A Comprehensive Review and Evaluation of the Red Wolf (*Canis rufus*) Recovery Program

Final Report - 11/14/2014

Wildlife Management Institute, Inc.
2014

Executive Summary

The United States Fish and Wildlife Service (FWS) contracted with the Wildlife Management Institute (WMI) to conduct an independent review and evaluation of the red wolf (*Canis rufus*) recovery program. At the direction of the FWS, the review focused on numerous questions with respect to three elements of the recovery program: supporting science, program management, and human dimensions. WMI reviewed more than 200 documents received from the FWS, interviewed 20 FWS employees and 4 North Carolina Wildlife Resources Commission (NCWRC) staff at various management levels, commissioned literature reviews of red wolf genetics and ecology, conducted 2 public meetings in the red wolf restoration area, and conducted public opinion surveys. Our report was reviewed by outside experts in wolf ecology and management. This report is an evaluation and synthesis of the available scientific literature, reports, documents, interviews with FWS staff, and public comments received during the review period. The report is not intended, nor should it be construed, to be a decision document with recommendations relative to the fate of the current red wolf recovery program. The report represents the views of the authors and not necessarily those of the FWS.

Supporting Science

The experimental release of captive red wolves to the wild in 1987 proved red wolves could survive and successfully reproduce in the wild. The FWS staff directly involved with the red wolf recovery program has a thorough understanding of the current science regarding red wolf ecology in the area. However, WMI has a number of concerns regarding the science behind the recovery program. Canid genetics and taxonomy are complex and there are conflicting theories about the taxonomy of wolves in North America. WMI was not asked to draw definitive conclusions about the status of red wolves as a species; however, this issue was raised throughout the period of our review and has implications that affect science, program management, and the human dimensions aspects of the recovery program. Given the current understanding of wolf taxonomy, maintenance of the current red wolf genome is a prudent endeavor. If red wolves remain a distinct species, the genome would be preserved. Further research may or may not provide more conclusive evidence of the red wolves' place in the canid taxonomy that occurs in North America.

Related to the issue of genetics and the hybridization between red wolves and coyotes (*Canis latrans*), WMI believes that the FWS placeholder strategy is a valid conceptual technique to reduce the introgression of coyote genes into the red wolf population. However, we were surprised that a rigorous analysis of the effectiveness and efficiency of this technique has not been completed. FWS staff informed us that such an analysis is underway. The results of that analysis are critical to the long-term success or failure of the red wolf recovery program. In any event, WMI identified issues regarding the practicality, expense, and seemingly indeterminate timeframe for the use of the placeholder strategy. WMI identified an alternative approach the FWS could adopt to test the consequences of suspending the placeholder strategy to inform future recovery planning.

WMI has concerns about the current level of understanding of red wolf population dynamics, specifically the trends in breeding pair numbers and pup production. In spite of the complexity of monitoring a wild canid population across the 1.7 million acre restoration area, WMI expected a more definitive explanation for the gradual decline in the red wolf population during the last 6-7 years and the recent decline in breeding pair numbers. FWS staff stated that they continue to modify and enhance population-modeling techniques. FWS provided documentation of an improved and more robust population estimate model and WMI is confident that this effort will provide more accurate, precise, and timely information in the near future. The monitoring of mortality rates throughout the year, especially to determine the impact of mortality on breeding behavior and reproduction would benefit the population modeling effort.

The FWS underestimated the habitat required to reach its original recovery population goals. The first estimate was 144,000 acres for 35-50 red wolves. Today, approximately 100 red wolves range across a restoration area defined as 1.7 million acres. The stated intent to manage red wolf recovery on National Wildlife Refuges (NWR) in the area demonstrated an overly optimistic and scientifically unsound approach. Shortly after the original red wolf release, red wolves traveled outside the refuge boundaries. It is our belief that habitat management on existing NWRs specifically to create high value red wolf habitat would be insufficient to keep wolves off of private property in the restoration area. Further, climate change impact models indicated that significant portions of the current restoration area on Albemarle Peninsula would succumb to sea level rise. Accordingly, over the long term, current federal lands will not provide sufficient habitat for red wolves in the restoration area.

Successful accomplishment of the current recovery plan objectives will require identification of suitable areas and reintroduction of red wolves to 2 other distinct locations within historic red wolf range. Because coyotes occupy all of this range, the FWS may have to continue efforts to reduce or eliminate interspecific breeding between red wolves and coyotes to assure red wolf genome integrity. The restoration area size necessary for these introductions will depend on available resources within the area and the landowner tolerance of red wolves. Future releases would need to be coordinated with and supported by the state wildlife agency or agencies and private landowners involved in the reintroduction sites. Among other issues, the FWS would also need to monitor and address canid disease and parasite issues within all restoration areas.

Program Management

WMI concluded that throughout much of the life of the red wolf recovery program, local program managers received inadequate oversight and coordination from the regional office. In addition, the program was supervised as a NWR activity rather than a national or regional Ecological Services' priority. We believe that program authority rested largely with local staff. Decisions made at the local level, although made with the best intentions and with the program's success in mind, did not always comply with the rules established for the reintroduction program. We would characterize the situation as one where local staff did their best to "make it work" and to build constructive relationships with local

landowners. Recent changes in the program structure should improve the situation. A clear understanding of the need for rules and oversight of those rules will be necessary for future compliance.

The first 10(j) Rule was deemed necessary to gain public acceptance for the reintroduction in the Alligator NWR. Future reintroductions in other areas of the country would need to evaluate the effectiveness of the 10(j) Rule to assess the appropriateness of developing a similar rule on a case-by-case basis. Given the public interest in predator reintroduction, the FWS must defend a legal designation that maintains the most flexible management strategy possible in order to gain public acceptance of the program. With the benefit of hindsight, it is clear that the 10(j) Rules implied that red wolves would stay on refuge property or that they would be immediately recaptured and returned to refuge property. These assumptions were unrealistic and scientifically unsound. The amendments to the 1986 rule were insufficient to address some landowners' concerns about red wolves on private property. Further complicating the issue was the recent court injunction that prohibited coyote hunting in the 5 county restoration area.

WMI expected greater oversight and support for a landmark recovery program involving one of the most imperiled canids in the world. A stable to declining population without a sound scientific explanation, inadequate public outreach, insufficient captive facility capacity, lack of the identification of suitable alternative reintroduction sites, and the lack of rigorous adaptive management approach that included evaluation and analysis, are signs of a recovery program that is in need of additional review and course correction.

WMI concluded that the recovery plan would benefit from a review, update and/or revision to incorporate the 27 years of knowledge and experience associated with the 5 county restoration area. This review would benefit from a thorough analysis of: the effectiveness of the placeholder strategy with respect to reducing hybridization, the population dynamics of the wild red wolf, the integrity of the red wolf genome in the wild and in captivity, the population size necessary to insure red wolf survival and genetic integrity, the restoration area size and resource availability necessary to support expanded red wolf populations, and the human dimension research and public outreach activity necessary to garner public support and tolerance for introduced predator populations.

Human Dimensions

We believe that public outreach and education for private landowners within the restoration area were not major program components at the onset and throughout the life of the red wolf recovery program. We are aware that local FWS staff met with numerous individual landowners; however, we did not observe evidence of a concerted effort to reach the entire landowner population within the restoration area. Private landowners were arguably the key stakeholders in this recovery program. Numerous public meetings were held in advance of the releases and the addition of Pocosin Lake NWR to the federal lands in the restoration area. However, we did not see a concerted effort to maintain those public outreach and education efforts. We were not made aware of any public meetings in the last few years

WMI concluded that the red wolf recovery program has a strong biological focus but lacks an interdisciplinary approach to public outreach and engagement that would garner public support and acceptance of the red wolf recovery efforts in the 5 county area. WMI believes that the lack of public awareness and support efforts has led to an atmosphere of distrust within some segments of the community. This level of distrust has intensified as a result of the recent court injunction on coyote hunting.

WMI concluded that the current level of resources available is inadequate to meet the evolving environmental, social, and management challenges that face the recovery plan. We do believe that the shift of program oversight from the NWR System to the Ecological Services program was a sound decision that should better align expertise and resources with the program mission.

Further, WMI believes that the FWS has existing multidisciplinary staff available that could improve the recovery program. To improve the recovery program management and increase public support for the program, staff must be aligned with the program mission. The following program elements currently receive inadequate emphasis: regional review and oversight, private landowner relations, public education and outreach, and Congressional, state, and local government relations. The FWS's Partners for Fish and Wildlife program provides a good model for use in the restoration area. WMI is familiar with community engagement efforts of the FWS (e.g., Blackfoot Challenge) that could improve community relations in the restoration area.

