qualified biologists who have knowledge of red wolves and their habitat requirements. The public notice for this review was published on September 20, 2005, with a 60 day comment period (70 FR 55157).

1.3. Background

1.3.1. FR Notice citation announcing initiation of this review:

70 FR 55157, September 20, 2005

1.3.2. Listing history

<u>Original Listing</u>
FR notice: 32 FR 4001
Date listed: March 11, 1967
Entity listed: Species
Classification: Endangered

1.3.3. Associated rulemakings

Determination of Experimental Population Status for an Introduced Population of Red Wolves in North Carolina and Tennessee, 56 FR 56325, November 4, 1991.

Determination of Experimental Population Status for an Introduced Population of Red Wolves in North Carolina, 51 FR 41790, November 19, 1986.

Two non-essential experimental red wolf populations (NEP) were designated in North Carolina and Tennessee (Parker and Phillips 1991). One population was established in 1991 in the Great Smoky Mountains National Park of eastern Tennessee and western North Carolina; this population was discontinued in 1998 primarily due to poor pup survival caused by domestic dog disease (Henry 1998). The other population began in 1987 on the Albemarle Peninsula of northeastern North Carolina near the Outer Banks region; this population is currently the only population of red wolves known to exist in the wild. (See section 2.3.2.4 for details on the NEP designation under the Endangered Species Act).

These regulations below describe special flexible regulations for people living in the vicinity of the two experimental populations.

Revision of the Special Rule for Nonessential Experimental Populations; 60 FR 18940, April 13, 1995.

Determination of Experimental Population Status for an Introduced Population of Red Wolves in North Carolina and Tennessee, 58 FR 52031, October 6, 1993.

1.3.4. Review history

Recovery/Species Survival Plan: 1990

Recovery Data Call: 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007

5-year review: November 6, 1991 (56 FR 56882) in this review, species were simultaneously evaluated with no in-depth assessment of the five factors as they pertained to the species' recovery. The notices summarily listed these species and stated that no changes in the species' status were appropriate at this time. In particular, no changes were recommended for the status of the red wolf.

5-year review: July 22, 1985 (50 FR 29901)

Various documents that have reviewed red wolf status since the last 5-year review are on file in the Red Wolf Recovery Program office. For example, see Kelly et al. (1999, 2004), Phillips (1995) and Phillips et al. (1995, 2003, 2004).

1.3.5. Species' Recovery Priority Number at start of review (48 FR 43098)

The red wolf has a Recovery Priority Number of 5C, indicating a species with a high degree of threat and a low potential for recovery.

1.3.6. Recovery Plan

The current *Red Wolf Recovery/Species Survival Plan* was approved in 1990 as a revised edition (USFWS 1990). The original and revised *Red Wolf Recovery Plans* (USFWS 1982, 1984) were approved when the only known remaining red wolves were held in captivity. These early versions of the plan were drafted after the Service and scientists realized red wolves were likely extinct in the wild by late 1980 (McCarley and Carley 1979; Service 1984, 1993), and before restoration efforts began in 1987 (Phillips and Parker 1988; Phillips 1994) at the Alligator River NWR.

1.3.7. Species Status: Declining short-term (2006 and 2007 Recovery Data Calls), but recorded as Improving long-term.

1.3.8. Recovery Achieved: 2 = 26% to 50% recovery objectives achieved (2007 Recovery Data Call)

2. REVIEW ANALYSIS

2.1. Application of the 1996 Distinct Population Segment (DPS) policy

The red wolf is not listed as a DPS. We currently recognize the red wolf as the species *C. rufus*. Some scientists (Wilson et. al 2000, 2003) believe the red wolf and the Algonquin wolf (*C. lupus lycaon*) should be classified together and renamed the eastern wolf (*C. lycaon*). If scientific consensus on the concept of the eastern wolf is reached, some justification may develop (Kyle et al. 2007, but see Murray and Waits 2007) for the Service to consider the red wolf a DPS of *C. lycaon* in the future. However, scientific consensus has not yet been achieved, so we currently recognize the red wolf as the species *C. rufus* (Audubon and Bachman 1851; Goldman 1937, 1944; Nowak 2002) with no DPS at this time. See Section 2.3 for discussion and updates regarding the genetics, origin, and taxonomy of the red wolf.

2.2. Recovery Criteria

The red wolf has a final approved recovery plan that contains objectives that are measurable (USFWS 1990). The recovery plan does not reflect the best available information on the biology and habitat of its species. (See section 4.0 for recommendations to revise the plan). However, the recovery objectives still apply and can be used with new information to show how recovery actions have reduced threats to this species. (See section 2.3.1. for updates on progress in biology and habitat of red wolves.)

The current recovery plan (USFWS 1990) specifies the following objectives listed below.

1) Objective: Establish and maintain at least three red wolf populations via restoration projects within the historic range of the red wolf. Each population should be numerically large enough to have the potential for allowing natural evolutionary processes to work within the species. This must be paralleled by the cooperation and assistance of at least 30 captive breeding facilities in the U.S.

Progress: The Service has established and maintained one wild red wolf population via collaboration with partners and local communities on the Albemarle Peninsula in North Carolina. We currently have red wolves at 40 captive breeding facilities across the United States, but additional facilities are needed to expand the captive population as defined under objective 3 below.

2) Objective: Preserve 80% to 90% of red wolf genetic diversity for 150 years.

Progress: Via species survival plan coordination through the Association of Zoos and Aquariums (AZA), captive breeding program cooperators currently maintain 89.65 percent of red wolf genetic diversity expressed in the original founder population (Long and Waddell 2006).

3) Objective: Remove threats of extinction by achieving a wild population of approximately 220 wolves and a captive population of approximately 330 wolves.

Progress: The wild red wolf population in North Carolina fluctuates between 100 and 130 wolves in annual calendar year counts that are not necessarily population estimates. Field data from known wild red wolves since 1999 suggest a minimum wild red wolf population size which fluctuates between 80 and 100 wolves. We currently have 208 red wolves (90 males, 113 females, 5 unknown pups) at 40 captive breeding facilities across the United States, but additional facilities are needed to reach the objective of 330 red wolves in captivity. (See section 4, Recommendations for Future Actions).

4) Objective: Maintain the red wolf into perpetuity through embryo banking and cryogenic preservation of sperm.

Progress: Via species survival plan coordination through the Association of Zoos and Aquariums (AZA), reproductive studies focusing on semen collection and processing, cryopreservation, non-invasive evaluation of female reproductive cycles, and artificial insemination have resulted in steady progress (Goodrowe et al. 1998, 2000a, 2000b, 2001; Koehler et al. 1994, 1998; Lockyear 2006; Walker et al. 2002), but additional work to improve and refine techniques is ongoing.

2.3. Updated Information and Current Species Status

See Appendix B for a description of red wolf conservation efforts before 2000.

2.3.1. Biology and Habitat

a. New Interpretations of Red Wolf Historic Range

Today, the majority of authors still agree that red wolves occurred historically in the United States from south central Texas to Florida, and north to the Ohio River (Nowak 1979). Nowak (1995) extended the historic range of red wolves into Pennsylvania, and Nowak (2002) extended the range into New England as far as south central Maine. Nowak (2002) also suggested that red wolves may have extended historically into eastern Canada, blending with gray wolves to create the Algonquin wolf (*C. lupus lycaon*). Lending support to Nowak's suggestion, or otherwise to the concept of the eastern wolf (*C. lycaon*), Wilson et al. (2003) described historic museum samples labeled in the late 1800's as gray wolves from New England, but found they contained new world DNA, not gray wolf DNA, that some scientists interpret to be coyote-like DNA.

Post-colonial information documents the presence of wolves in New England (Cronan 2003; Krohn 2006, Univ. of Maine, unpublished data), but which wolf species occurred there historically is subject to further discussion. Physical specimens and pre-Columbian information are scarce for New England, so a combination of reasoning, science, historic accounts and minimal physical evidence potentially support the occurrence of red wolves (*C. rufus*, Nowak 2002), eastern wolves (*C. lycaon*, Wilson et al. 2000, 2003; Kyle et al. 2007), or gray wolves (*C. lupus*, Foster et al. 2002, Paquet et al. 1999; Wydeven et al. 1998). Occurrence of these three kinds of wolves in New England may have differed over geologic time. Yet, reasoning based on the ecology of wolves and their prey leads us to believe the northeastern United States and southeastern Canada were likely a contact zone between the smaller red wolf in the south and the larger gray wolf in the north (Amaral 2007 *in litt.*). This north/south interface likely occurred where the northern edge of mixed coniferous-deciduous forest with smaller prey (white-tailed deer) met the southern edge of boreal forest with larger prey (moose, caribou, elk). Areas of overlap could have brought the two wolves together in evolutionary time to form the eastern wolf, but full scientific consensus has not yet been reached regarding the eastern wolf concept.

b. Three Hypotheses - Updates of Red Wolf Origin and Taxonomy

The Service currently recognizes the red wolf as the species *Canis rufus*. Species status is supported in part by recent genetic findings where mtDNA sequencing of 340 base pairs of the control region revealed a unique sequence (haplotype) in red wolves that has not been observed in coyotes, gray wolves, or dogs (Adams 2002; Adams et al. 2003a); this DNA sequence differed from coyote sequences by 4 to 34 base pair changes. Species status is also supported by morphological, paleontological and other data described and discussed by Goldman (1937, 1944), by Henry (1992), by McCarley (1962), by Nowak (1979, 1992, 1995, 2002), by Nowak and Federoff (1996, 1998), by Nowak et al. (1995), and by Paradiso and Nowak (1971, 1972).

Nowak (2002) suggested the red wolf is the original small wolf of the eastern United States, descended from the Eurasian wolf (*Canis mosbachensis*). Small North American descendents of the Eurasian wolf became isolated by glaciation, leaving the red wolf to persist 10,000 years into the 20th Century. Reich et al. (1999) suggested the red wolf resulted from natural evolutionary hybridization between gray wolves and coyotes up to 12,000 years ago. Wilson et al. (2000) suggested red wolves, Algonquin wolves (*C. lupus lycaon*), and coyotes diverged in a separate line of evolution away from gray wolves approximately 1.2 million years ago, followed by divergence of coyotes away from red and Algonquin wolves approximately 150,000 to 300,000 years ago. Hedrick et al. (2000, 2002, and 2004) showed major histocompatibility complex genetics data which indicates red wolves are more closely related to coyotes than to gray wolves.

Red wolves were originally described by Audubon and Bachman (1851) as a subspecies (*rufus*) of the gray wolf (*C. lupus*), and reasoning supporting this possibility is provided by Phillips and Henry (1992). Goldman (1937, 1944) combined *rufus* with other wolves of the southeast USA to form the distinct species of red wolf (*C. rufus*) separate from gray wolves. Numerous other studies supported Goldman's suggestions until approximately 1990. With the onset of applied genetic techniques came new hypotheses suggesting the red wolf evolved via natural evolutionary hybridization between gray wolves and coyotes (Roy et al. 1994, 1996; Wayne and Jenks 1991; Wayne 1992; Wayne and Gittleman 1995; Wayne et al. 1998; Reich et al. 1999; but see Gardner 1998 and Mech 1970).

Wilson et al. (2000, 2003) suggested the red wolf and Algonquin wolf are similar enough genetically to be combined into one species newly named the eastern wolf (*C. lycaon*). Kyle et al. (2006, 2007) supported the hypothesis, recognizing the eastern wolf as taxonomically distinct from gray wolves and coyotes. Murray and Waits (2007) debated with Kyle et al. (2007) about potential management implications for red wolves, considering their possible conspecific relationship with Algonquin wolves. We await further scientific data, discussion, debate and consensus for consideration concerning the taxonomic and related management status of red wolves.