Table of Contents

Executive Summary **2**

Table of Contents **6**

Introduction **9**

Methodology **11**
- **Supporting Science** **11**
- **Program Management** **12**
- **Human Dimensions** **13**
- **Independent Evaluation of Review** **14**

Findings and Conclusions **17**
- **Supporting Science** **17**
  - a. What does current science tell us about this project? What are the challenges and impediments to the project? What are strategies to overcome them? What are the pros and cons of different strategies for moving forward? 17
  - b. What are the project goals outlined in the original Red Wolf Recovery Plan, 10j Rules and Environmental Assessments? Are they still feasible at this time? 29
  - c. Are the habitat conditions on federal lands within the recovery area conducive to holding viable self-sustaining red wolf populations for the long term? If not, can the NWR lands be restored or are there other lands outside federal lands (i.e., State, private) that could support populations and would landowners support those populations? 37
  - d. The 1990 red wolf recovery plan identifies the need for 3 self-sustainable populations in at least 3 distinct locations. Is this assumption still valid? If so, what progress has been made to identify other sites? Does the recovery plan need to be revised? 38
  - e. What is the current role of the captive population? How is the Service incorporating it to the recovery efforts? Is the Species Survival Plan (SSP) still relevant and is it being followed? Does it need to be revised? 39
  - f. How will sea level rise affect red wolf restoration in the recovery area in the foreseeable future? 39
- **Program Management** **46**
  - a. Have the rules/policies/guidance issued been followed by the Service? 46
  - b. The Alligator River NWR and Pocosin Lakes NWR were established primarily for migratory birds. They are now in the primary cores areas for supporting red wolves. Are the lands within Alligator River NWR and Pocosin lakes NWR adequately managed for red wolves? If not, why? Can the management regime be changed to better support the population of red wolves and still support the original mission? If not, why? 47
  - c. What level of management-related support has this project been given by the Service? 48
  - d. What is the total financial cost of the recovery effort (including costs from the regional office, field and Washington when appropriate)? Where does it fit in the overall priority system within the southeast and across the nation? 49
  - e. Has the project received adequate funding and institutional support to meet its goals? 50
  - f. Based on science-based recovery recommendations, how much funding will be needed to achieve success within the current recovery area and with two additional population sites? .. 51
  - g. In recent months, the Service has received an unprecedented number of red wolf removal requests from private landowners. Is the current management structure equipped to handle an increasing number of requests for red wolf removal from private property? Is the Service

responding to these requests appropriately based on what is mandated in the 10j Rules? Does the Service have adequate facilities to handle captured wolves? 53
h. If red wolves are removed from the core area where will they be placed? If some red wolves are identified as "repeat offenders" should they also identified as "nuisance wolves"? If so, how should this be defined and where will the service place these wolves? In zoos? Island populations? Others? 54
Human Dimensions 54
a. Is there institutional (e.g., State) and public (e.g., private landowners) support for this project? Do the public and private sector support the overall recovery plan? 54
b. Is effective cooperation occurring with other agencies and the public? How has the red wolf recovery program affected the working relationship between the Service and the North Carolina Wildlife Commission and key public stakeholders? 55
c. What information is available to assess public awareness of and support for the red wolf recovery program? 56
d. Are current agency funds and staff adequate to carry out needed management, monitoring, and research? Would success be possible if the Service worked with the North Carolina Wildlife Commission? 63
e. Do the financial and institutional resources currently exist to meet the evolving environmental, social and management challenges that will be seen for recovery? 64
f. What additional Human Dimensions information could be gathered to assist the Service in improving the red wolf recovery program? 65

Summary of Significant Conclusions 66
Supporting Science 66
Population Dynamics 66
Taxonomy/Hybridization 66
Habitat 67
Recovery Plan 67
Additional Reintroduction Sites 67
Program Management 68
Program Management – oversight and coordination 68
Program Management - resources 69
Program Management - rules 69
Human Dimensions 69

Appendix A. Exhibit A of the FWS/WMI Contract 71

Appendix B. Red Wolf Literature Review 73
Red Wolf Introduction 73
Life History and Habitat Characteristics 74
Food habits 74
Breeding and Reproduction 75
Denning 77
Social and Behavioral Characteristics 77
Rearing Pups and Pack Dynamics 77
Home Range 78
Habitat Utilization, Needs, and Availability 79
Existing Habitat Description 79
Current Habitat Use 80
Habitat Availability within the Red Wolf Recovery Area and Beyond 81
Taxonomy and Population Dynamics 82
Taxonomy 82

Population Dynamics 83
Natality, Growth Rates, and Mortality/ Survival Rates 83
Population Dispersal 84
Threats to Red Wolves 85
Hybridization 85
Interspecific Breeding 85
Adaptive Management Plan 86
Interaction with Coyotes – Food and Habitat 87
Red Wolf Diseases 88
Human Based Threats (Interactions and Public Perceptions) 88
Human Interactions 89
Public Perception 89
Climate Change and the Red Wolf 91
Temperature and Precipitation Impacts 91
Albemarle Peninsula and Red Wolf Vulnerability to Temperature and Precipitation Changes 92
Sea-Level Rise Impacts 92
Albemarle Peninsula and Red Wolf Vulnerability to Sea-Level Rise 95
Storm Events (Hurricanes) 97
Storm Impacts 97
Albemarle Peninsula and Red Wolf Vulnerability to Storms 98
Summary of Threats to Red Wolf Recovery 98

Appendix C. Literature Cited 99

Appendix D. List of FWS Documents Reviewed 110

Appendix E. Written survey instruments 116

Appendix F. WMI's online survey instrument 124

Appendix G. Responses to WMI public meeting surveys, interview surveys, and WMI's online survey 126

Appendix H. Reviewer Comments 139
Kim Titus, Ph.D., Chief Wildlife Scientist, Alaska Fish and Game Department 139
Michael Phillips, Executive Director, Turner Endangered Species Fund 143
John Kilgo, Ph.D., Research Wildlife Biologist, U.S. Forest Service Southern Research Station 161
Douglas Smith, Ph.D., National Park Service Rocky Mountain Wolf Recovery Lead Biologist 166

Appendix I. Biographies of Review Participants 171

Introduction

The Wildlife Management Institute (WMI) was established in 1911 with a mission to provide leadership and advocacy for the enhancement, conservation, and professional management of wildlife and its habitat. Our mission remains unchanged today. WMI has a 103-year tradition of science-based wildlife management which values wildlife as a public trust resource, habitat as necessary for wildlife, and conservation education. During our history, WMI has conducted more than 70 independent reviews of state and federal fish and wildlife programs.

On August 11, 2014, WMI signed a contract with the United States Fish and Wildlife Service (FWS) to conduct a review and evaluation of the red wolf recovery program in northeastern North Carolina. The initial period of performance for this contract was August 11, 2014 to October 10, 2014. Effective September 24, 2014, the period of performance was extended to November 14, 2014. The contract clearly spelled out the components of the project (Appendix A) to include a review of the supporting science, program management, and the human dimensions aspects of the recovery program. Each component included a number of specific questions to help assess the program's status. WMI structured this report to respond to those questions. Due to the nature of the questions, some of our findings and conclusions may appear redundant. That was by intention to provide a comprehensive response to each question.

WMI approached this review with the understanding that our evaluation of the red wolf recovery program should include findings and conclusions based on the best available science, interviews with FWS and North Carolina Wildlife Resources Commission (NCWRC) staff, public meetings, and our professional judgment. At the direction of the FWS, WMI did not include recommendations with respect to the future fate of this recovery program. Decisions based on our review, if any, are within the purview of the FWS.

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

In addition, we employed Dr. Randy W. DeYoung of Texas Agricultural and Mechanical University (TAMU) for genetics expertise. Dr. John Kilgo, United States Forest Service Southern Research station; Dr. Kim Titus, Chief Wildlife Scientist for Alaska Fish and Game Department; Mike Phillips, Executive Director, Turner Endangered Species Fund; and Doug Smith, National Park Service Rocky Mountain Wolf Recovery Lead Biologist, provided an independent review of the draft version of our report. Reviewer comments are included in

this report (Appendix H). We made appropriate amendments to our draft report based on reviewer comments and they are reflected in this final report.

Finally, this report is an evaluation and synthesis of the available scientific literature, reports, documents, interviews with FWS and NCWRC staff, and public comments received during the review period. The report represents the views of the authors and not necessarily those of the FWS.

Methodology

The programmatic review of the red wolf recovery and restoration project in eastern North Carolina focused on three distinct aspects: Supporting Science, Program Management, and Human Dimensions. The purpose of the Supporting Science review was to assess the scientific understanding of the species, evaluate the obstacles to a successful species recovery, and to determine the impacts of exigent environmental circumstances, such as climate change, to the success of the recovery effort. The purpose of the Program Management review was to evaluate the performance of the FWS as the lead agency for the red wolf recovery program. While WMI considered and reviewed aspects of the entire FWS red wolf recovery program as background, this review principally focused on the restoration in northeastern North Carolina. Specifically, we were to determine if pertinent laws, rules, policies, procedures, and guidance were followed. The purpose of the Human Dimensions review was to determine the degree of public support for the restoration and to evaluate the impacts of the restoration on state and local partnerships.

Supporting Science

WMI commissioned the Conservation Management Institute at Virginia Polytechnic and State University to conduct a literature review of red wolf ecology (Appendix B). As directed by WMI, the review focused on specific core questions defined by the FWS. We also reviewed red wolf recovery program documents, resources listed in program bibliographies, and reports to identify pertinent scientific literature. For reports and scientific literature other than recovery program documents, we focused on identifying materials published in 2007 through 2014 using targeted searches with online resources (Virginia Tech Library database and Google Scholar). We reviewed any publications identified as relevant to the red wolf recovery program (e.g., red wolf biology, red wolf behavior, red wolf genetics, etc.).

We summarized the reviewed research to establish the current state of knowledge about the key issues surrounding red wolf recovery as well as identify other related research that would assist in framing these issues or demonstrated alternative approaches to the recovery effort and their outcomes. Our objective was to provide a solid foundation to inform our assessment of the red wolf recovery program.

To evaluate the genetic relationship between red wolves, coyotes, and other canids, WMI contracted with Dr. Randy W. DeYoung, Research Scientist and Associate Professor at the Caesar Kleberg Wildlife Research Institute, Texas Agricultural & Mechanical University (TAMU)-Kingsville. He received his B.S. from TAMU, M.S. from TAMU-Kingsville, and Ph.D. from Mississippi State University.

Our approach summarized recent literature on the application of genetic markers to the wild canids that inhabit the eastern US. Recent technological advances in the use of single nucleotide polymorphisms (SNPs) and the ability to examine ancient DNAs have provided

important information. Because of their potential similarities, studies on the "eastern wolf" (*Canis lycaon*) as well as the red wolf were included in the review.

Search strategies included use of the terms "Canis, wolf, DNA, genetic" and were restricted to more recent studies (ca. 2009 to present), as previous reviews have adequately summarized the literature prior to that date. An additional search strategy highlighted studies that cited key literature on the red wolf or eastern wolf and coyote. From these and previous reviews, a consensus was constructed where possible. WMI identified areas where additional information would be useful.