See Appendix C for additional notes on the origin, taxonomy, genetics and management of the red wolf NEP.

c. Red Wolf Genetics and Management

Conservation of the red wolf gene pool and associated genetic fitness are primary concerns in the red wolf recovery and species survival plan (USFWS 1990). The current red wolf captive breeding program began with 14 founders. With very small populations, survival can be affected by genetic drift (random loss of genetic diversity) and inbreeding depression (i.e., increased genetic homozygosity and subsequent expression of deleterious genes). Genetic diversity of less than 90 percent in founder populations can result in compromised reproduction (Garelle et al. 2006). Gene diversity in the current captive red wolf population is approximately 89.65 percent of that in the founder population (Long and Waddell 2006). Kalinowski et al. (1999) reports no inbreeding depression in the red wolf captive program. However, physical anomalies have been observed in a small number of captive and wild red wolves such as progressive retinal atrophy, malocclusion and undescended testicles (Waddell, pers. comm. 2007). Yet, steady progress is being made in red wolf reproductive research (section 2.2) in the captive breeding program that includes two red wolf litters produced in 1992 and 2003 via artificial insemination (Lockyear 2006).

Kelly et al. (1999) recognized that interbreeding between eastern coyotes and red wolves produces hybrids and results in coyote gene introgression into the wild red wolf population. To reduce introgression and interbreeding while simultaneously building a restored red wolf population, an adaptive management work plan was developed (Kelly 2000; Fazio et al. 2005). The adaptive plan effectively uses techniques similar to Bromley and Gese (2001) to sterilize hormonally intact coyotes and hybrids via vasectomy and tubal ligation, then use them as territorial “place-holders” until replaced by wild red wolves. “Placeholder” canids will not interbreed with wild red wolves, and they exclude other coyotes or hybrids from the territory they hold. Ultimately, the “place-holder” canids are replaced by red wolves either naturally (e.g. displacement) or via management actions (e.g., removal followed by pairing wild or translocated wolves into the territory). The adaptive plan is effective because we utilize newly developed non-invasive, genetics-based techniques to identify canids in the field (Adams 2002, 2006; Adams and

Waits 2007; Adams et al. 2003a, 2007; Waits 2004; Waits and Paetkau 2005), incorporating methods developed by Miller et al. (2002, 2003).

We have effectively reduced interbreeding and coyote gene introgression using the adaptive plan and associated non-invasive techniques, all with assistance from scientists on the Red Wolf Recovery Implementation Team (Adams 2006, Beck 2005, Stoskopf et al. 2005). Early models by Dr. Phil Hedrick in 2001 showed sterile hybrids function as effective "place holders." Modeling by Hedrick in 2002 projected another 60 years of adaptive management would bring the red wolf NEP to the level of 99% red wolf genes, effectively reducing coyote gene introgression to acceptable biological levels (1%). Hedrick's projection implied dramatic improvement in the restored red wolf population over the former 15% coyote gene introgression reported by Kelley et al. (1999). Further simulation modeling by Frederickson and Hedrick (2006) confirmed our sterilization method can be effective, but also emphasized long-term reproductive barriers are important, especially assortative mating and red wolf challenges to coyotes or hybrids. To date, red wolf biologists have documented 32 events since 1993 where a red wolf displaced or killed a non-wolf (coyote or hybrid). In contrast, red wolf biologists and Red Wolf Recovery Implementation Team scientists have not been able to document any evidence of reciprocal activity (i.e. usurpation or killing of red wolves) by coyotes or hybrids.

Advances in genetics and associated field techniques provide new information helpful in managing wild red wolves. Using data on grizzly bears (*Ursus arctos),* Miller and Waits (2003) demonstrated that only a small number of individuals per generation are needed to maintain sufficient genetic diversity in a carnivore population, and we believe this to be true also for red wolves. Adams (2006) noted strong evidence that a single hybridization event in 1993 resulted in most introgression of coyote genes into the red wolf population observed to date. From this evidence, Adams (2006) infers that hybridization with coyotes has had less genetic impact on the restored red wolf population than originally thought by Kelly et al. (1999), largely because backcrossing has been rare in the population.

d. Dynamics of the Restored Red Wolf Population

Recent calendar year counts for red wolves in the wild population fluctuate between approximately 100 to 130 red wolves, depending on births, deaths, related social dynamics, and other factors (Figure 1; Table 1; see also section 2.3.2.). Field data from known wild red wolves since 1999 suggests a minimum red wolf NEP size which fluctuates between 80 and 100 wolves. The number of breeding social groups maintaining territories rose to 22 in 2004, fell to 15 in 2005 and 2006, then rose to 20 in 2007 (Figure 4, below).

Table 1 and Figures 1, 2, 3 and 4, below, show upward trends in red wolf population parameters (i.e. calendar year counts for adults and pups born, wolf litters, and breeding pairs over time). Table 1 and Figure 1 show the annual calendar year counts of red wolves in the NEP (D. Murray 2007, unpublished data; Service 2007, unpublished data). Table 1 and Figure 1 also contain separate data describing the number of red wolf pups born each calendar year, as tracked by red wolf biologists during field activity (Service 2007, unpublished data). Note that the numbers in Table 1 represent animals known to be alive during a given calendar year, and therefore do not constitute an actual population size estimate. Figures 2 and 3 show the upward trend in number of red wolf litters born annually, while Figure 3 shows the low occurrence of hybrid litters subsequently removed once found (Service 2007, unpublished data). Figure 4 shows a rise in number of red wolf breeding pairs over time (Service 2007, unpublished data).

Table 1. Annual calendar year counts of red wolf adults and pups for free-ranging red wolves in eastern North Carolina (1990 to 2006).

YEAR	NUMBER OF RED WOLVES	PUPS
1990	18	3
1991	27	13
1992	26	5
1993	44	16
1994	78	35
1995	74	23
1996	70	16
1997	85	21
1998	95	12
1999	126	37
2000	128	25
2001	131	37
2002	123	33
2003	119	39
2004	125	55
2005	115	41
2006	114	51

Figure 1. Annual counts of free-ranging red wolves in North Carolina (1990 through 2006) are shown in red with square marks. Annual counts of pups are shown in blue with diamond marks. Annual counts do not constitute actual population size estimates.

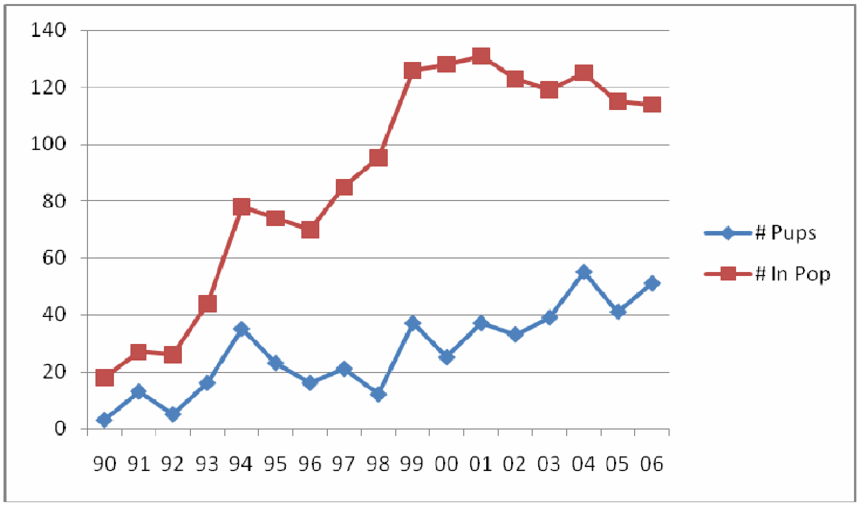


Figure 2. Number of known red wolf pups born annually from 1987 to 2007. The blue line (diamonds) and the red line (squares) indicate the number of pups respectively born before and after adaptive management plan implementation.

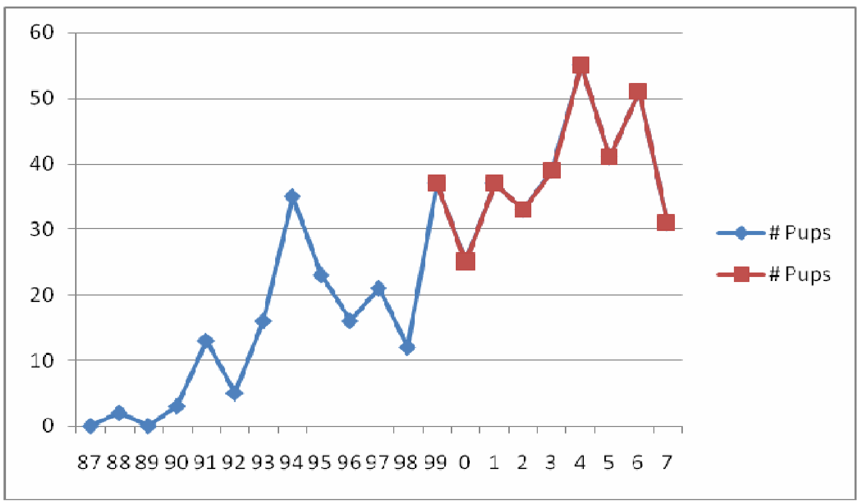


Figure 3. Annual number of litters found from1988 to 2007. The gold (tall) bars indicate red wolf litters, while the red (short) bars indicate hybrid litters detected. Hybrid litters were promptly removed from the red wolf population area.

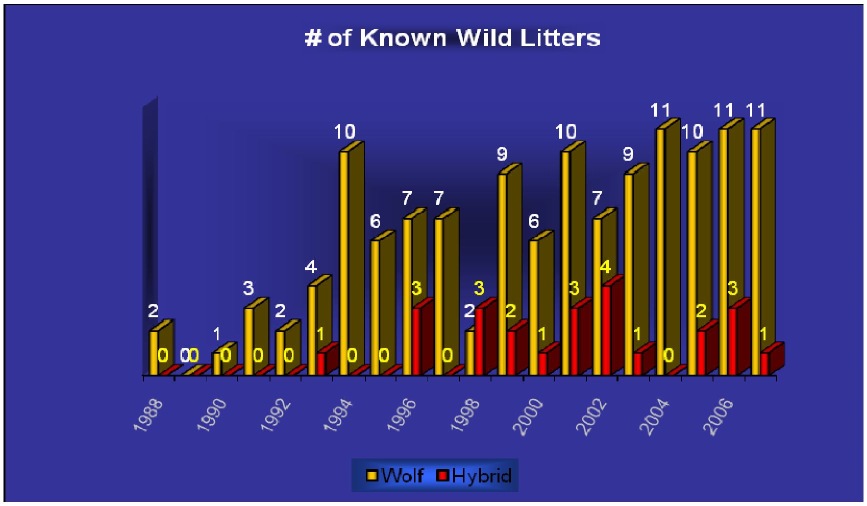
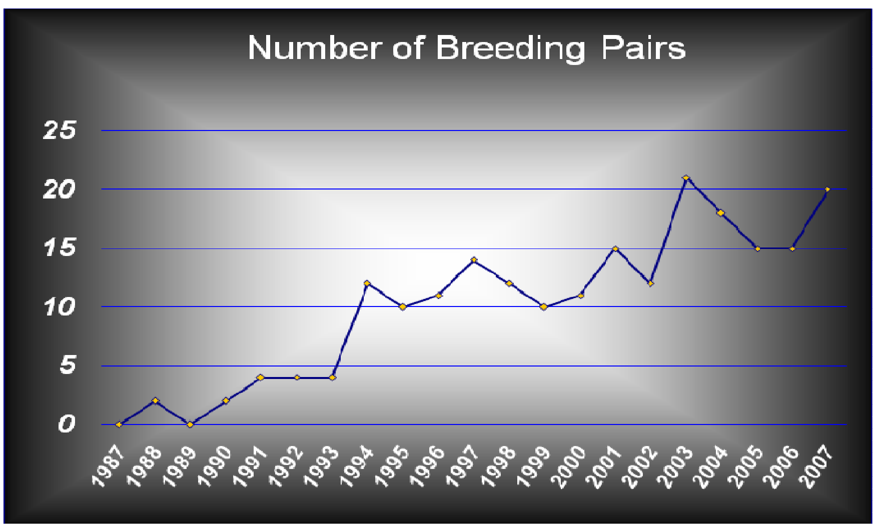


Figure 4. Annual number of known red wolf breeding pairs from 1987 to 2007.