Program Management

Federal document review

To delineate the extent to which the FWS followed appropriate laws, rules, policy and guidance as requested under the Program Management inquiry, we reviewed approximately 200 documents related to the red wolf recovery program. These included, but were not limited to the following:

- Federal register notices – official notification to the public that a federal project is being considered with a request for comments. Also used to provide public notice of a final rule.
- Federal rules – documents delineating when, where, how, and why a project will move forward. Gives specific federal authority for a project to take place.
- Environmental Assessments – National Environmental Policy Act required evaluation of the potential impacts that the red wolf recovery may have on areas/projects with a federal nexus.
- FWS policies, and guidance – documents delineating or clarifying the appropriate application of federal rules, policies etc.
- FWS programmatic reports – annual, quarterly, and monthly reports on the red wolf project, including specifics such as population estimates, dispersal, radio tracking, reproduction and litter sizes, disease and mortality issues, and other challenges associated with the project.
- Annual work plans – descriptions of the types of activities that are conducted on a NWR the previous year, including operations & maintenance, projects, research, and restoration reports.
- Reintroduction, recovery, and survival plans – official FWS plans that provide specific goals, objectives, deliverables, timelines, and measurables.
- Budget documents – documents that describe the fiscal situation of the red wolf recovery program over its lifetime.
- Correspondence – letters, memoranda, and other documents that discuss, describe, or clarify issues and opportunities with the red wolf recovery program, including compliance with federal rules and policy.
- Research articles – seminal research articles that provide essential background information on the science and management of species recovery.

- Landowner agreements – documents that demonstrate willingness of landowners to cooperate with the red wolf recovery, and restrictions that they may have, if any.
- Organizational charts – hierarchy of FWS personnel at the field level.

Reviewed documents are delineated in Appendix D. Documents were evaluated based on compliance with project administration. Discrepancies between documents or between document and application are noted in our response to the FWS questions.

Staff Interviews

We conducted interviews with 2 FWS staff from the Headquarters office (Washington DC), 10 staff from the Region 4 Office (Atlanta, GA), 2 staff from the Ecological Services Field Office (Raleigh, NC) and 6 staff from the field (Manteo, NC and affected programmatic and refuge staff). Each staff member was first asked to evaluate the success of the program and the performance of the FWS in a short written survey (Appendix E). Staff was then interviewed about aspects related to the objectives of this review (Supporting Science, Program Management, and Human Dimensions).

We also conducted interviews with 4 headquarters staff and 1 Commission member of the NCWRC leadership to assess their perspectives on the red wolf recovery project. Finally, we conducted interviews with two of the plaintiffs (Defenders of Wildlife and Red Wolf Coalition) in a recent lawsuit regarding coyote hunting and the red wolf recovery program.

Human Dimensions

Online Survey

We conducted an online survey (Appendix F) for a two-week period (August 29-Sept 12, 2014) through a dedicated website (http://jgassett.polldaddy.com/s/red-wolf-restoration-recovery-program). We received 13,456 responses to this survey, which were exported to a Microsoft Excel spreadsheet. This spreadsheet was then converted to an SPSS dataset. Data were analyzed for all respondents, North Carolina residents, restoration zone residents, North Carolina residents not in the restoration zone, and respondents outside of North Carolina, and comparisons (differences of proportions) of all groups were conducted. Comments attributed to this survey were reviewed and found to be consistent with the respondents' answers to other survey questions – although typically comments were too general in nature to provide substantive input that was not covered by other portions of this report

FWS e-mail Comments

The FWS solicited e-mail comments for a two-week period (August 29-Sept 12, 2014) through a dedicated e-mail address (redwolfreview@fws.gov). This comment period was later extended for two additional weeks (until Sept 26, 2014) due to technological issues with the e-mail server. The FWS received more than 43,000 comments from this

solicitation. The FWS provided these comments to WMI. Because the solicited e-mail comments were the requested by the FWS; we did not provide a detailed analysis. However, we did identify that the comments ranged from strong support to strong opposition for the recovery program. The comments indicated the passion of supporters and opponents of the recovery program but do not provide decision-makers with a scientifically valid public opinion or attitude survey. Commenters were self-selected as opposed to randomly sampled. It was also evident that outside organizations rallied their membership to participate during the e-mail comment period. WMI concluded that self-selected e-mail comments might provide a quick and easy view of some of the public's opinions; however, they should not be construed as an alternative to a science-based survey.

Public Stakeholder Sessions

Public meetings were advertised in a FWS press release on August, 29, 2014 and were held in the cities of Swan Quarter (Sept 10, 2014) and Columbia (Sept 11, 2014) from 7:00 p.m.-9:00 p.m. local time, within the red wolf restoration range of eastern North Carolina. Attendees at both meetings were asked to complete hardcopies of anonymous surveys (Appendix E) to gauge their perceptions regarding issues related to the red wolf recovery project. All respondents were asked to complete Questions 1-6 of the survey. Only respondents that live in the 5 county red wolf restoration area were asked to respond to Questions 7-16 of the survey.

Opportunities for written comments were also provided with the survey, and comments were categorized according to their relevance (Biological, Management, Sociological, and Other) and later assigned a designation of Actionable, Educational, or Informational. "Actionable" comments are ones that could potentially be addressed by specific actions such as a change in activity, policy, guidelines, or the execution thereof. "Educational" comments could potentially be addressed through public information and outreach. "Informational" comments contained neither actionable nor educational components, and were typically general in nature – usually reflecting support of opposition to the project.

At each of the public meetings, individuals were allowed to singly approach a microphone and make a comment or suggestion. At the moderator's discretion, a member of the public making a comment was asked for more details, specific examples, or follow-up questions. Members of the audience were not allowed to question each other. Responses were collected via digital recording and written notes, as well as displayed visually for the audience to minimize any misunderstanding or misrepresentation of comments by the moderator.

Independent Evaluation of Review

Four independent reviewers were chosen to evaluate the final draft of the programmatic review. These reviewers were chosen for their extensive expertise in carnivore biology, management, and recovery. Each reviewer was vetted by the FWS to ensure that no

conflicts of interest existed. The programmatic review was independently evaluated for thoroughness, accuracy, and relevancy to the red wolf recovery.

Brief biographies of the independent reviewers appear below:

Dr. John C. Kilgo is a Research Wildlife Biologist with USDA Forest Service Southern Research Station in New Ellenton, South Carolina. He holds a B.S. in Biology from Wofford College, an M.S. in Wildlife Ecology from the University of Florida, and a Ph.D. in Wildlife Ecology from the University of Georgia. Since 1996, he has been stationed at the U.S. Department of Energy's Savannah River Site near Aiken, SC, where for the last 10 years he has studied the ecology of southeastern coyotes and their effects on deer populations.

Dr. Kim Titus is the Chief Wildlife Scientist for the Division of Wildlife Conservation – Alaska Department of Fish and Game. He oversees a number of programs including Wildlife Health and Veterinary Services, Marine Mammals, and Wildlife Diversity. During his 25 years with the department, He conducted extensive field studies on brown bears and goshawks associated with forest management. He has served as a regional supervisor (10 years) and Deputy Director (7 years). Dr. Titus has worked on a number of wolf/bear science, regulatory and policy issues for the department in his career. He works on a variety of ESA-related issues including those for the goshawk and wolf in Southeast Alaska and other birds and marine mammals. He presently serves on the polar bear Recovery Team. He holds a Ph.D. in Wildlife Science from the University of Maryland – Appalachian Laboratory.

Dr. Douglas W. Smith is a Senior Wildlife Biologist in Yellowstone National Park. He supervises the wolf, bird and elk programs – formerly three jobs now combined into one under Doug's supervision. His original job was the Project Biologist for the Yellowstone Wolf Project, which involved the reintroduction and restoration of wolves to Yellowstone National Park. He helped establish this project and position. Doug received a B.S. degree in Wildlife Biology from the University of Idaho in 1985. While working toward this degree he became involved with studies of wolves and moose on Isle Royale with Rolf Peterson, which led to long-term involvement (1979-1994) with this study as well as a M.S. degree in Biology under Peterson at Michigan Technological University in 1988. His M.S. research focused on beavers in northern Minnesota and resulted in an 11 year study of beavers in Voyageurs National Park which eventually led to a PhD from the University of Nevada, Reno in Ecology, Evolution and Conservation Biology in 1997 under Stephen H. Jenkins. He has also conducted beaver research in Wisconsin and Michigan as well as studying wolves in Minnesota with the world's leading wolf expert L.D. Mech (1983). His professional interests include wolf population dynamics, wolf-prey relationships, restoration of ecological processes, raptor conservation, and beaver population dynamics. He is a member of the Mexican Wolf Recovery Team, the Re-Introduction Specialist Group, and Canid Specialist Group for the IUCN.

Mike Phillips has served as the Executive Director of the Turner Endangered Species Fund (TESF) and Coordinator of the Turner Biodiversity Divisions (TBD) since he co-founded

both with Ted Turner in June 1997. Prior to that, Mr. Phillips had worked for the WS and National Park Service since 1981. During his employment with the federal government he served as the leader of historic efforts to restore red wolves to the southeastern U.S. and gray wolves to the Yellowstone National Park. He also conducted important research on the impacts of oil and gas development on grizzly bears in the Arctic National Wildlife Refuge and dingo ecology in Australia. Throughout his career as a conservation biologist he has focused on the recovery of imperiled species, integration of private land in conservation efforts, ecological economics, and socio-political aspects of natural resource use and management. In 2013, Dr. E. O. Wilson nominated Mr. Phillips for the prestigious 2014 Indianapolis Prize. He received his M.Sc. in Wildlife Ecology from the University of Alaska (Fairbanks) in 1986 and his B.Sc., Ecology, Ethology, Evolution from the University of Illinois (Champaign) in 1980.

Findings and Conclusions

Our findings and conclusions track the questions asked in Exhibit A of the FWS contract. We based our conclusions on the program's objectives, our review of scientific literature and numerous documents provided to WMI by the FWS, through public listening sessions, independent reviewer comments, and on our professional judgment.

Supporting Science

Questions posed by the FWS:

a. What does current science tell us about this project? What are the challenges and impediments to the project? What are strategies to overcome them? What are the pros and cons of different strategies for moving forward?

Our review of current science and interviews with FWS biologists indicated that the FWS had a clear understanding of the general life history characteristics of the red wolf. These characteristics included: food habits, breeding, reproduction, denning behavior, social behavior, pup rearing, pack dynamics, home range size, and dispersal.