Red wolf biologists recorded a total of 495 pups born between 1987 and 2007. Figure 2 shows 146 pups were born prior to, with 349 pups born after, implementation of the adaptive management work plan in late 1999 and early 2000 (Kelly 2000, Fazio et al. 2005). In 2007, 31 red wolf pups were born (Figure 2), a decline of 20 pups compared to 51 pups the previous year. Murray (2007, unpublished data) reported litter sizes are largest among adult breeding pairs approximately 5 to 6 years old. The Service noted a significant milestone achieved in winter of 2002, when Service data showed all red wolves in the NEP at that time were actually born in the wild. In other words, the wild NEP no longer contained captive-born nor island-born red wolves in early 2002; the NEP was reproducing in the wild on its own without augmentation by the Service.

Excluding uninhabitable locations rigorously surveyed, roughly two-thirds of the five-county red wolf NEP area (i.e. the Albemarle Peninsula, hereafter called Peninsula) is currently occupied by red wolf territories. (See section 2.3.2.4 for further details.) Red wolf field biologists believe there is enough space available on the western end of the Peninsula for wild red wolves to establish additional territories, though some of the remaining habitat may be of low quality. Yet, Stoskopf (2007 *in litt.*), Murray (2007 *in litt.*), and Knowlton (2007 *in litt.*) suggest the wild red wolf population may have reached its functional carrying capacity with little room for significant additional numbers of wolves on the Peninsula, noting that suitability of remaining habitat may be poor. If this is true, the red wolf NEP will fall below the 220 wolves identified in the recovery plan as a population objective, making additional population release sites necessary to achieve further red wolf restoration and recovery. (See section 4.)

Recognizing the limitations of the counts in Table 1 in accurately reflecting actual red wolf wild population size, we can inform our general understanding of population status by fitting growth models to time series (D. Murray 2007, unpublished data). Of the four models under consideration (density-independent, logistic density-dependent, theta-logistic density-dependent, inverse density-dependent), superior fit was obtained from the linear density dependent model for both the total number of wolves (column 2 in Table 1, corresponding to maximum population count), and total number excluding pups (column 2 minus column 3 in Table 1, corresponding to number of yearlings and adults only in the population). For the total count, intrinsic rate of increase (r_{max}) for the population is 0.346 (0.037, 0.655; 95% CI) which is generally comparable to rates of increase observed in other wolf populations (see Fuller et al. 2003); this rate is also similar to population growth recently observed in gray wolves translocated to Yellowstone National Park and central Idaho. In this exercise, the estimated carrying capacity (K) of red wolves in the NEP is 138.7 (66.0, 211.4), which implies that the population reached its plateau in 2001. However, we remind that this estimate should be considered highly qualitative given the uncertainty associated with the population time series used to generate the growth curve. We also note that in 2001 approximately 40% or more of the Peninsula land area was not yet occupied by red wolf territories, leading us to believe population expansion would continue in subsequent years. Additional analysis of red wolf population status, using demographic population projections and habitat suitability thresholds, likely will provide a more robust red wolf population status assessment.

Preliminary population viability analyses revealed early estimates of survival for the red wolf NEP (D. Murray 2004, unpublished data). Annual survival rates in the wild NEP were 78.2% overall, with adults (80.6%), pups (67.8%), and yearlings (79.3%) all showing high survival rates that reflected a stationary or increasing red wolf population (Figure 5). Annual survival rates for male (76.8%), female (79.6%), wild born (83.6%), island-reared (67.3%), and captive-reared (56.8%) red wolves were also reported (Figure 6). The survival rates for lone red wolves (66.8%) differed sharply from red wolves in a group (81.3%).

Figure 5. Survival rates of wild red wolves (D. Murray 2004, unpublished data). Rates are high relative to other canid species.

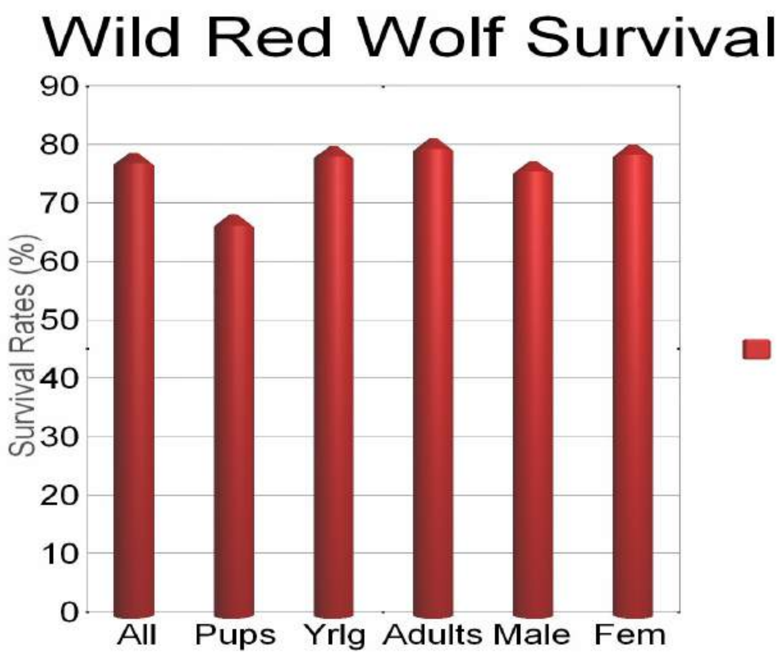
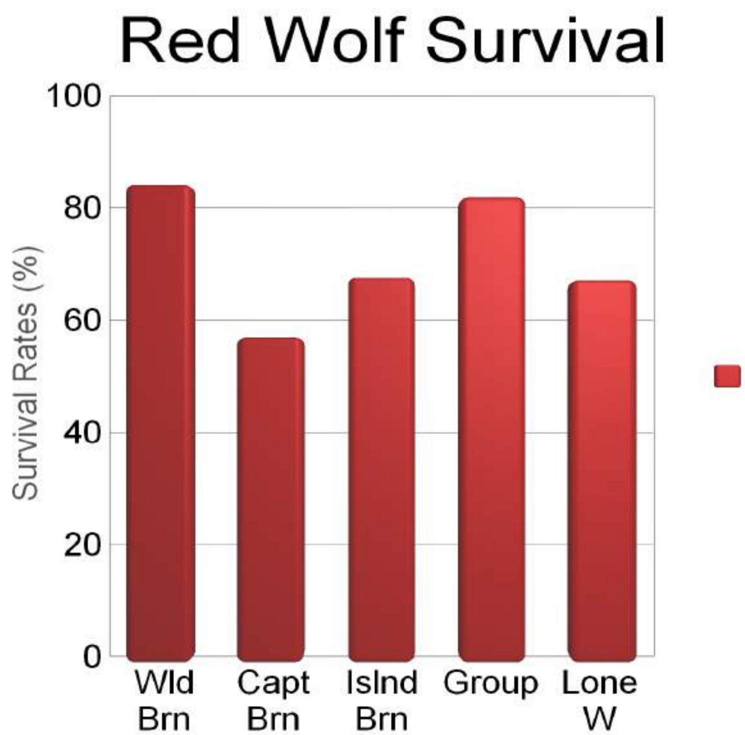


Figure 6. Survival rates of specific red wolf cohorts (D. Murray 2004, unpublished data). Wild born red wolves showed higher survival than captive born or island born red wolves. Red wolves in a group showed higher survival than lone wolves.



New survival figures will be calculated and published from on-going population viability analyses by Dr. Murray and colleagues during the next few years. Currently, correlates of red wolf survival, productivity, and dispersal (i.e., genetic factors, habitat occupation patterns, demographic attributes) are being examined via model selection and multi-model inferences to better understand determinants of red wolf population status in North Carolina. A discussion of population viability analyses performed as part of recovery planning can be found in Morris et al. (2002).

From 270 known red wolf losses in the NEP during the time period of September 1987 through January 2007, figures were calculated (D. Murray 2007, unpublished data) which showed proportions of red wolves lost to vehicle strikes (17.4%), illegal/incidental activity (19.2%), natural causes (22.2%), unknown causes (19.2%), and management actions (21.1%). From 166 known red wolf losses in the NEP during the period of

1999 through 2006, figures were calculated (Service 2007, unpublished data) which showed proportions of red wolves lost (Figures 7, 8, 9) to gunshot (22%), disappearance (22%), vehicle strikes (14%), management (13%), unknown causes (11%), mange disease (8%), intraspecific aggressions (wolves killing wolves, 5%), poison (3%) and accidental loss during private trapping activity (2%). Preliminary analysis shows the majority of management mortality is accounted for by trapping incidents (e.g., drowning, injury, etc.) and by changes in genetics identification methods earlier in the program. We used 8 known gene loci to identify canids earlier in the program, whereas we used 19 loci to identify canids later. This change in known loci informed us some canids formerly identified as hybrids were unfortunately wolves euthanized before newer identification methods became available. Overall, Figure 8 shows gunshot and disappearance are the leading losses among 67 red wolf breeders, while Figure 9 shows the leading losses of 99 red wolf non-breeders are vehicle strikes, gunshot and disappearance. A breeder is a paired adult wolf holding territory that potentially will dig dens and birth pups in a given calendar year. Age of breeding can be 2 years and up. A non-breeder is a single wolf not holding territory and likely to travel more widely. Both sets of loss figures show more than half (at least 58%) of red wolf losses are directly or indirectly related to human activity. Preliminary analysis of these data suggests the high proportion of red wolf losses from human factors is additive (and not compensatory) to other mortality sources (D. Murray 2007, unpublished data).

Figure 7. Pie chart showing loss of red wolves in the NEP calculated from 166 red wolves lost (1999 – 2006).

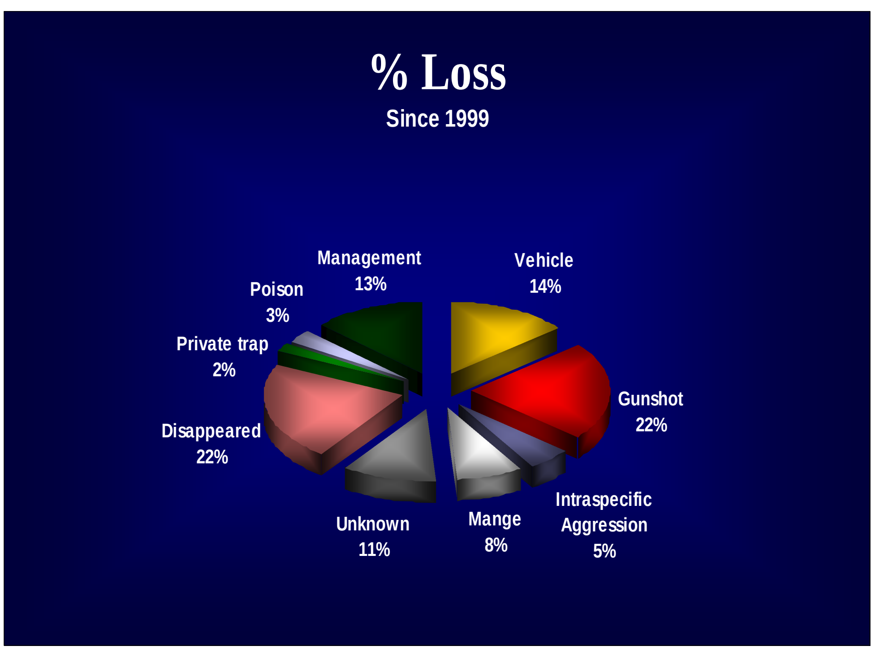


Figure 8. Pie chart showing loss of 99 non-breeding red wolves in the NEP (1999 – 2006). Vehicle strike, gunshot, and disappearance are the leading categories of non-breeder loss.

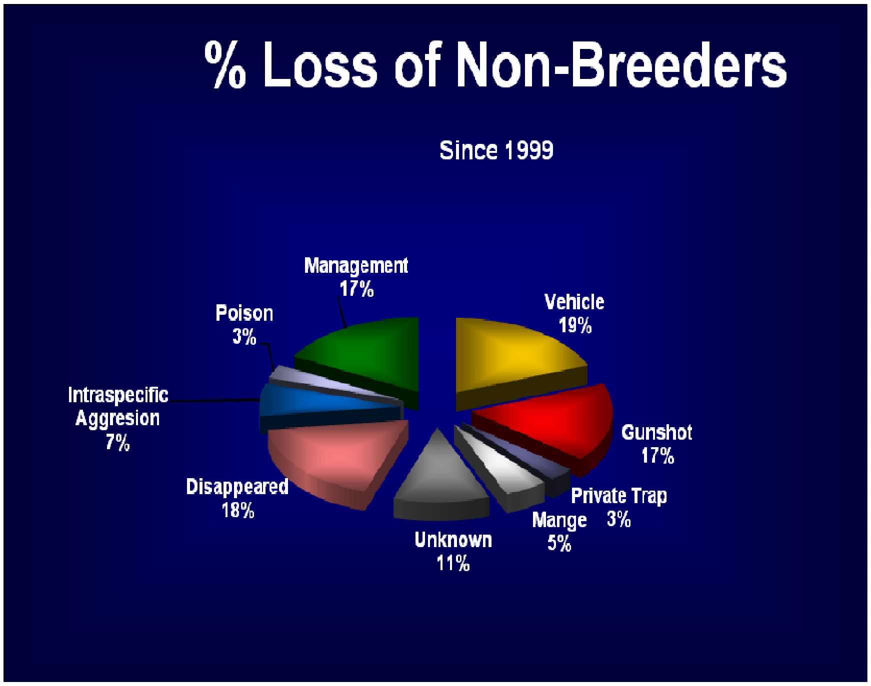
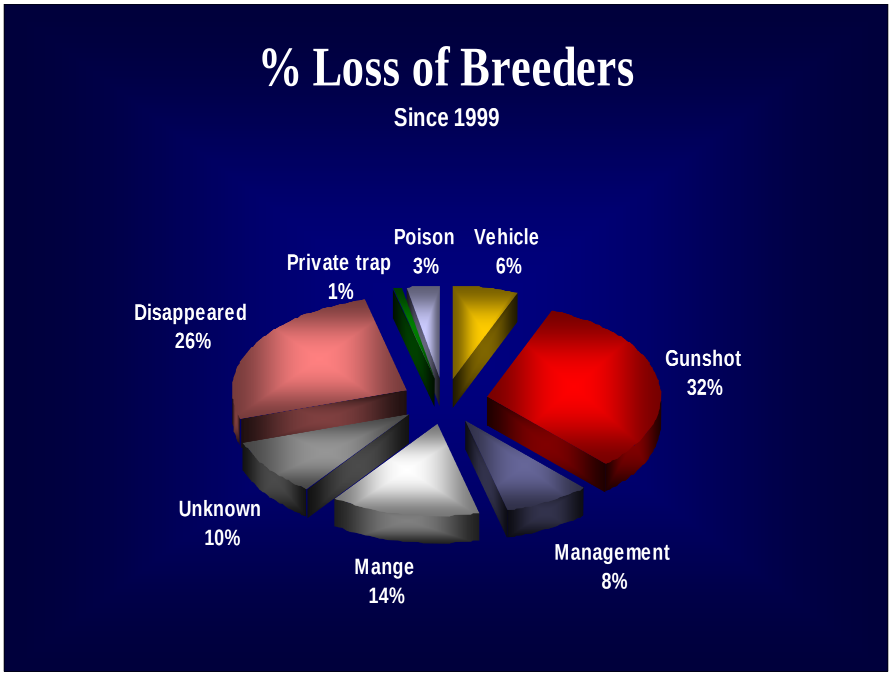


Figure 9. Pie chart showing loss of 67 breeding red wolves in the NEP (1999 – 2006). Gunshot and disappearance are the leading categories of breeder loss.



During the past five years, pup fostering has developed as a significant and useful population management tool in red wolf recovery (Waddell et al. 2002; Kitchen and Knowlton 2006). Fostering involves placing captive-born pups less than two weeks old into the den of wild red wolf parents. The parents adopt and raise the fostered pups, teaching them valuable survival skills. Twenty red wolf pups were fostered into the NEP in 2002, 2004, 2006 and 2007, including 9 wild born pups. Facilities in the red wolf captive program provided 9 pups, and the Bulls Island (Cape Romain NWR) propagation site provided 2 pups. Fostering offers many options, including augmentation of the wild red wolf gene pool with "under-represented" genes from the captive red wolf population.

See Appendix D for additional new information useful in red wolf NEP management.

2.3.2. Five Factor Analysis

2.3.2.1. Present or threatened destruction, modification or curtailment of habitat or range.

Red wolves declined early in the settlement history of North America, long before scientists could fully study and observe them in unaltered native habitat. It is possible red wolves used higher elevation habitat in hills and mountains of eastern North America, but supporting documentation is scarce. Red wolves may have occurred in extensive bottomland forests and wetlands along rivers of the southeastern United States (Paradiso and Nowak 1971, 1972; Riley and McBride 1972). The few remaining wild red wolves captured during the mid-1900's used prairies and wetlands of coastal Texas and Louisiana (Carley 1975; Shaw 1975); these locations were less altered or less disturbed by human activity, but were possibly marginal for red wolves.

We can infer functional habitat for red wolves from the kinds of habitat used in the North Carolina NEP. Since 1987, red wolves restored in the NEP have used a mosaic of habitat types across 1.7 million acres that include wetlands, pine forests, upland shrubs, crop land, and pocosins. Christensen et al. (1981) described pocosins as wetland forests with pine tree overstory and evergreen shrub understory. Wooded areas seem important for dens and pup rearing, though dens are built in a variety of habitat types (Hinton 2006, Kelly et al. 2004, Phillips et al. 2004). Red wolves in the NEP frequently have used edge interface habitat for ease in travel and access to prey. Hahn (2000) suggested low human density, wetland soil type, and distance from roads may influence habitat suitability for red wolves in the NEP. We also know that large acreage, rural or wild settings, and the abundance and diversity of prey species are important factors in success of the red wolf NEP. Overall, these observations suggest red wolves are habitat generalists able to live in areas where prey and shelter are sufficient, so long as habitat fragmentation, disturbance or harassment by humans are minimal or do not occur.

To better understand red wolf habitat requirements and examine potential influences by population variables, we work with scientists to develop resource selection functions (RSF's) for red wolves in the North Carolina NEP. We collaborate with scientists involved in similar work on Algonquin wolves (*C. lupus lycaon*; or, eastern wolves, *C. lycaon*) in Algonquin National Park, Ontario, Canada. We will use RSF's developed for wolves in both the North Carolina NEP and Algonquin Park to develop spatial models of wolf habitat requirements in eastern North America. Over the next few years, these spatial models will be applied to regions across the eastern United States to evaluate candidate areas for additional red wolf population releases.

For centuries, fragmentation in red wolf historic range has come in the form of habitat conversion and land development by humans. Proposed development projects on the Albemarle Peninsula will have short-term and long-term effects on red wolves in the NEP unless potential effects are addressed early via planning, designs, and project implementation. We ask managers of large development projects on the Albemarle Peninsula to work with us in incorporating red wolf recovery concerns. Development projects could incorporate such concepts as habitat corridors, habitat linkages, population genetics, prey species, red wolf sociality, movements and dispersal. Efforts to address potential effects of proposed development projects are further discussed in sections 2.3.2.4 and 2.3.2.5 below.

Viable populations of wildlife, such as red wolves and their prey, depend on movement and dispersal to maintain genetic diversity. Barriers to dispersal that fragment habitat (e.g., highways, airports, or large fenced areas) can have long-term effects upon genetic diversity. For restored populations of small size, such as the red wolf NEP, fragmenting barriers can magnify these genetic effects and potentially dampen or reverse population growth to a greater degree.

Riley et al. (2006) found a southern California freeway is a significant barrier to gene flow for western coyotes (*C. latrans*) and bobcats (*Lynx rufus*). Roads or other linear barriers may also cause changes in use of spatial habitat, affecting population stability via region-wide social organization. For gray wolves (*C. lupus*), a Wisconsin highway did not influence wolf movements (Kohn et al. 1999), whereas a fenced freeway in Banff National Park, Alberta, Canada, significantly hindered movements of wolves and other carnivores (Paquet and Callaghan 1996). Animal overpass structures helped to mitigate barrier effects in Banff National Park (Clevenger and Waltho 2000, 2005). Forman et al. 2003 found that wolves prefer large, open wildlife overpass or underpass structures.

Habitat fragmentation remains one of the biggest challenges in red wolf recovery. Fragmentation contributed to the initial decline of the red wolf species. Now, fragmentation threatens red wolves in the North Carolina NEP via proposed barriers and habitat conversion on both public and private land. Because red wolves are wide-ranging in their movements, conservation of large tracts of wildlife habitat is beneficial across their historic range. This is especially important if we are to eventually restore two additional red wolf populations within their historic range.

2.3.2.2. Overutilization for commercial, recreational, scientific, or educational purposes.

We do not consider over-utilization for commercial, recreational, scientific, or educational purposes to be a direct threat to the species. Red wolves are not legally hunted or trapped, aside from incidental or special permitted events. We are not aware of any deliberate trade in red wolves or in their parts. However, sections 2.3.2.4 and 2.3.2.5 highlight problems related to state licensed or permitted utilization (i.e. wildland hunting, hunt enclosures, trapping) of other species which sometimes results in red wolf injury and mortality.

All red wolves are currently located either in captive breeding facilities, at two island propagation locations, or in one heavily managed and monitored NEP that occurs across the 1.7 million acre Albemarle Peninsula. The captive red wolf population is managed under an AZA (Association of Zoos and Aquariums) species survival plan to conserve the red wolf genome, coordinate captive breeding, provide select red wolves for restoration in the wild, and advance the sciences of cryopreservation and banking of red wolf gametes. Thus, captive red wolves are utilized for conservation, propagation, and selectively for both scientific and educational purposes (USFWS 1990). However, because these activities are focused toward specific recovery and conservation objectives, they are not considered over-utilization for commercial, recreational, scientific, or educational purposes.

2.3.2.3. Disease or predation

Because canid diseases can spread quickly, they can cause serious setbacks in red wolf recovery. Canid diseases remain a serious threat to the red wolf NEP and to captive red wolves. The magnitude of risk to the red wolf species overall is partly offset by captive red wolves held in 40 facilities across America. Risk of disease is also partly offset by intensive vaccination programs for both wild and captive red wolves. However, veterinary research scientists caution we should not presume vaccinated red wolves are adequately protected against diseases. An example is CPV2 parvovirus, a disease which could have serious impacts upon pup survival in the NEP (Action et al. 2007, *in review;* Stoskopf 2007 *in litt*.). Acton and colleagues found that titers against parvovirus are not detectable in a large portion of vaccinated red wolves, indicating the NEP is still very much at risk to CPV2 parvovirus. This is important because poor pup survival from parvovirus caused the Service in 1998 to discontinue the Great Smoky Mountains red wolf NEP (Henry 1998).

Additional precautions are needed to proactively address potential disease outbreaks in the red wolf NEP and captive population. Establishing two more NEPs within red wolf historic range will partly alleviate disease risk. However, we are particularly concerned about import of existing and new strains of canid disease carried into a red wolf NEP by outside sources. Hunting dogs and imported coyotes from elsewhere in America are two outside sources of prime concern. (See section 4 for future recommended actions to be taken to address disease.)

Scientists on the Red Wolf Recovery Implementation Team recommended in 2006 that a red wolf disease prevention and surveillance program be developed to ensure long-term survival in the red wolf NEP. Specifically, a canid disease prevalence program should be developed and implemented in the five counties occupied by the NEP. The diseases of greatest concern are canine distemper (Genus *Morbillivirus; CDV),* canine parvovirus (Genus *Parvovirus; CPV1, CPV2),* leptospirosis (Genus *leptospira*), hemobartonellosis (*Haemobartonella canis*), borrelliosis (Lyme disease, *Borrelia sp.*), demodectic mange (*Demodex canis* mites), sarcoptic mange (*Sarcoptes scabiei* mites), heart worm (*Dirofilaria immitis*), and rabies (Genus *Lyssavirus, rabies virus*). We are fortunate that none of these diseases to date have occurred at sufficiently high levels to cause an epidemic in the current NEP. However, sarcoptic mange contributed to the deaths of 14 red wolves in the NEP since 1999.