The project demonstrated that captive-born red wolves could be successfully reintroduced into the wild and rear offspring of their own in an area not occupied by coyotes. It also demonstrated that captive born red wolves could be acclimated in a manner that reduced the tendency for individuals to exhibit wide-ranging post release behavior. In the presence of coyotes, intensive management is necessary to reduce the frequency of interbreeding between coyotes and red wolves. Substantial management actions have been taken to assure this success ranging from vaccinations of red wolf pups, radio telemetry to monitor wolf movements and breeding pair dynamics, sterilization of coyotes, and maintenance of a captive population. However, the first successful reintroduction of red wolves in 1987 occurred when coyotes were absent from the reintroduction area. Given the current distribution of coyotes, any future releases in other areas will occur in the presence of coyotes. Future releases would need to be informed by the reintroduction in eastern NC but will have to make management adaptations due to coyote interactions with red wolves.

There are a several scientific issues that require further evaluation from the FWS and the scientific community. Notably, the taxonomy of the red wolf remains unclear. Unfortunately, resolution of red wolf taxonomy is complicated by the paucity of historic specimens, past and ongoing interbreeding between red wolves and coyotes, and disagreement among geneticists regarding the appropriate methods to determine what constitutes a species or subspecies. Further, while FWS staff involved in red wolf conservation in the 1970's used their best judgment and the available taxonomic information available at that time to guide decisions, it is beyond dispute that the current red wolf genome is the result of artificial, selective breeding of an extremely small number of founders.

The implications of taxonomic uncertainty are nontrivial. If further investigation of red wolf taxonomy or genetics ultimately leads the FWS to determine that red wolves are derived from a hybrid origin of coyotes and gray wolves as suggested by Mech (1970:25) and Wayne et al (1991). The FWS should consider if the current red wolf genome reflects excessive introgression of coyote genes due to interbreeding prior to the time when the surviving red wolves were taken into captivity in the 1970's. That consideration may inform the FWS's judgment regarding whether today's red wolves qualify for protection under the Endangered Species Act. This could lead to a difficult decision to terminate a nearly three decades' long recovery effort.

Conversely, if further evaluation reaffirms the FWS' current interpretation that red wolves arose as a separate taxon from gray wolves and coyotes, and that the current genome is sufficiently distinct from coyote-red wolf hybrids, the FWS will be faced with equally difficult choices regarding this species' future, given the ongoing expense and uncertainty regarding efforts to reduce the risk of interbreeding with coyotes. These issues are discussed in more detail below.

The FWS needs to assess the role hybridization of red wolves and coyotes play in the continued existence of the current red wolf genome, which is one objective of the current recovery program. Further analysis of the effectiveness and efficiency of the placeholder strategy should be conducted within the context of the program's management. WMI also concluded that detailed analysis of the population dynamics of the red wolf should be undertaken to understand the decline in population growth and breeding pair numbers. The timeline for this review did not permit WMI to undertake such an analysis and FWS staff indicated that they are currently drafting a manuscript that will be submitted for publication in a peer-reviewed journal to fill this void. Another issue that requires additional monitoring and research is the impact of canid disease and parasites. Finally, the program should assess the habitat requirements, including prey availability, of self-sustaining, wild red wolf populations released in other restoration areas.

WMI was not asked to determine the appropriateness of the red wolf as a distinct species; however, this issue was a predominant theme in public meetings held in the restoration zone. WMI employed Dr. Randy DeYoung, a wildlife genetics expert at TAMU-Kingsville, to synthesize current literature regarding the genetics and taxonomy of the red wolf. His findings and conclusions are presented below (in italics):

Genetics and Taxonomy

The main genetic issues associated with the red wolf management program are taxonomic uncertainty, historical and ongoing hybridization with coyotes, and inbreeding and genetic drift. The taxonomic issue is not fully resolved, but there is sufficient evidence for further consideration of a North American origin for the eastern wolf, red wolf, and coyote independent of the gray wolf (e.g., non-hybrid origin of red and eastern wolf taxa). Current technologies that incorporate next-generation DNA sequencing and single nucleotide polymorphism (SNP) arrays offer promise for additional insights into the phylogenetic history

of canids in the Americas. Nonetheless, a full resolution of taxonomy may require additional genetic analysis of historic specimens from a wider sampling distribution than has been presented to date. Contemporary hybridization of red wolves with coyotes will be a persistent issue for management.

The placeholder strategy appears adequate to prevent introgression into the red wolf population and current genetic technology allows for the identification and removal of hybrids to prevent introgression into the red wolf genome. It is not clear if a sustaining population of red wolves can be maintained without active management against hybridization. Overall, the placeholder strategy is labor-intensive and the efficiency further reduced by the killing of placeholder coyotes and dispersing red wolves. The take of placeholders may de-stabilize social order of coyotes in the buffer region and increase the chances for additional hybridization. Changes in public attitudes or other means to reduce take of canids in the management area might aid in the placeholder strategy or help the current population expand. The red wolf population experienced a bottleneck through founding by a small number of individuals. No serious physical consequences of inbreeding on fitness have been observed to date. Unless the population can expand or additional populations are established, the red wolf is prone to further loss of diversity through the accumulation of inbreeding, genetic drift, and stochastic events. The future of the red wolf in the wild may hinge on the establishment of additional free-ranging populations. The main question is whether a sufficiently large, self-sustaining wild population can be established to ensure the preservation of the red wolf genome.

Questions of historical and contemporary hybridization appear frequently in the context of red wolf and eastern wolf conservation, most recently debated by vonHoldt et al. (2011) and Rutledge et al. (2012). Early genetic data led to the hypothesis that the red wolf was a hybrid taxon, the result of historical hybridization between gray wolves and coyotes (Wayne and Jenks 1991, Roy et al. 1994, Reich et al. 1999). Recent genetic data have cast doubt upon the hybrid origin hypothesis and the balance of evidence has tilted towards a North American canid assemblage composed of the eastern wolf, the red wolf, and the coyote as distinct taxa that are descended from a common ancestral canid of North American origin (Rutledge et al. 2010a, Rutledge et al. 2012, Wilson et al. 2012). If this reasoning is correct, gray wolves of Eurasian origin immigrated to the Americas more recently (within the past million years) and were relative latecomers to the geographic region of the U.S. (Chambers et al. 2012). However, the hybrid origin hypothesis has not been conclusively refuted.

Taxonomic uncertainty continues in part due to recent and historical hybridization between wild and domestic canids, differences in the interpretation of genetic data, different suites of molecular markers, and the sampling distribution upon which the analyses were based (Wheeldon and White 2009, vonHoldt et al. 2011, Chambers et al. 2012, Rutledge et al. 2012, Wilson et al. 2012, Hinton et al. 2013, Monzon et al. 2014). The common theme among genetic studies of canids in the Americas is admixture and complicated phylogenetic history. Furthermore, the definition of a species, subspecies, or evolutionary significant unit depends on whether one views the data through the lens of the biological species concept or the genetic species concept (Baker and Bradley 2006). Recent advances in high-throughput analysis of DNA, including next-generation sequencing and SNP arrays, promise to clarify

some of the taxonomic uncertainty. The analysis of SNP data has proven informative, yet limited by recent hybridization events, the distribution of samples, and the recent demographic history of some populations, such as the red wolf.

Genetic data from several historical specimens supports the eastern wolf as a distinct taxon from gray wolves (Wilson et al. 2003, Rutledge et al. 2010d), but historical or ancient specimens of red wolves are lacking. Therefore, the resolution of taxonomic uncertainty for both red and eastern wolves may ultimately require the inclusion of additional 'ancient' DNA samples from specimens that predate the collapse of wolf populations in the eastern US, and perhaps prior to European contact with the Americas. For instance, multiple sets of genetic data and independent studies were needed to understand the history of hybridization and backcrossing between grizzly bears and polar bears (Cronin et al. 1991, Miller et al. 2012, Cahill et al. 2013).

The management of endangered taxa must proceed on the best available data and cannot await taxonomic resolution. Most studies of North American canids have found evidence for contemporary hybridization among taxa, including gray wolves, the eastern and red wolves, coyotes, and domestic dog (Bohling and Waits 2011, vonHoldt et al. 2011, Benson et al. 2012, Wilson et al. 2012, Monzon et al. 2014). Eastern and red wolves readily hybridize with coyotes, while gray wolf–coyote hybrids appear rare, though it appears that coyotes and gray wolves are physiologically capable of producing offspring (Mech et al. 2014). The introgression of coyote genes into gray wolf populations appears to be the result of backcrossed eastern wolves mating with gray wolves (Rutledge et al. 2010b).

Potential explanations for the asymmetric propensity to hybridize include lack of reproductive isolation due to recent common ancestry for North American canids (eastern wolf, red wolf, and coyote), increased propensity for hybridization due to inbreeding avoidance in red and eastern wolves, and hybridization as a result of social disruption due to human-induced mortality. Social disruption via harvest appears to increase the chances for hybridization (Rutledge et al. 2010c, Rutledge et al. 2011), yet there appear to be behavioral or other physiologic barriers to mating between gray wolves and coyotes. Hybridization between red wolves and coyotes does not appear sex-biased, though Monzon et al. (2014) found evidence for sex-biased hybridization between female coyotes and male eastern wolves and domestic dogs. The complexity and dynamics of hybrid swarms in regions of sympatry among North American canids limits direct inference. However, it appears that landscape features, especially related to human development, and prey availability influence the occurrence of hybridization and introgression of hybrid genes into parental populations (Benson et al. 2012, Monzon et al. 2014)

In terms of management, hybridization between red wolves and coyotes is a persistent and vexing problem. The FWS has employed a 'placeholder' strategy to discourage hybridization with coyotes. The placeholder technique involves the capture and sterilization of coyotes on the fringe of the red wolf population to act as territory holders to prevent coyote immigration into the red wolf population. The placeholder technique appears to rely on sound principles; current genetic methods can discriminate between red wolves and coyotes and has been employed successfully to limit introgression of coyote genes into the free-ranging red wolf

population (Miller et al. 2003). However, ongoing harvest mortality poses a serious complication for both the placeholder strategy and for the survival of dispersing red wolves (discussed by Hinton et al. 2013). Studies of the eastern and red wolf suggest that human-induced mortality can disrupt the social structure of wolves and increase the probability that the surviving member of the pair will mate with a coyote (Rutledge et al. 2010c). Thus, the death of placeholder coyote wastes effort expended to mark, sterilize, and monitor the population and might increase the chances of hybridization. The apparent illegal killing of dispersing red wolves may further limit the expansion or introgression of red wolves beyond the peninsula. Regardless, there is little evidence for expansion or introgression of red wolf genes into the surrounding canid populations (Bohling and Waits 2011).