Numerous diseases and other ailments have been documented during the past thirty years in individual red wolves. During 2007, we observed eye entropia in three young captive program red wolves being held at Alligator River NWR. Other physical anomalies were observed in captive red wolves in recent years, such as progressive retinal atrophy, malocclusion and undescended testicles (Waddell, Pers. Comm. 2007). Heartworms, hookworms (*Ancylostoma caninum*), and sarcoptic mange, are serious concerns, but heartworms and hookworms have so far not been identified as a significant source of mortality in the NEP (USFWS 1990; Phillips and Scheck 1991). Tick paralysis was reported by Beyer and Grossman (1997), while Rothschild et al. (2001) reported arthritis, and Harrenstein et al. (1997) reported antibody responses to canine distemper and canine parvovirus indicating prior exposure. Penrose et al. (2000) reported the lyme disease causing bacteria *Borrelia burgdoferi* in a red wolf. Neiffer et al. (1999) reported abdominal disease involving cecal inversion and colocolic intussusception. Kearns et al. (2000) reported dermatosis.

Acton et al. (2000) surveyed necropsy results in 62 captive program red wolves for the period of 1992 to 1996. They documented numerous ailments in individual red wolves of many different ages. Of 22 neonatal deaths, major causes included parental trauma, parasitic pneumonia, and septicemia (systemic bacteria often found in the blood). Two juvenile red wolves died of cardiovascular anomalies or systemic parasitism. Of 38 adult red wolf deaths, causes included neoplasia and gastrointestinal diseases. Of the fatal neoplasm conditions, 50% were lymphosarcoma.

Natural predation on red wolves is minimal, especially since red wolves are top predators in their ecosystem. Though uncommon, red wolves are most vulnerable as small pups exposed to threats of predation by black bears (*Ursus americanus*), bobcats (*Lynx rufus*), coyotes (*C. latrans var*.), alligators (*Alligator mississippiensis*),), eagles (*Haliaeetus leucocephalus* or *Aquila chysaetos*), hawks (*Buteo spp*.), or owls (*Bubo virginianus* or *Strix varia*).

2.3.2.4. Inadequacy of existing regulatory mechanisms

a. Designation and Restoration of Experimental Populations

Under section 10(j) of the Endangered Species Act of 1973 (Act), as amended (U.S.C. 16 section 1531 et seq.), the Secretary of the Department of the Interior may designate restored populations established outside the species' current range, but within its historical range, as "experimental." Based on the best scientific and commercial data available, we must determine whether experimental populations are "essential" or "nonessential" to the continued existence of the species. Regulatory restrictions are considerably reduced under a NEP designation.

Without the NEP designation, the Act provides that species listed as endangered or threatened are afforded protection primarily through the prohibitions of section 9 and the requirements of section 7. Section 9 of the Act prohibits the take of an endangered species. "Take" is defined by the Act as "harass, harm, pursue, hunt, shoot, wound, trap, capture, or collect, or attempt to engage in any such conduct." Service regulations (50 CFR 17.31) generally extend the prohibitions of take to threatened wildlife. Section 7 of the Act outlines the procedures for Federal interagency cooperation to conserve federally listed species and protect designated critical habitat. It mandates that all Federal agencies use their existing authorities to further the purposes of the Act by carrying out programs for the conservation of listed species. It also states that Federal agencies will, in consultation with the Service, ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat. Section 7 of the Act does not affect activities undertaken on private land unless they are authorized, funded, or carried out by a Federal agency.

A population designated as experimental is treated for the purposes of section 9 of the Act as threatened, regardless of the species' designation elsewhere in its range. Threatened designation allows us greater discretion in devising management programs and special regulation for such a population. Section 4(d) of the Act allows us to adopt whatever regulations are necessary to provide for the conservation of a threatened species. In these situations, the regulations that generally extend most section 9 prohibitions to threatened species do not apply to NEPs, although the special 4(d) rule contains the prohibitions and exceptions necessary and appropriate to conserve that species. Regulations issued under section 4(d) for NEPs are usually more compatible with routine human activities in the NEP area.

For the purposes of section 7 of the Act, we treat a NEP as a threatened species when the NEP is located within a National Wildlife Refuge or National Park, and section 7(a)(1) and the consultation requirements of section 7(a)(2) of the Act apply. When NEPs are located outside a National Wildlife Refuge or National Park, we treat the population as proposed for listing and only two provisions of section 7 apply: section 7(a)(1) and section 7(a)(4). In these instances, NEPs provide additional flexibility because Federal agencies are not required to consult with us under section 7(a)(2). Section 7(a)(4) requires Federal agencies to confer (rather than consult) with the Service on actions that are likely to jeopardize the continued existence of a species proposed to be listed. The results of a conference are advisory in nature and do not restrict agencies from authorizing, funding, or carrying out activities.

b. NEP Status for Red Wolves on the Albemarle Peninsula

The current location of the red wolf NEP within historic range is the Albemarle Peninsula of northeastern North Carolina. The Peninsula is composed of five counties (Beaufort, Dare, Hyde, Tyrrell, Washington) and contains four National Wildlife Refuges (Alligator River NWR, Pocosin Lakes NWR, Mattamuskeet NWR, Swan Quarter NWR). The red wolf NEP began with the release of four pairs of wolves on the Alligator River NWR. The red wolf is otherwise believed to be extirpated from the wild, implying there are no other extant populations with which this NEP could come into contact (51 FR 41797; 58 FR 52031).

As described above, NEP status for red wolves on the Albemarle Peninsula means reduced protections for red wolves under the Act. However, NEP status is a helpful mechanism which allows us to work cooperatively with partners to enhance red wolf recovery and resolve problems. NEP status also allows flexibility for landowners, land managers, communities and other citizens (Parker and Phillips 1991). For example, the Federal rules (51 FR 41797 and 50 CFR 17.84) that contain necessary prohibitions and exceptions allow for take of red wolves which constitute a demonstrable threat to human safety or livestock, provided it has not been possible to eliminate such threat by live capture and relocation of the wolf.

On the Albemarle Peninsula, proponents should both consult formally under section 7(a)(2) and confer under section 7(a)(4) of the Act in cases when projects or activities with a Federal nexus have potential adverse effects to red wolves on NWR land and could jeopardize red wolves off NWR land. In these cases, formal consultation is required to address potential effects to red wolves on NWR land, while conferencing is done to address potential effects to red wolves not on NWR land. These cases result in the Service recommending consideration of the red wolf NEP as a whole in both biological assessment and biological opinion documents. Relevant project and effects information is written into a biological assessment to initiate formal consultation under section 7(a)(2).

We encourage partners and project proponents to weigh potential biological effects on red wolves across the entire NEP in overall support of our effort to recover red wolves, even though as stated above, the results of a conference report are advisory in nature. For example, proposed expansion of U.S. Highway 64 from Columbia to Manns Harbor could mean impacts of habitat fragmentation, barriers to red wolf gene flow, and increases in red wolf mortality from vehicle strikes. Considering the level of protection red wolves receive both on and off NWR land, we need partners like the Federal Highway Administration and the North Carolina Department of Transportation to assist us in addressing the recovery needs of the red wolf NEP during highway expansions. In another example, we are working with the U.S. Navy under sections 7(a)(2) and 7(a)(4) of the Act toward resolving potential adverse impacts upon red wolves from a proposed outlying landing field. The project involves extensive fencing, habitat conversion and development proximal to the Pocosin Lakes NWR. We are also concerned about noise disruption, red wolf prey, coyote management, and potential loss of red wolves via territory disruption that leads to intra-specific strife and subsequent dispersal. We need partners like the U.S. Navy to assist us in addressing the recovery needs of the red wolf NEP during the planning of proposed military projects.

c. State Status

The red wolf remains federally listed as endangered throughout its historic range in the southeast USA west to central Texas. However, the red wolf was recognized as extinct in the wild in 1980 (see appendix B), and the last known remaining red wolves were brought into captivity. Therefore, red wolves in captivity are endangered and wolves in NC are designated as a NEP. New information suggests red wolf historic range extends farther north than previously believed (section 2.3.1.a).

Five states actively post the red wolf on their state status lists of threatened or endangered species. The red wolf has state endangered status in Texas, Louisiana, Missouri, and Florida, with state special concern status in Georgia. In North Carolina, a state non-game advisory committee is evaluating whether or not the red wolf should have special concern status at the state level. Special concern status would acknowledge the red wolf as a species in need of monitoring which occurred historically in North Carolina. Special concern status would encourage new partnerships with the North Carolina Wildlife Resources Commission (NCWRC) to address management of red wolves.

Except for the five states listed above which actively post state status for red wolves, we are aware of no other laws, regulations, policies, or programs which afford red wolves protection, conservation or recovery outside of the Act. We are also not aware of any regulatory mechanisms for red wolves or their habitat afforded at the city or county levels. Therefore, the primary mechanisms currently available to achieve red wolf recovery are voluntary partnerships, community stewardship, project planning and design, federal, state, and other agency cooperation, protections of the Act on NWR's and in National Parks, and limited protections of the Act on land not in NWRs nor in Parks.

d. Conclusions About Regulatory Mechanisms

We conclude that NEP status is effective in red wolf conservation and in allowing flexibility for red wolves and people. Such flexibility allows less regulation while addressing needs in human safety and property. However, we also believe we must give consideration to making improvements in the current experimental rule (50 CFR 17.84) in cooperation with the State to address additional issues related to wolf mortality, law enforcement, coyote management, clarifications, and additional flexibility for people.

2.3.2.5. Other natural or manmade factors

We consider other natural and manmade factors described below to be among the most serious current threats to red wolves. Together with the threats described above, we are concerned cumulative effects may cause the current red wolf NEP status to remain stationary or otherwise decline. These concerns can be resolved if human factors become ameliorated via partnerships, outreach and education

a. Gunshot Mortality

Gunshot mortality is a serious threat to red wolves in the North Carolina NEP. Preliminary figures generated in 2006 and 2007 (D. Murray unpublished data) showed that a wild red wolf is 7.2 times more likely to be killed by gunshot during the hunting season than during the non-hunting season. The number of red wolves shot during the 79 day annual hunting season exceeds the number of red wolves shot during the remaining 286 days of the year, and this applies to every year except 1997 and 1998 when fewer wolves were lost to gunshot. Per day, red wolves were 1.7 times more likely to disappear during the hunting season. Significantly fewer red wolves whose signal were lost during the hunting season were recovered (29.4%) compared to red wolves with lost signals during the rest of the year (52.1%).

Whether accidental by licensed hunters, or illegal, gunshot mortality since 2004 is hampering the ability of the red wolf NEP to continue its upward trend in growth. Since 2004, gunshot mortality has reduced the number of breeding pairs and pups in the NEP and otherwise removed growth potential (Figures 10 and 11). Declines from gunshot show as dips in counts that occur in Figures 1, 2 and 4 from 2004 to 2007, even though the overall population trend from 1987 to 2007 remained upward. When gunshot reduces the existing or potential number of wolves, the NEP suffers reduced ability to hold and defend territories against coyotes, sometimes allowing interbreeding. We believe gunshot mortality must be addressed to in order to main the upward growth trend of the red wolf NEP.

We used data collected since 1999 to calculate mortality, replacement and litters related to incidents of gunshot and disappearance. From 166 known mortalities for all red wolves since 1999, our data show 22% (n=39) killed by gunshot and another 22% (n=38) which disappeared (Figure 7). Of 67 known mortalities for breeding red wolves only, our data show 32% (n=21) killed by gunshot and another 26% (n=17) which disappeared (Figure 9). From April 2006 to April 2007 alone, we lost a total of eight breeder red wolves to gunshot (Figure 10), with two to five red wolves lost in prior years back to April of 1999. Thus, gunshot mortality contributed in part to a reduction in the number of red wolf breeding pairs from 22 in 2003 to only 15 in 2005 and 2006, rebounding to 20 in 2007 (Figure 4) largely because of hard work by red wolf field biologists to create additional red wolf breeding pairs. Our data (Figure 11) further show that loss of 27 breeders in specific territories since 1999 to gunshot and suspected gunshot resulted directly in 23 cases of no wolf litters and 4 cases of hybrid litters. The loss of 27 breeders (Figure 11) also resulted in only 7 lost breeders replaced in territories by other adult wolves, with 10 lost breeders replaced by 10 non-wolves (coyote or hybrid), and with 10 lost breeders not replaced at all. We conclude that gunshot mortality on the breeding segment of the red wolf NEP is disproportionately high, implying that the population consequences of such mortality is highly limiting to red wolf NEP population growth.

Figure 10. Loss of NEP red wolf breeders to gunshot and suspected gunshot since 1999.

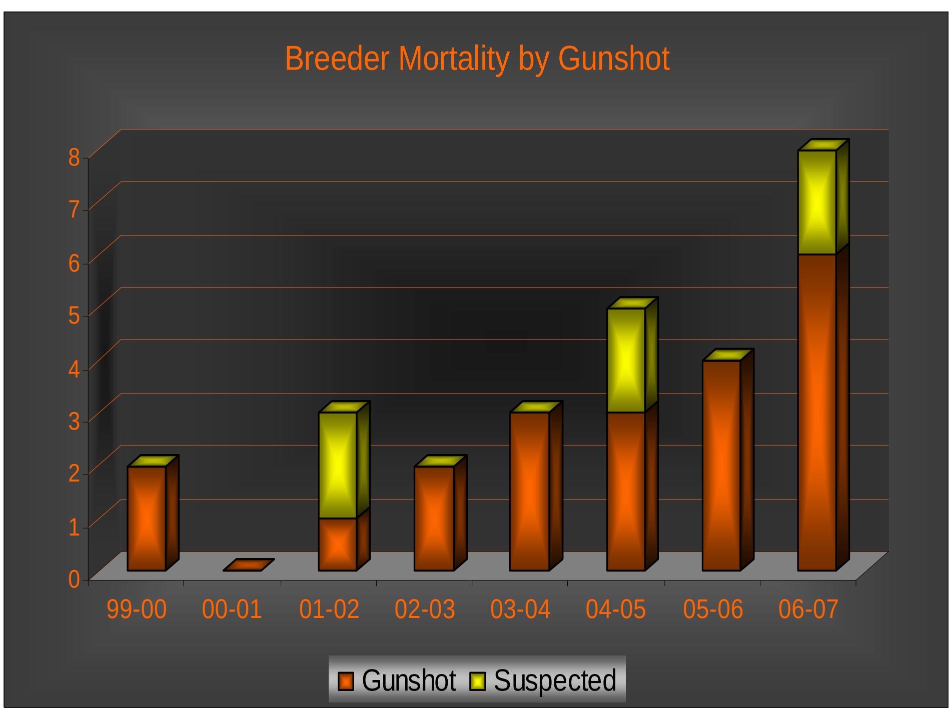
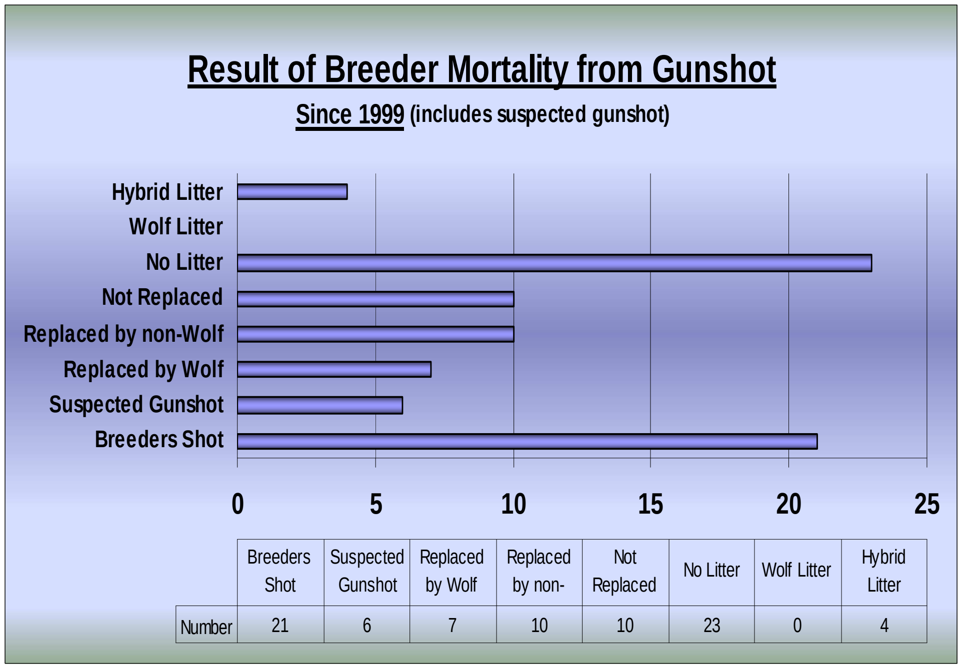


Figure 11. “Replacement result” from loss of NEP red wolf breeders from known or suspected gunshot. Of 27 breeders lost, 23 resulted in no wolf litters, four resulted in hybrid litters, and only seven were replaced in territories by other wolves. Ten were replaced by non-wolves (coyote or hybrid), while ten others were not replaced.



b. Mortality From Vehicle Strikes

Trombulak and Frissell (2000) showed roads can result in mortality events in large carnivores from causes that are direct (e.g., vehicle strikes) and indirect (e.g., behavior changes affecting food acquisition). Vehicle strike mortality significantly impacts the red wolf NEP in North Carolina. Of 166 known adult red wolf loses since 1999, vehicle strikes are three times higher in non-breeder (19%) vs. breeder (6%) red wolves of the NEP (Figures 8 and 9). This is partly explained by single red wolves dispersing or roaming over large distances. From 270 known red wolf mortalities recorded for the NEP between 1987 and 2006, vehicle mortality was calculated to be 17.4 percent (D. Murray 2007, unpublished data).

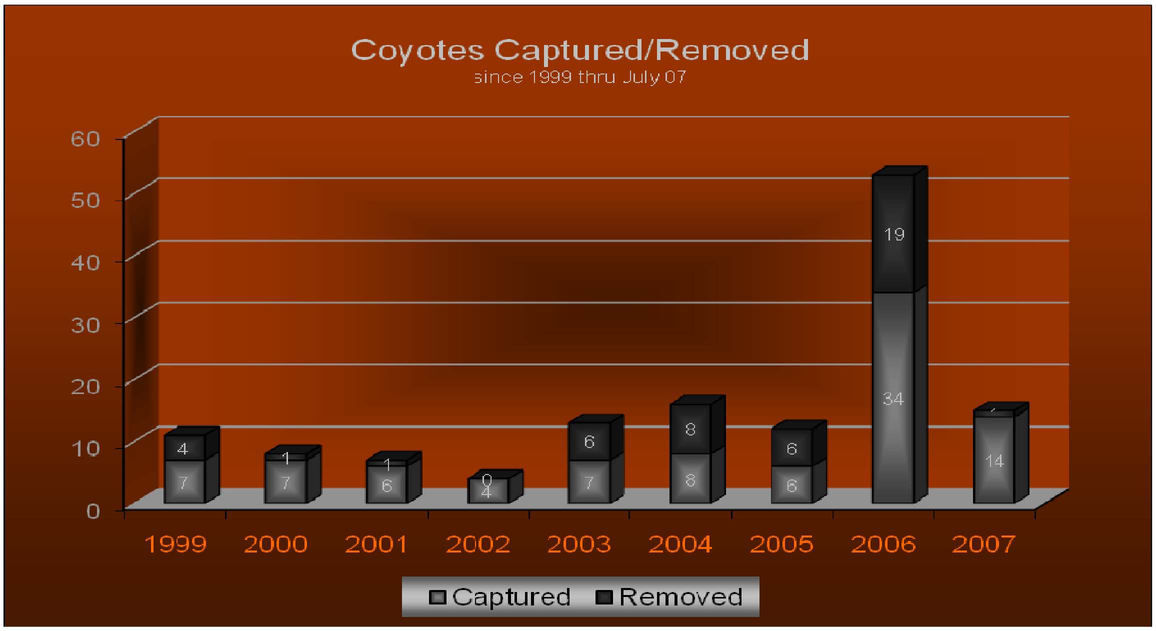
c. Eastern Coyotes

Eastern coyotes, sometimes called brush wolves, continue to be a serious threat to the red wolf across its historic range. In North Carolina, we have made good progress in managing eastern coyotes and their gene introgression threat. Implementation of our adaptive management plan (Kelly 2000; Fazio et al. 2005) since the year 2000 has led to good progress in reducing introgression of coyote genes and reducing the number of coyotes in the red wolf NEP area (Adams 2006, Beck 2005, Stoskopf et al. 2005.)

Our adaptive management and monitoring efforts prior to 2006 effectively reduced the number of coyotes on the Albemarle Peninsula where the red wolf NEP occurs. Yet, an unusually large increase in eastern coyotes was detected in 2006 and 2007 on the Peninsula (Figure 12). This is partly explained by gunshot mortality of red wolves creating open territories which invite eastern coyotes. This is also partly explained by accidental release of eastern coyotes from hunting enclosures ("fox pens") used to hunt imported coyotes. However, based on first-hand accounts, deliberate release of eastern coyotes by a small number of people explains much of the increase in coyotes observed. From 1999 through 2005, an average number of six eastern coyotes were captured each year by red wolf field biologists and cooperating local trappers on the Peninsula (Figure 12). During 2006, a total of 34 coyotes were captured, with an additional 14 coyotes captured during the first 6 months of 2007 (Figure 12). (Note that increases in both our trapping effort and the size of the area trapped could also account for some of the increase in coyotes captured.)

Recognizing the NCWRC has lead authority in management of furbearers such as coyotes and foxes, we would like to work collaboratively with the NCWRC on statewide approaches to manage canids and address mutual issues of concern. We encourage approaches which include trappers and animal damage control specialists as part of the solution in reducing state-wide coyote numbers. We suggest addressing the import, health and containment of coyotes used for hunting in enclosures (locally called, "fox pens"). We also suggest uniform standards for construction and maintenance of fox pens to prevent coyote escapes. New safeguards which prevent red wolves from being trapped and hunted in fox pens will be helpful. We also hope approaches will address the unauthorized import and release of eastern coyotes directly into the wild by people. The problem of people shooting what they believe to be a coyote on the Albemarle Peninsula, only to learn they shot and killed a red wolf, is another serious issue we hope will be addressed. Statewide precautions in canid disease management can be designed to fit with the Albemarle Peninsula NEP disease prevention and management plan described in section 2.3.2.3 above.

Figure 12. Numbers of eastern coyotes captured from 1999 to 2007 in the red wolf experimental population area located on the Albemarle Peninsula in North Carolina. Figures for 2007 are for the first six months only. Captured coyotes are sterilized and returned to a territory to hold space until replaced by red wolves over time. If a there is no space available for a sterilized coyote, we euthanize at the request of the landowner.



We conclude management of eastern coyotes on the Albemarle Peninsula continues to be necessary to further reduce the threat of coyote gene introgression into the red wolf NEP. Interaction studies between red wolves and coyotes will be helpful to determine dynamics necessary for long-term management. Partnerships and education are important to help people understand the problems eastern coyotes cause. Involvement of local communities and other stakeholders will be helpful in curbing the deliberate release of eastern coyotes.

d. Hurricanes/Tropical Storms and Global Climate Change

Natural weather events and global climate change will play growing roles in long-term survival and recovery of red wolves. The red wolf NEP in North Carolina is subject to annual tropical storm activity. In fact, Hurricane Isabel resulted in the deaths of two captive red wolves during September of 2003, with no noticeable long-term impacts observed in the NEP. However, the NEP and associated prey species remain vulnerable to sea level rise and flooding related to climate change and hurricanes. Additional long-term changes in habitat availability, prey abundance, and other ecological or landscape factors will occur with climate change (Parry et al. 2007). Thus, long-term assessment and planning are needed that consider the current NEP and future populations in the context of tropical storm activity, global climate change, and resulting changes in the North American landscape over time.