Coyotes are currently present through much of the eastern US. Therefore, the expansion of red wolves beyond the Albemarle Peninsula will likely require continued use of the placeholder strategy. To be successful, this technique would need to be combined with public outreach or other means to minimize human-induced mortality of coyotes and wolves in and adjacent to the experimental area. The availability of large mammals as prey may have acted to maintain wolf-like traits in the zone of admixture between eastern wolf and coyotes in Ontario (Benson et al. 2012, Monzon et al. 2014).

It is possible that ongoing recovery of elk (Cervus elaphus) to the eastern US might promote the retention of wolf-like traits in the presence of a hybrid swarm. Although portions of eastern wolf populations remain relatively intact while surrounded by hybrids (Rutledge et al 2010b), the dynamics of the hybrid swarm are complicated and it is uncertain if distinct red wolf genes would be maintained. In the end, this is a question of the future of canids in the region and less relevant to current management of the red wolf; clearly, ongoing threat of hybridization will continue to confound contemporary management of the red wolf.

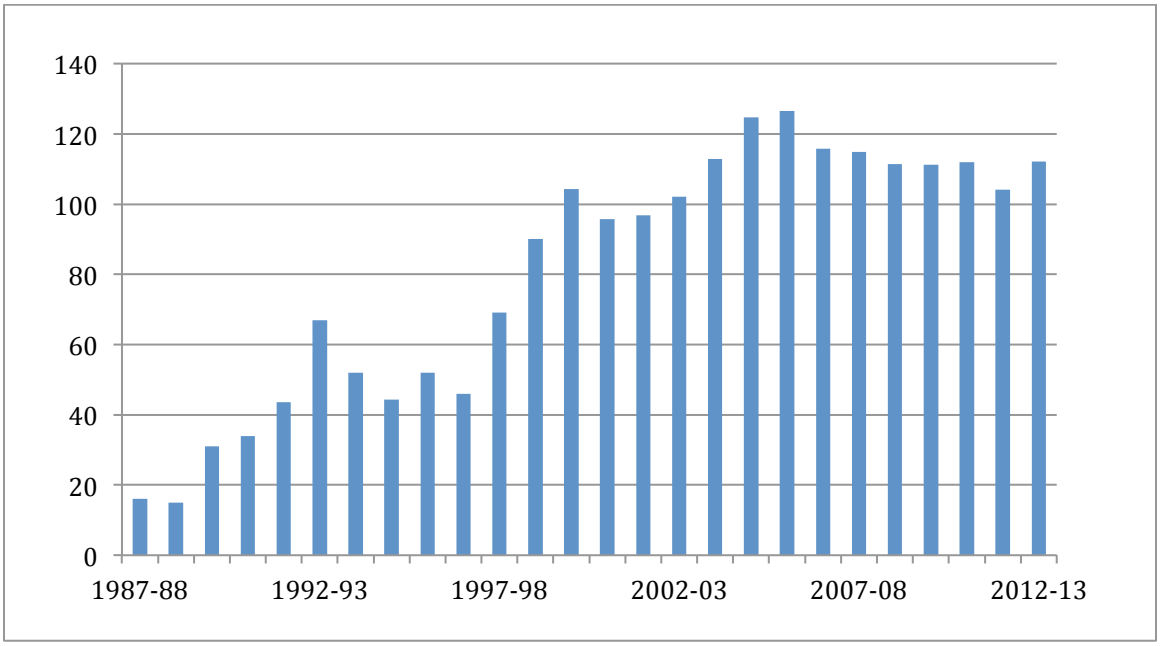
The red wolf stock was derived from a small number of founders, including individuals that had experienced prolonged decline of census size. The red wolf population has retained some adaptive diversity at the major histocompatibility complex (MHC) loci, though the distribution of MHC alleles may suggest past hybridization with coyotes (Hedrick et al. 2002). Furthermore, the loss of individuals to apparent illegal harvest (discussed in Hinton et al. 2013) maintains a low effective number of breeders, increasing the chances for inbreeding and genetic drift. Physical abnormalities indicative of inbreeding were observed in some captive individuals, while the free-ranging population displays increased pedigree co-ancestry and inbreeding effects on non-reproductive traits, such as body size (Brzeski et al. 2014). Without additional population growth or the establishment of new populations, the free-ranging population will be vulnerable to additional accumulation of inbreeding, and loss of diversity due to genetic drift or other stochastic events. Ongoing monitoring should be vigilant for signs of physical abnormalities or depression of fitness. Active management may eventually be needed to reduce further inbreeding through the introduction of unrelated individuals, termed 'genetic rescue' (Brzeski et al. 2014).

Population Dynamics

FWS staff uses population-modeling techniques to estimate the total size of the wild red wolf population. The model accounts for collared and un-collared wolves within the restoration area. Un-collared wolf survival is estimated using Burnham joint Live-Dead model (Burnham 1993) in Program MARK (White and Burnham 1999). FWS calculate annual population estimates combining the number of known (actively monitored) radio-collared animals together with age-specific survival estimates of the un-collared animals using knowledge about their individual fates. In the last 2 years, FWS staff has refined the population modeling procedure resulting in a more statistically robust model.

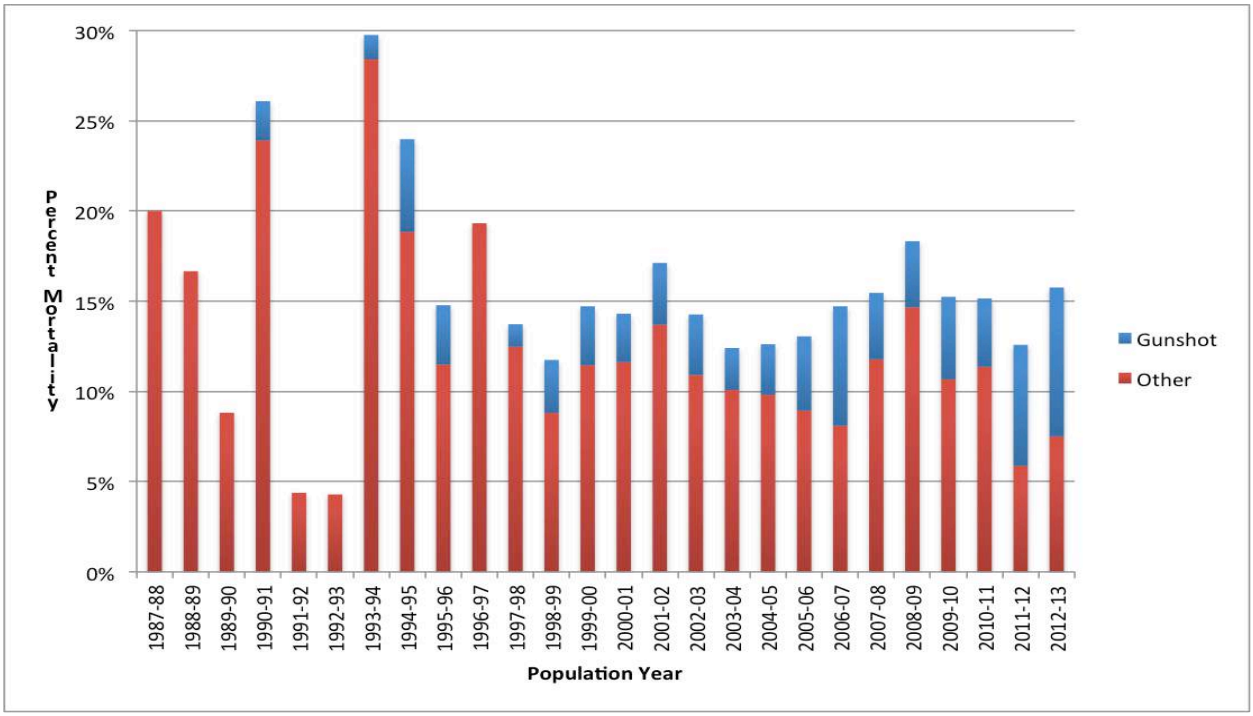
The red wolf population trend within the five-county restoration area increased up until 2005-2006. Since that time, the population has exhibited a gradual decline (Figure 1).

Figure 1. Total absolute population estimate for the population years of 1987-88 to 2012-13 (population year is October 1- September 30).



Discussions with FWS staff indicated that a recent concern was the impact of the increase in gunshot mortality. Gunshot mortality has become more prevalent numerically; however, WMI questioned the relative impact of this mortality rate on the total population. To assess that impact we calculated the percent of the estimated population removed by gunshot and other mortality causes by the absolute population estimate. The following assumptions were made: 1) the total absolute population estimate calculated by the population model is precise and 2) the total population within the population year consisted of the estimate and the number of mortalities that occurred within the population year. We considered the trend over time to be only an index and not an estimate of yearly mortality rates. Figure 2 indicates a relatively stable total mortality rate index (approximately 15%) over the last 15 or so years.

Figure 2. An index of the gunshot and other cause mortality rates for the total absolute population estimate for the population years of 1987-88 to 2012-13 (population year is October 1- September 30).