2.4. Synthesis

Considering the grave challenges red wolves faced when first listed as endangered in 1967, efforts to restore, recover and conserve them have been remarkably successful. Red wolves have been transformed from nearly extinct at a count of only 14 individuals in the 1970’s to a captive population of 208 and a restored wild NEP with counts up to nearly 130. The red wolf was pulled back from the brink of extinction and given a fighting chance for survival. We conclude that NEP status is effective in red wolf conservation and in allowing flexibility for red wolves and people. The red wolf faces many more challenges, but its journey in science and wildlife management to date has been extraordinary with assistance from many partners and scientists who truly make a difference. We thank all those who have worked so hard in red wolf recovery since the 1960’s. We particularly thank the landowners who work with us regularly to conserve red wolves in a balance that also conserves their own rural heritage and lifestyle.

Data presented above and in noted published papers show the red wolf adaptive management work plan is effective at reducing coyote gene introgression while restoring the wild red wolf NEP. Field data shows red wolves are beginning to challenge non-wolves for territorial space. Data collected over 20 years shows trends of increase in size of the wild red wolf NEP. New, preliminary data suggests the red wolf NEP may be reaching carrying capacity, but closer examination of data is needed to verify if this is true.

The wild red wolf NEP today experiences a series of threats that originally caused the red wolf to decline across its historic range starting with early settlement of North America. Early persecution and habitat fragmentation originally reduced red wolves to the point of human-induced near-extinction and interbreeding with coyotes. Today, gunshot mortality removes breeders from the wild NEP and, along with habitat fragmentation from mounting development, invites eastern coyotes to enter the NEP area. Releases of coyotes and canid disease outbreaks are additional threats we must work to reduce. Interruption of gene flow by barriers and habitat alterations are a new concern we must manage.

Future success in red wolf recovery will depend heavily upon the assistance and actions of partners that include local communities and state wildlife agencies like the NCWRC. Mortality and loss in the NEP related to human activity represent more than half of all losses. So, mortality and loss from gunshot, vehicle strikes and disappearance are factors we must reduce via education, community participation, law enforcement, and planning. Our objective of 330 wolves in captivity will only be met with the help of our very capable species survival plan partners that include the AZA. Our other objective of two additional wild red wolf populations within historic range will be more easily achieved with state participation and local support.

The Red Wolf Recovery Program is one of the oldest recovery programs for an endangered species in the USA. Significant amounts of red wolf recovery have been achieved, and we believe significantly more success is possible. The red wolf remains one of North America's most critically imperiled vertebrates (NatureServe 2007) and one of the world's most critically endangered canids (IUCN 2006). We look forward to working with our partners at all levels to reach new milestones in science, cooperation, and conservation to achieve new levels in red wolf recovery.

3. RESULTS

3.1. Recommended Classification

__X__ No change is needed

3.2. Recovery Priority Number

The red wolf's Recovery Priority Number should remain at 5C.

4. RECOMMENDATIONS FOR FUTURE ACTIONS

At this time, two contributions can result in immediate gains in red wolf recovery. One immediate contribution involves actions which result in significant reduction of the portion of red wolf mortality attributed indirectly or directly to humans. Another immediate contribution involves concurrent work to assist in the development of a cooperative statewide canid management plan or policy with NCWRC and U.S. Department of Agriculture Wildlife Services officials. Three additional contributions can result in long-term species stability. These long-term contributions involve expanding the captive red wolf population, establishing additional wild red wolf populations, and developing effective disease prevention and management plans. Overall, we recommend the following actions be implemented during the next five years.

a. Develop an effective disease prevention and management plan for red wolves and other canid species in northeastern North Carolina.

b. Expand the number of facilities participating in the Red Wolf Species Survival Plan to continue to meet genetic diversity objectives and to aid in establishing any future additional red wolf populations. Support Tacoma Metroparks and the Point Defiance Zoo and Aquarium in Washington with relocation and reconstruction of the flagship red wolf captive breeding facility located there. Enhance partnerships in the Red Wolf Species Survival Plan with staff at facilities across North America to enhance red wolf captive breeding.

c. Identify and evaluate land areas in red wolf historic range that could be considered for potential establishment of second and third wild red wolf populations. Examine biological and human factors important in identifying new restoration locations. Evaluate site selection concepts offered by states, scientists, and partners (Knowlton 2007 *in litt*.; Kyle et al. 2007; Van Manen et al. 2000; Defenders of Wildlife 2005 *in litt*.; Scott et al. 2005; Stoskopf 2007 *in litt*.; Murray 2007 *in litt*.; among others). Biologists have known since the first wolf was released in North Carolina and based on the recovery plan for the red wolf, that the species cannot be recovered by restoring it only to the Albemarle Peninsula. Before release of red wolves in North Carolina, the Service recognized the impacts this action would have and cooperated extensively with the State and local communities in order to be able to initiate an important recovery action while maintaining flexibility to ensure human safety and activities would be considered. One of the objectives to attain the red wolf's recovery is to restore and expand the red wolf into other suitable habitats within its historic range. The Service's immediate focus is on its recovery efforts for the red wolf NEP. The Service would like to explore the feasibility of restoration of other populations and intends to work in cooperation with States, partners, and local communities.

d. Work collaboratively with the U.S. Department of Agriculture Wildlife Services in support of efforts by the NCWRC to develop a cooperative statewide canid management plan or policy. With NCWRC leadership, develop a plan or policy concurrent with developing new state and federal regulations which address the most pressing canid issues in the State of North Carolina. Include the issues of landowner needs, hunter stewardship, trapping opportunities, wolf management areas, and canid disease management. Focus on the illegal import, illegal release, and fox pen hunting of invasive eastern coyotes, with safeguards ensuring wolves are not hunted in fox pens. Focus on elimination of eastern coyotes from the Albemarle Peninsula to the extent feasible. Include in the cooperative plan provisions to effectively manage wolves, coyotes, wolf-dog hybrids, foxes and exotic variations of these animals.

e. Develop cooperative actions which result in significant reduction of the portion of red wolf mortality attributed indirectly or directly to people. Work with the North Carolina Wildlife Resources Commission and the North Carolina Department of Transportation to develop cooperative measures which reduce the loss of red wolves caused by gunshot and vehicles strikes. Develop and implement educational outreach measures to highlight to people and local communities we need their assistance in reducing red wolf mortality. Encourage managers of large development projects and partners on the Peninsula to work with us in incorporating red wolf recovery concerns. Develop mutually beneficial landowner incentive measures. Explore potential joint state and federal law enforcement measures.

f. Draft a new recovery plan and species survival plan for the red wolf. These plans should incorporate significant advances in science and information developed since approval of the 1990 Red Wolf Recovery/Species Survival Plan. The 1982, 1984 and 1990 plans were written to identify measures which ensure immediate survival of red wolves in captivity and in the red wolf NEP. Many tasks in these early plans associated with captive rearing and restoration into the wild are completed or ongoing with significant gains in survival pulling the red wolf away from the brink of extinction. After 20 years of restoration and management of red wolves in the wild and in captivity, we must set new recovery goals, objectives, criteria, tasks and research needs. These should focus on population management, restoration in historic range, expanded captive breeding, reduction of new threats, long-term conservation, delisting, and down-listing.

g. Establish a human dimensions sub-team and a community stakeholder group to advise the Service and Red Wolf Recovery Implementation Team scientists on human factors and issues important in successful red wolf recovery.

h. Maintain at least two locations which fulfill the vital restoration roles of island propagation sites that contribute directly to both wild red wolf population(s) and captive breeding. The two sites currently with such capabilities are St. Vincent NWR in Florida and Cape Romain NWR in South Carolina.

i. Launch studies of wolf/coyote interaction and monitoring to identify additional long-term strategies for wolf and coyote management, with focus on the western end of the red wolf NEP.

j. Consider updating the red wolf 4(d) rule in cooperation with the State to reflect additional strength and flexibility needed for landowners, land managers, hunters, trappers, communities, red wolves and law enforcement officers. Another option is to identify alternate conservation incentive agreements with land owners and land managers.

k. Engage further science in the discussion of relationships between red wolves and Algonquin wolves and whether or not they should be managed together across a broader geographic continuum.

l. Launch enhanced, expanded and new efforts to educate local communities and visitors about red wolf conservation and ecosystem values. Share red wolf conservation values with children, families, other stakeholders and the general public. Enhance partnerships developing ecotourism values for local communities proximal to the wild red wolf population(s). Assist partners in their efforts to promote ecotourism and establish an education center emphasizing red wolf, refuge, farming, hunting and other natural resource community values.

m. Evaluate how the effects of climate change will influence red wolf recovery. Develop plans which address the effects of climate change via strategies in long-term conservation.

n. Continue to implement and further develop the red wolf adaptive management plan for wild red wolf population(s), based on regular evaluations and recommendations by scientists from the Red Wolf Recovery Implementation Team.

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APPENDICES

Appendix A – Peer Review Process and Highlights of Comments

1. Summary of Results of Peer Review Process

Public Comments: The Service received public comments from two non-profit organizations. Defenders of Wildlife sent a six page letter dated November 21, 2005. The Red Wolf Coalition provided oral comments reflecting Defenders' comments before close of the 2005 public comment period. The concerns and recommendations expressed by Defenders and the Coalition are addressed in the threats and synthesis sections of the document. Members of Defenders are greatly concerned about anthropogenic mortality (e.g., gunshot, vehicle, etc.) and lack of state protections for red wolves. They are also concerned about cumulative impacts from habitat fragmentation and development pressures across the Albemarle Peninsula. They ask that our adaptive management and restoration efforts continue, and they encourage us to move forward in identifying new locations for establishing red wolf wild populations.

Scientific and Technical Peer Reviewer Comments: The red wolf five year review document underwent scientific and technical peer review at the four levels shown below.

Comments from Review Level 3 scientists highlighted the possibility that the wild red wolf population on the Albemarle Peninsula in North Carolina may have reached its functional carrying capacity. These scientists note that remaining unoccupied habitat may be of low quality and limiting to the red wolf wild population. Some of these scientists also express serious concern about vulnerability of red wolves in the NEP to disease. Comments, reasoning and data submitted by these scientists are incorporated into the biological updates section and habitat threats section of this document.

Highlights of comments from Review Level 4 scientists are as follows.

1) Comment: General need exists for the Service and the NCWRC to work more closely together on canid management and related issues, especially in eastern North Carolina. Response: We encourage improvements in partnership between the Service and our state partners, including NCWRC.

2) Comment: Data on sex and age structure in both the red wolf NEP and the captive breeding population should be included in this document. Response: We intend to present red wolf NEP sex and age information in the broader framework of a demographics paper to be published within the next year.

3) Comment: The finite rate of population increase (lambda) is a useful and more commonly reported measure in science that would be useful in analysis of red wolf NEP growth; data provided in the review indicated lambda may be very high for the red wolf NEP. Response: Growth in the red wolf NEP has generally been

upward. We will present estimates of lambda in demographic and modeling papers published within the next year or two.

4) Comment: It will be helpful to relate functional carrying capacity to both biological carrying capacity and cultural carrying capacity. Response: These are important questions currently under our consideration. We will examine these in more detail with greater peer review as we undergo a more rigorous analysis of carrying capacity in the red wolf NEP in the coming months.

5) Comment: With respect to red wolf habits and habitat fragmentation, is data available about prey species utilized by red wolves? If so, it would be helpful. Response: There are two reports on red wolf food habits which examined remains of prey in red wolf scat. Primarily five species of prey were documented, where the proportion of prey species eaten varied with availability in a given territory. Data from NCWRC indicates the deer population in the area of the red wolf NEP remains healthy. These data are published elsewhere, and so far have not been related to potential impacts from proposed development projects.

6) Comment: More thorough analysis of mortality data and other information is needed before concluding that all anthropogenic mortality is additive. Response: We agree our conclusion about additive anthropogenic mortality is based on preliminary data analysis. We also agree more rigorous analysis is necessary.

7) Comment: In Figure 11, why were 10 of 27 breeders not replaced? Response: We do not yet know the answer, but we are concerned other red wolves did not fill in a territory once made vacant via gunshot. More study is needed to find the answers, including whether or not there is a lack of potential breeders in the red wolf NEP.

8) Comment: Suggest a closer look at the coyote influx that occurred in 2006 and 2007; for example, compare ages of coyotes captured in the last two years vs. prior years. Response: We agree a closer look is needed. Comparisons of age, DNA and other parameters may be helpful in understanding the recent influx and where those coyotes came from. We know from first hand accounts that at least a few people are actively releasing coyotes into the wild for purposes of sport, though illegal.