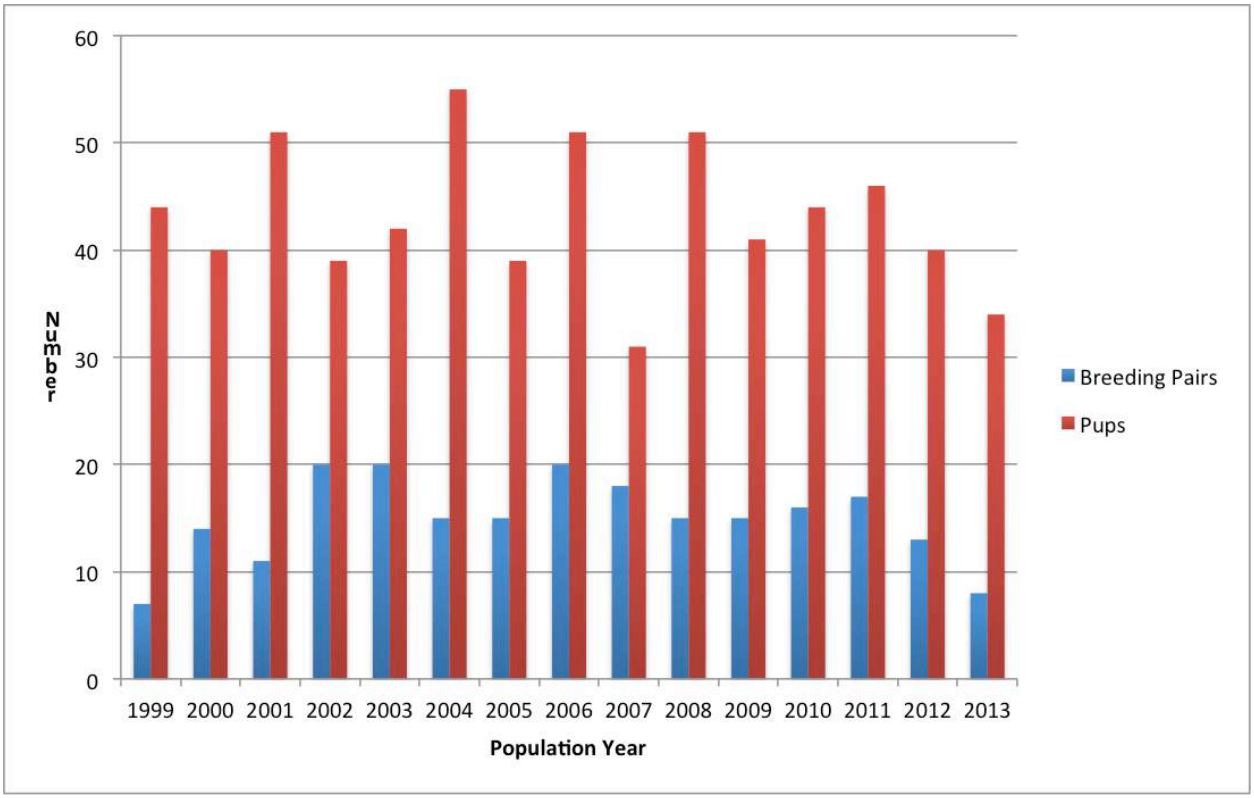
WMI agreed with FWS biologists with respect to the negative impact of any mortality on a small population. Canid behavior and breeding behavior warrant a close monitoring of mortality by any cause. Loss of a member of a breeding pair or a red wolf of breeding age can have a negative impact on a small population. Because red wolf breeding pairs defend a territory against other wolves or coyotes, loss of a member may result in a "hole" within the red wolf restoration area, depressing the production of pups and a reduction in population numbers. In addition, the loss of a member of a red wolf breeding pair may result in interspecific breeding and wolf/coyote hybridization. It is not just the loss of an individual that is of concern; it is when it occurs relative to the breeding season and the role that individual may play in the future production and recruitment of adults into the population.

However, based on available information, we were unable to ascertain the specific reasons for the decline in the red wolf population that originated in the 2005-2006-population year. FWS staff informed WMI that they are continuing to examine existing data to better explain this trend. FWS staff is examining the loss of breeding-age wolves through anthropomorphic causes, the timing of those causes, red wolf/coyote hybridization, reduction in prey base that hampered survival and productivity, and carrying capacity issues to better understand the recent declining population trend.

Breeding pair numbers have declined since the 2002-2006 time period (Figure 3). Current breeding pair numbers are similar to those found in 1999-2000 time period. Pup numbers

have fluctuated throughout the life of the project (mean = 43). The most recent estimate (2013) was 34 pups in the population.

Figure 3. Breeding pair and pup numbers occurring during the population years from 1999 to 2013.



FWS staff told WMI they were currently involved in an in-depth analysis of breeding pair trends and pup production trends. Current information indicated that since 2005-2006, a preponderance of gunshot mortalities on breeding-aged red wolves occurred during the months of October, November, and December prior to breeding season. This information lends credence to the FWS's concern about which red wolves died and when they died. We expected that the research on the population dynamics of marked (collared) red wolves would lead to a more definitive explanation for the current population status. Having drawn that conclusion, WMI understands that the complexity of wild canid population dynamics and behavior complicates such an analysis.

Habitat Requirements

The red wolf is a food and habitat generalist. Neither of these characteristics presents an ecological issue for the recovery program; however, the geographic area necessary to sustain red wolf populations presents jurisdictional, social, and political issues that need to be addressed. The red wolf population in North Carolina spans 5 counties and includes both public and private land. FWS staff informed WMI that nearly 60 percent of red wolves in the area occupy private land. Dispersal of wolves has proceeded westward and southward indicating that range saturation may have occurred within portions of the

restoration area. The original recovery plan anticipated that 144,000 acres of federal land would be sufficient area for a projected population 35-50 wolves. As the wolf population increased, the restoration area was expanded to include 1.7 million acres (an area almost 12 times the size originally intended). Habitat suitability and prey availability measures have not been calculated to determine if the existing restoration area adequately provides the resources necessary for an estimated population of 100-130 individuals.

Even with the addition of Pocosin Lakes NWR and agreements with private landowners, the restoration area has been expanded in response to wolf population growth and dispersal patterns. Table 1 presents the variations in FWS documents with respect to projected habitat use and the estimated population size within that habitat. We understand that science-based recovery programs are adaptive in nature; however, we suspect that some of the public frustration and concern with the program has been due to changing expectations and plans for the recovery project. This issue will be addressed in the context of FWS assertions and public understanding of the 10(j) Rule in the Program Management section of this report.

Table 1. Variation in projected habitat use and population sizes found in FWS documents for the time period of 1984-2007.

Year	Document	Home Range	Minimum Land Area	Projected Population	Estimated Population	Proposed Release
1984	Recovery Plan	25-45 mi^2	144,000 acres	35-50		6 mated pairs over 2 years
1986	Proposed Reintroduction		144,000 acres	20-30		6-8 mated pairs
1986	FR Notice	25-45 mi^2		25-35		5 mated pairs
1990	Recovery/Species Survival Plan				20	
1991	Pocosin Lakes NWR Release Plan (see 1993 document)		250,000 acres		28-31	
1993	Pocosin Lakes NWR Release Plan		500,000 acres	50-100		
1993	AR and PL NWR Reintroduction		144,000 acres	20-30		
2003	Restoration of the Red Wolf	35-48 mi^2	1.7 million acres		100	
2007	5-Year Status Review				(80-100) 100-130	

Blank cells indicate a lack of data.

Challenges and Strategies

The primary challenges associated with the overall recovery program are fourfold: the need for redundancy in wild populations, genome integrity and the impact of interspecific breeding with coyotes, the necessary recovery area size, and land ownership patterns within restoration areas. Disease and parasite risk within a small population and climate change impacts to the original restoration area are additional concerns in addition to the four aforementioned issues.

The recovery of the red wolf in the wild will require additional restoration areas to provide redundancy and resiliency for the program. Reliance on one site leaves the program vulnerable to stochastic events that could derail the recovery program. This is particularly of concern, given the projected impacts of sea level rise on the Albemarle Peninsula. Objective 1 of the Recovery Plan calls for establishing at least 3 reintroduced populations. Selecting additional restoration areas will be hampered by the size of the areas needed and land ownership patterns within those areas, as well as, the fact that coyotes now fully occupy all former red wolf range. Further, future restoration areas should consider the opportunity for genetic exchange between the 3 populations.

The challenges of establishing additional restoration sites are numerous. Site selection would require additional time and expense. New sites would require extensive baseline and ongoing ecological monitoring. Program management and maintenance expense would presumably increase arithmetically for each reintroduction. New restoration programs might lead to loss of individual red wolves. Finally, the human dimensions efforts associated with additional reintroductions into new sites must exceed the original effort in Alligator River NWR. Due to the widespread distribution of coyotes, new sites must also contend with management actions necessary to reduce or eliminate red wolf/coyote hybridization.

The "placeholder strategy" appears to be theoretically sound; however, we have not seen a robust evaluation of its success to date. FWS staff informed WMI that an analysis of the placeholder strategy is currently being conducted. Intended to reduce hybridization, it has led to public frustration with the program. The expense and indefinite time period for success are problematic. Success is dependent on the restoration area size, coyote and red wolf density and distribution, and logistics associated with this management intensive procedure. Coyote population reduction may lead to a reduction of hybridization. However, the current coyote hunting prohibition within the 5 county restoration area makes this point, at least temporarily, moot.

Monitoring and treating individual red wolves and other canids that inhabit the restoration area can address some canid disease and parasite control. This effort would reduce the potential impact of widespread disease outbreak. Non-canid reservoirs do exist for diseases such as: rabies, parvovirus, distemper, and heartworms that may potentially threaten the program. The effort is expensive, needs to be conducted for an indefinite time period, and involves handling numerous individuals throughout the restoration area.

Strategies to overcome the challenges and impediments are available. Using modeling procedures, van Manen, et al. (2000) ranked prospective sites for red wolf releases in the eastern United States. Due to the habitat generalist nature of red wolves, we believe that restoration sites do not need to be coastal areas. In addition, we are unaware of island sites on the east coast that would provide adequate area for population growth and dispersal. Reintroduction of red wolves to other areas would increase the program's redundancy and resiliency, diminish the impacts of climate change on the total red wolf population by mitigating the impacts to the current coastal restoration site, and provide an opportunity to engage in public outreach for support. However, any future reintroduction effort must address the issue of interbreeding with coyotes

The primary ecological challenge associated with maintaining or increasing the current red wolf population or establishing additional populations is maintaining red wolf genome integrity in the face of potential hybridization with coyotes. WMI found the FWS is using a "placeholder" strategy to address this issue in the current population. The apparent advantages of this strategy are that it is based on sound theoretical grounds and anecdotal evidence suggests this approach is limiting gene flow from coyotes into the red wolf population. However, a rigorous analysis of efficacy or effectiveness has not yet been completed.

One major disadvantage of the placeholder strategy is the expense and amount of human resources it requires. A significant portion of the recovery program's annual budget of $1.3 million can be attributed directly or indirectly to implementation of the placeholder strategy. Application of this strategy to a larger area capable of supporting a viable, self-sustaining population or to two additional restoration areas could be expected to add several million dollars per year to the cost of the recovery program.

Another major disadvantage of the placeholder strategy is uncertainty regarding how long it would need to be applied. When asked, FWS staff were not able to say whether or at what point they thought the red wolf population in eastern North Carolina would be able to maintain genetic integrity, absent active management of placeholders. It is conceivable that the placeholder strategy may be required indefinitely if the recovery program goal continues to be maintenance of the existing red wolf genome. It is debatable whether any species that requires this level of ongoing, intensive management could ever be considered "recovered." This suggests the FWS may need to consider alternative strategies.

One such alternative would be to allow red wolves and coyotes to interact without human intervention for a pre-determined period of time and monitor gene flow within the resulting hybrid swarm using existing, effective techniques to monitor genetic composition of coyotes, red wolves and hybrids in the experimental area. WMI envisions two approaches that would allow the FWS to assess the ability of red wolf genes to persist under this scenario. If conducted as a management experiment, these approaches should be defensible, given the experimental, non-essential designation of red wolves in North Carolina and the ability to designate any other reintroductions as experimental, non-essential under Section 10(j) of the ESA.

The first approach would be to reintroduce red wolves into one or more areas of suitable habitat within the historic range of the species. The primary disadvantage of this approach is that it would risk loss of red wolves from the small captive population or the wild population in North Carolina, depending on the source of translocated wolves. However, if successful, this approach would advance the stated goal of establishing 3 separate populations. The FWS would need to weigh the risks and benefits of this approach, as well as added cost of additional reintroductions.

A second approach would be simply to suspend current efforts to preclude interbreeding between red wolves and coyotes in the North Carolina recovery area. Advantages of this alternative include significantly reduced cost and the opportunity to evaluate the actual, ecological effects of hybridization on red wolves. The results would give the FWS empirical information to supplement the theoretical basis that currently drives decisions regarding red wolf recovery. Indeed, the results of one or more of these experimental approaches may be the only way the FWS can determine whether recovery of the red wolf in the classic sense of the ESA is possible or if red wolves will remain a "conservation-reliant" species (sensu Carroll et al 2014) in perpetuity.

The main disadvantage of this alternative is that it would almost certainly lead to some reduction in genetic integrity of red wolves in the wild. The FWS would need to weigh the merits of this potential loss against the opportunity to increase the number of red wolves or at least red wolf hybrids living in the wild, fulfilling the ecological functions they formerly did.

A lesser ecological challenge is the potential impact of disease or parasites on red wolves. Diseases and parasites pose a greater risk to a small population. WMI found the FWS is addressing the threat of disease and parasites as a routine part of their capture and handling procedures. For the present, this approach is sound. Over the longer term, establishment of a larger population and/or establishment of additional populations would further reduce the risk of disease or parasites to persistence of red wolves.

The final ecological challenge WMI identified was the long-term impact of climate change on red wolf habitat in coastal North Carolina. As discussed elsewhere in the review, climate models suggest that much of the Albemarle Peninsula will succumb to sea level rise over the next 75–100 years. The only viable strategy to address this challenge is to secure sufficient habitat in upland areas to support red wolves.

A socio-political challenge associated with maintaining the existing population or establishing additional populations of red wolves is the need for support from state wildlife agencies, private landowners and the broader public to create a sufficiently large restoration area. One strategy to address this challenge is development and implementation of a communications strategy that embodies leading social science methodology.

The reintroduction of new predators to an area prompts public reaction both positively

and negatively. Extensive human dimensions research, public outreach strategy development, and a human-red wolf conflict management program would be necessary to improve the social acceptance of red wolves. Such efforts would need to be conducted in the existing restoration area to address current public opposition to red wolves as well as in advance of any future reintroductions. Numerous public outreach efforts were employed during the early stages of the Alligator River NWR reintroduction program, yet public controversy and confusion remains. Advances in human dimension research would need to inform future reintroduction efforts to reduce these problems. Public information and involvement would need to be conducted with a conflict management and mediation approach (Clark and Rutherford 2014). Given the controversial nature of predator reintroduction, even the best intentions and efforts may be ineffective if community leaders or influential spokespersons are resolved to be intolerant of predator reintroduction. Finally, effective public outreach would increase the expense of the program.

b. What are the project goals outlined in the original Red Wolf Recovery Plan, 10j Rules and Environmental Assessments? Are they still feasible at this time?

The original red wolf recovery plan (USFWS 1982) contained no measurable goals. Instead it stated its goal as "return the red wolf to non-endangered status." The 1984 plan (USFWS 1984) restated the 1982 plan goals with further elaboration: reestablish self-sustaining wild populations within the species' historic range and establish pure red wolf stock for reestablishment in the wild and to zoos and other facilities. The 1984 plan provided measurable goals as follows: establish 3 viable, self-sustaining population widely distributed across the species' range consisting of 35-50 animals per location on a minimum land area of 225 square miles (144,000 acres). The plan stated that the minimum area was established as a planning guide only.

WMI identified several flaws in the 1984 recovery plan and reasons to question the feasibility of establishing 3 viable, self-sustaining red wolf populations widely distributed across the species' range at this time. The flaws in the stated goals include the population objective of 35–50 animals and the implied small size of each restoration area. Two factors that compromise the feasibility of establishing 3 viable, self-sustaining populations at this time are the lack of support for reintroduction to other areas, and the fact that coyotes have now fully occupied the former range of the red wolf.

The 1984 goal of 35–50 animals for each population is unrealistically low, if the population is expected to be viable and self-sustaining. Given the potential impact of interbreeding with coyotes, the consequences of stochastic events or incidental and illegal human-caused mortality, each population of red wolves would need to exceed 100 or more animals to remain viable and self-sustaining. Further, to enhance viability of a red wolf metapopulation, there should be potential for gene flow between the 3 populations.

The 1984 population goal of 35–50 red wolves in each population stands in stark contrast to recovery goals for gray wolves in the Northern Rocky Mountains. The FWS initially

identified 100 as the minimum population size for each of the gray wolf population segments in the Montana, Idaho and Wyoming restoration areas. The minimum population segment size was subsequently increased to 150. Some scientists suggest that an even greater number of wolves in each subpopulation, as well as effective interconnectivity among the subpopulations are required to consider this metapopulation viable (Bergstrom et al. 2009). Although gray wolves in the Northern Rockies may be more vulnerable to intentional human-caused mortality than red wolves due to conflicts with livestock, the lower human population and road densities in the Northern Rocky Mountains mean that gray wolves are rarely struck by vehicles – one of the main causes of incidental human-caused mortality of red wolves. In addition, gray wolves are not susceptible to interbreeding with coyotes.

Although the 1984 recovery plan referred to 225 square miles (144,000 acres) as a "minimum" and for planning purposes only, this may have contributed to designation of a proposed restoration area for the Great Smoky National Park (GSMNP) reintroduction that was unrealistically small. WMI found that the failure of the GSMNP reintroduction was due to inadequate size and configuration of the restoration area. The wolves reintroduced to the GSMNP immediately and continually left the reintroduction area and had to be recaptured and returned.

Wolves are highly mobile and adaptive animals. It is unrealistic to think that they will remain in an artificially designated area if their needs for food or space cannot be met within that area. Selection of reintroduction sites must recognize that the wolves themselves, not a planning document, will ultimately determine where the wolves will be located on the landscape. Thus any future reintroduction site must be large enough to accommodate the wolves' need for space and prey. The need for larger restoration areas leads to the next challenge for establishing additional red wolf populations.

WMI found that the effort to establish a red wolf population in the Land Between the Lakes (LBL) area in Tennessee and Kentucky was abandoned because the FWS was unable to secure the support and cooperation of the states and private landowners in the proposed restoration area. Given the substantial area a viable, self-sustaining red wolf population will require, it will be essential to gain the cooperation of state wildlife agencies and private landowners. Any effort to identify future reintroduction sites will require extensive inter-agency and public relations efforts to secure the broad-based social and political support necessary to create a suitable environment for reintroduction. The recent court ruling prohibiting coyote hunting in the 5 county area occupied by red wolves in North Carolina will intensify the difficulty associated with this issue.

Finally, the fact that coyotes now occupy all former red wolf range adds a challenge to establishing additional populations that did not exist in 1984. As discussed under the preceding questions, this suggests the FWS may need to revisit and revise the red wolf recovery plan.

The 10(j) Rules established the reintroduced wolves as a non-essential, experimental population. This designation was deemed appropriate because the red wolf population

held in captivity was sufficient to preclude extinction of the species. As an experimental, non-essential population, reintroduced red wolves were treated as a species "proposed to be listed" and without the requirement for critical habitat designation.

The management advantage of the nonessential status derives from the fact that it would change the application of section 7 of the Act (interagency consultation) for the reintroduced population. Off of the refuge (i.e. on private lands), the nonessential experimental population would be treated as if it were a species proposed for listing rather than a listed species. This means that only two provisions of section 7 would apply on these non-Service lands: Section 7(a)(l), which authorizes all Federal agencies to establish conservation programs; and section 7(a)(4), which requires Federal agencies to confer informally with the Service on actions that are likely to jeopardize the continued existence of the species. The results of a consultation are only advisory in nature; agencies are not required to refrain from commitment of resources to projects as a result of a conference.