9) Comment: Further comparison studies should take place to more closely examine genetic relationships between red wolves and Algonquin wolves and New England canids. Response: We agree, and some researchers are working on these comparisons now. We encourage more scientific study to more fully explain relationships between these wolves and other New England canids.

10) Comment: Whole skeletons of red wolves (not just skulls) should be saved to allow analysis of morphological features and potential inbreeding effects. Two potential inbreeding conditions to watch for are enamel hypoplasia (slightly

purple tinge in tooth enamel) and vertebrae problems (extra, or asymmetry). Response: We appreciate the advice and will consider saving whole specimens. So far we have not documented the two conditions described, but we will look for these conditions from this point forward.

11) Comment: Management actions appear to be a significant source of mortality. There needs to be a thorough analysis and discussion of this mortality and its nature and rationale. Response: We agree, and we are currently re-evaluating why that portion of mortality over time appears high. Preliminary analysis shows the majority of management mortality is accounted for by trapping incidents (e.g., drowning, injury, etc.) and by changes in genetics identification methods earlier in the program. We used 8 known gene loci to identify canids earlier in the program, whereas we used 19 loci to identify canids later. This change in known loci informed us some canids formerly identified as hybrids were unfortunately wolves euthanized before newer ID methods became available.

We thank all reviewers of this document for their thoughtful responses. The names of reviewers are described below.

Level 1 – Review & Data by Red Wolf Staff (Biologists, Captive Program, Outreach)

Chris Lucash (Wildlife Biologist), Michael L. Morse (Wildlife Biologist), Art Beyer (Wildlife Biologist), Ford Mauney (Wildlife Biologist), Leslie Schutte (Wildlife Biologist), Scott McLellen (Biological Technician), and Ryan Nordsven (Biological Technician), and Diane Hendry (Outreach Specialist).

Will Waddell, Coordinator, Red Wolf Species Survival Plan / Captive Breeding Program, Point Defiance Zoo and Aquarium (PDZA), Tacoma, WA.

Level 2 – Review by Managers/Biologists at USFWS Refuge and Ecological Services Offices

Alligator River National Wildlife Refuge, NC
Pocosin Lakes National Wildlife Refuge, NC
Mattamuskeet National Wildlife Refuge, NC
St. Vincent National Wildlife Refuge, FL
Cape Romain National Wildlife Refuge, SC
Ecological Services Field Office, Raleigh, NC

Level 3 – Review by scientists on the Red Wolf Recovery Implementation Team

Michael K. Stoskopf, DVM, Environmental Medicine Consortium, School of Veterinary Medicine, North Carolina State University, Raleigh, NC

Karen B. Beck, Ph.D, DVM, Environmental Medicine Consortium, School of Veterinary Medicine, North Carolina State University, Raleigh, NC

Lisette Waits, Ph.D / Wildlife Genetics, Dept. of Fish and Wildlife Resources, University of Idaho, Moscow, ID

Dennis L Murray, Ph.D / Population Dynamics, Canada Research Chair in Terrestrial Ecology, Dept. of Biology, Trent University, Peterborough, Ontario, Canada

Todd K. Fuller, Ph.D / Mammalian Ecology, Dept. of Natural Resources Conservation, University of Massachusetts, Amherst, MA

Eric M. Gese, Ph.D / Predator Ecology, Behavior and Depradation, Research Wildlife Biologist, National Wildlife Research Center, USDA Wildlife Services, Utah State University, Logan, UT

Frederick F. Knowlton, Ph.D / Predator Ecology and Control, Research Wildlife Biologist, National Wildlife Research Center, USDA Wildlife Services, Utah State University, Logan, UT

Will Waddell, Coordinator, Red Wolf Species Survival Plan / Captive Breeding Program / Reproduction Research, Point Defiance Zoo and Aquarium (PDZA), Tacoma, WA.

Level 4 – Independent Peer Reviewers

Tim Langer, Ph.D, Bear Biologist, Appointed Commissioner, North Carolina Wildlife Resources Commission, Raleigh, NC

Rolf O. Peterson, Ph.D, Wolf Ecology and Behavior / Mammalian Ecology, School of Forest Resources and Environmental Science, Michigan Technological University, Houghton, MI

Michael R. Vaughan, Ph.D, Large Animal Population Dynamics and Ecology / Bear Research; Professor of Wildlife Science, Dept. of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University (i.e. Virginia Tech); Cooperative Wildlife Research Unit, USGS-BRD, Blacksburg, VA.

Appendix B – Red Wolf Conservation History Prior to 2000

After three centuries of decline from extermination and habitat alteration, the red wolf was thought functionally extinct in the wild by approximately 1980 (Carley 1975; McCarley 1962; McCarley and Carley 1979; USFWS 1984, 1993). The last remaining 17 red wolves were held in captivity for breeding and release purposes (USFWS 1990). Restoration efforts since 1987 established one wild population of red wolves on the Albemarle Peninsula of northeastern North Carolina (Phillips 1994).

During the 1960s, biologists realized that red wolves were well on their way to extinction. Biologists sought legal protection for red wolves by listing the species under the 1966 and 1973 versions of the U.S. Endangered Species Act, as amended (U.S.C. 16 section 1531 et seq.). During the 1970s, biologists determined that only 17 red wolves remained after extensive searches and trapping efforts in southwest, coastal Louisiana and the central, southeastern and coastal portions of Texas. Of the 17 red wolves identified, all were taken into captivity, and 14 were selected to begin a captive breeding population that still exists today. Over the next 20 years, eastern coyotes (*C. latrans var.*) continued to develop, move eastward, and create management challenges across the United States, arriving on the Albemarle Peninsula in northeastern North Carolina during the early 1990s. Thanks to innovative and intensive field management of both red wolves and eastern coyotes, red wolves now roam 1.7 million acres on the Albemarle Peninsula in northeastern North Carolina. Family groups of red wolves have also lived on each of two island locations for purposes of propagation and translocation to the mainland wild population. These two locations, respectively since 1988 and 1990, are Cape Romain National Wildlife Refuge in South Carolina and St. Vincent National Wildlife Refuge in the Florida panhandle.

The red wolf was first described by Audubon and Bachman (1851). Goldman (1937, 1944) initially described *Canis rufus gregoryi*, *C. r. floridanus*, and *C.r. rufus* as the three red wolf subspecies recognized by biologists. These three subspecies were further confirmed by Paradiso and Nowak (1971, 1972), and the historic ranges of the three red wolf subspecies were adjusted by Nowak (2002). The only surviving red wolf subspecies is likely *C .r. rufus*, according to Nowak (2002), so this subspecies was restored to North Carolina in what is now the world's only free-ranging red wolf population.

Appendix C – Notes About Red Wolf Origin, Taxonomy, Genetics and Management

The U.S. Fish and Wildlife Service must use the best available scientific information and data in evaluating red wolf status, including genetics, morphometrics, palentological, geographical, ecological, behavioral and historical information (Dowling 1992, Cronin 1993, Crandall et al. 2000). In our discussions with lead scientists involved in wolf taxonomy, there exists consensus that the red wolf is a natural entity worth conserving under the U.S. Endangered Species Act. Constructive debate is occurring primarily with respect to the origin of red wolves, the taxonomic name to assign, and how best to manage red wolves over the long-term.

Gene introgression is not unique to red wolves. In fact, Lehman et al. (1991) documented coyote gene introgression into gray wolves, and Adams et al. (2003b) documented dog gene introgression into coyotes, while Kolenosky and Standfield (1975) described hybridization among canids in eastern Canada. Hybridization and gene introgression occur naturally as part of evolutionary processes among many species of fauna (Allendorf et al. 2001, Grant and Grant 1992, Kraus 1995, Mallet 2005, Schwartz 2004, Smith 2003). However, hybridization and introgression caused by humans can also endanger fauna to the point of extinction (Frederickson and Hedrick 2006, Rhymer and Simberloff 1996).

In the past, questions about the hybrid or genetically introgressed nature of a species caused some people to reconsider whether or not species should be conserved or restored (Brownlow 1996, Geise 2006, Kraus 1995). Yet, in select cases, species hybrids can be used as scientific tools to effectively manage endangered wildlife populations. For example, gene diversity and overall survival in Florida panthers (*Puma concolor coryi*) have improved using genes of Texas cougars (*Puma concolor stanleyana*) as “genetic rescue” tools (Creel 2006; Pimm et al. 2006). The Red Wolf Recovery Program uses a different set of scientific tools to improve genetics of the restored red wolf population. Refined genetics-based field techniques and protocols (Adams 2006, Adams and Waits 2006, Adams et al. 2007, Fazio et al. 2005) allow us to use hybrid canids as tools to purge coyote genes and retain red wolf genes in the restored red wolf population (section 2.3.1.d, above). Part of this strategy involves removal of any back-crossed canid found.

Appendix D – New Information Pertinent to Red Wolf Population Management

Beck (2005) described various aspects of field biology and management of red wolves in coastal North Carolina. She modeled introgression as a "disease" and confirmed that non-wolf (coyote or hybrid) survival rates are effectively controlled by the combination of den visits, sterilization of non-wolf adults, and euthanizing non-wolf litters. She calculated red wolf home range sizes from 6.4 to 222.4 square kilometers, where field biologists know home range size varies depending upon availability of prey, habitat, disturbance, and other factors. She also confirmed there is no significant effect on survival of pups from annual den visits at pup ages 5 to 19 days for handling, blood collection, and transponder placement for identity.

Mauney (2005) used geographic information systems to examine red wolf home range and habitat use in the Great Smoky Mountains National Park in western North Carolina and eastern Tennessee. Red wolf restoration was attempted there until 1998 when a decision was made to discontinue (Henry 1998), moving all remaining red wolves to northeastern North Carolina. Mauney (2005) found mean home range size in square kilometers to be 18.44 for males and 18.98 for females with no significant difference between sexes. Red wolves used pasture and deciduous forest habitat more than expected, using mixed and evergreen forest less than expected. Red wolves used slopes under 20% more than expected and used steeper slopes (>20%) less than expected.

Hinton (2006) examined home range, habitat use and pup attendance by red wolves during the pup rearing season in the restored red wolf NEP. He reported mean home range sizes in square kilometers of 74.1 (average overall), 76.1 (adults), 88.9 (juveniles) and 61.5 (pups). Pups implanted with abdominal transmitters in a pilot study showed red wolves used multiple rendezvous sites during the pup rearing season. Pups were moved by adults into adjacent agricultural fields from woodland dens during summer months. Yearling and breeding females attend pups more frequently than do yearling and breeding males. Red wolf pups were rarely alone, indicating pup rearing is shared, with males playing a significant role.

McLellan and Rabon, Jr. (2006) discussed the soft-release technique as a way of translocating adult red wolves into the free-ranging North Carolina population. They reported that use of a portable, electrified corral is an effective method for soft release of male-female paired red wolves. Releases using solitary wolves showed mixed results, where solitary wolves failed to pair with a mate and failed to defend territory.

Additional advances have occurred in our knowledge of red wolf physiology. Crissey et al. (2001) report serum concentrations of cartenoids and vitamins A and E in canids and ursids. Young et al. (2004) demonstrate non-invasive monitoring of adrenocortical activity in carnivores using feces; these are techniques important in the study of red wolf behavior, reproduction and disease. Larsen et al. (2002) and Sladky et al. (2000) discuss cardiorespiratory effects of immobilization drugs on red wolves, knowledge important to red wolf health and safety during handling activities in the field and in captivity.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW OF THE RED WOLF

Current Classification: Endangered Throughout Its Historic Range
Non-essential Experimental In Declared Areas in NC

Recommendation resulting from the 5-Year Review

__X__ **No change is needed**

Review Conducted by: Bud Fazio, Team Leader, Red Wolf Recovery Program, USFWS

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approval Buddy B. Fazio Date 9/26/07

REGIONAL OFFICE APPROVAL:

for **Lead Regional Director, Fish and Wildlife Service**

Approve Noreen E Walsh Date 9/28/07

Cooperating Regional Director, Fish and Wildlife Service

_____ Concur _____ Do Not Concur

Signature ______________________ Date ______________________