On the Alligator River National Wildlife Refuge the experimental population would continue to receive the full range of protections of section 7. This would prohibit the Service or any other Federal agency from authorizing, funding or carrying out an action on the refuge, which is likely to jeopardize the continued existence of the red wolf. Service regulations at 50 CFR 17.83(b) specify that section 7 provisions shall apply collectively to all experimental and non-experimental populations of a listed species, rather than solely to the experimental population itself. The Service reviewed all ongoing and proposed uses of the refuge, including traditional trapping and hunting with or without dogs, and found that none of these would jeopardize the continued existence of the red wolf, nor would they adversely affect the success of the reintroduction effort (FR Notice (51)41790-41797).

The 10(j) Rule was deemed necessary to gain public acceptance for the reintroduction in the Alligator NWR. Future reintroductions in other areas of the country should evaluate the appropriateness of this designation on a case-by-case basis. Given the public interest in predator reintroduction, the FWS must defend a legal designation that maintains the most flexible management strategy possible in order to gain public acceptance of the program. However, there was an apparent public misperception with respect to "incidental" and "accidental" take. Some individuals expressed the concern that a red wolf shot accidentally while coyote hunting was not characterized as an incidental take, in fact that action could still be prosecuted as a violation of the Endangered Species Act (ESA). FWS law enforcement staff indicated that those prosecutions were not significant within the restoration area.

With the benefit of hindsight, it is clear that 10(j) Rule indicating that red wolves would stay on refuge property or would be immediately recaptured and returned to refuge property was unrealistic and scientifically unsound. The amendments to the 1986 rule were insufficient to address some landowners concern about red wolves on private property. Further complicating the issue was the recent court injunction that prohibited coyote hunting in the 5 county restoration area.

WMI concluded that the amendments to the original 10(j) Rule, although intended to remedy management problems for FWS staff and the public, were not effective. We believe that was due to poorly constructed rules resulting from a lack of adequate involvement of local staff with rule-making staff, inconsistent or inappropriate application of the rules at the local level, and/or miscommunication within the FWS and with the public. Table 2 demonstrates the evolution of 10(j) Rules through the life of the program.

Table 2. Comparison of red wolf 10(j) Rules from 1986-1998 (as provided by the FWS).

(see next 4 pages)

COMPARISON OF RED WOLF EXPERIMENTAL POPULATION RULES/NOTICES

Established to aid in the recovery of the Red Wolf by reestablishing a wild population.

	1986 Final Rule[2] (51 FR 41790)	1991 Final Rule (56 FR 56325)	1995 Final Rule (60 FR 18940)	1998 Notice (63 FR 54151)
Experimental Population Area for Red Wolves [1]	U.S.A. NC- Dare, Tyrrell, Hyde, Washington Cos.	U.S.A. NC- Dare, Tyrrell, Hyde, Washington Cos. + **Beaufort Co.** **U.S.A. NC – Haywood, Swain, Graham, Jackson, Madison Cos.; U.S.A. TN – Blount, Cooke, Sevier, Monroe Cos.**	U.S.A. NC- Dare, Tyrrell, Hyde, Washington Cos. + Beaufort Co. U.S.A. NC – Haywood, Swain, Graham, Jackson, Madison Cos.; U.S.A. TN – Blount, Cooke, Sevier, Monroe Cos.	Notice to terminate Great Smoky Mountains National Park reintroduction effort due to parasites, predation, disease (parvovirus); and poor nutrition due to low prey and inability due to similar factors to establish home ranges
Release site identified where recovery actions would begin	Alligator River NWR – Dare County, NC	Alligator River NWR – Dare County, NC **Great Smoky Mountains National Park**	Alligator River NWR and **Pocosin Lakes NWR** – Dare County, NC[3] Great Smoky Mountains National Park	
Timeline to monitor effectiveness of reintroduction	11/19/1991	**10/1/1992** (revised review time period since the original reintroduction was delayed 11 months)	**1992 monitoring report included in the 1995 Final Rule** (to demonstrate success and explain the need to expand sites where recovery actions would take place in the Experimental Population Area)	
General Support indicated by State in Final Rule	Yes--as long as traditional hunting and trapping on the NWR are maintained. (These have been maintained.)	Yes	Yes (provided comments on reporting requirements and take language)	

Special Rule Provisions (NC):	1986 Final Rule[2] (51 FR 41790)	1991 Final Rule (56 FR 56325)	1995 Final Rule (60 FR 18940)	
	Any person may take red wolves in defense of that person's own life or the lives of others (Reported immediately to NWR mgr).	Any person may take red wolves in defense of that person's own life or the lives of others (Reported immediately to NWR mgr).	Any person may take red wolves in defense of that person's own life or the lives of others (Reported **within 24 hours** to the NWR mgr).	
	Any person with a valid permit issued under 17.32 may take red wolves for educational & scientific purposes, enhancement or propagation for survival of the species; zoological exhibition, and other conservation purposes consistent the ESA and in accordance with State laws and regulations.			
	Any employee or agent of the FWS or State conservation agency when acting in the course of official duties, may take a red wolf if such action is necessary to aid a sick, injured or orphaned animal; dispose or salvage a dead species; or take an animal that is a demonstrable but non-immediate threat to human safety or is responsible for depredations or loss of personal property (if it has not been possible to eliminate such action) (Report immediately to NWR mgr.) Taking must be humane & only involve killing or injury if live capture & release unharmed on NWR is not possible.	**Move an animal for genetic purposes** (added to this provision)		
	No additional take provisions provided in the formal rule;	No additional take provisions provided		

	however, the text of the full rule preamble shares there will be no penalty for taking a red wolf where the take, incidental to an otherwise lawful activity was unavoidable, unintentional, and did not result from negligent conduct lacking reasonable due care (provided must report immediately to NWR mgr.)			
Special Rule Provisions (NC):	1986 Final Rule[2] (51 FR 41790)	1991 Final Rule (56 FR 56325)	1995 Final Rule (60 FR 18940)	
			Private Land: Any person may take red wolves provided that such taking is not intentional or willful (Reported within 24 hours to NWR mgr). Any private landowner or any other individual having his or her permission, may take red wolves found on his or her property when the wolves are in the act of killing livestock or pets provided that fresh kills are evident (Reported within 24 hours to NWR mgr). Any private landowner or any other individual having his or her permission, may harass red wolves found on his or her property provided the harassment is by methods that are not lethal or physically injurious to the wolf (Reported within 24 hours to NWR mgr). Any private landowner may take red wolves found on his or her property after efforts by	

			project personnel to capture such animals have been abandoned; provided the Service project leader has approved such actions in writing (Reported within 24 hours to Service project leader)	
			Public Land: Any person may take red wolves found on lands owned or managed by federal, state, or local government agencies provided that it is incidental to lawful activities; is unavoidable, unintentional, and not exhibiting a lack of reasonable due care (Reported within 24 hours to NWR mgr.)	
Wolves that move out of the originally described release site of the experimental population area	Will be immediately recaptured given appropriate care and will be released back to the wild on the NWR as soon as possible, unless physical or behavioral problems make it necessary to return the animal to a captive facility.	Will be immediately recaptured given appropriate care and will be released back to the wild on the NWR as soon as possible, unless physical or behavioral problems make it necessary to return the animal to a captive facility.	For wolves that move onto lands where the landowner requests their removal, will be recaptured if possible; given appropriate care; and **will be released back into the wild** as soon as possible, unless physical or behavioral problems make it necessary to return the animals to a captive facility.	

[1]Boundaries are identified when an experimental population is established and the entire population within these boundaries (or experimental population area) will be experimental.

[2]Any regulation promulgated pursuant to this section shall, to the maximum extent practicable, represent an agreement between the USFWS, the affected State and Federal agencies, and persons holding any interest in land which may be affected by the establishment of an experimental population area.

[3] We indicated in this final rule that efforts would be made to work with private landowners to allow wolves on private property. In addition as described at 49 FR 33885, "the Service does not believe that private lands should be summarily excluded from consideration. If

c. Are the habitat conditions on federal lands within the recovery area conducive to holding viable self-sustaining red wolf populations for the long term? If not, can the NWR lands be restored or are there other lands outside federal lands (i.e., State, private) that could support populations and would landowners support those populations?

Based on the history of the red wolves reintroduced at Alligator River NWR, WMI concluded that the original 144,000-acre restoration area (USFWS 1984) was of insufficient size and character to hold a viable, self-sustaining red wolf population for the long term. Currently red wolves inhabit portions of a 1.7 million acre area within 5 counties in eastern North Carolina. Given the likely impacts of sea level rise on the Alligator River NWR, the need to sustain a larger number of red wolves to prevent introgression of coyote genes into the population and the recent declining population trajectory, WMI concluded that even the current 1.7 million acre restoration area may not be conducive to holding a viable, self-sustaining red wolf population for the long term.

WMI concluded that the NWRs (Alligator River, Pocosin, Mattamuskeet, Swan Quarter) and the Dare County Bombing Range managed by the Navy and Air Force within the current restoration area cannot be managed or restored in a manner that would provide sufficient habitat for the current population of red wolves. Reintroduced red wolves moved off the refuge lands almost immediately after the original release in 1987. WMI concluded that there is no theoretical or practical reason to believe that red wolves will constrain their activities or movements to a jurisdictional boundary, especially when red wolf density increases within that boundary and prey levels fluctuate through time. The numerical and spatial expansion of gray wolf packs and their ranges within the Greater Yellowstone ecosystem and across portions of the intermountain West reinforced this conclusion.

FWS refuge managers informed WMI that only about 5,000 acres of Alligator River NWR are managed for cooperative farming and Conservation Reserve Program lands. Pocosin Lakes NWR is managed primarily for waterfowl with about 1,250 acres of farmland, and Mattamuskeet contains only about 400 acres of farmland. Much of the habitat used by red wolves (particularly with pups) within the restoration area was associated with agricultural lands. Existing federal lands cannot be managed to replace or even significantly supplement the extensive private agricultural lands within the restoration area landscape.

WMI concluded that habitat restoration on the NWRs could not be accomplished at the scale necessary to support the current population of red wolves due to the geology, hydrology, soil, and habitat types found on the refuge lands. Further, sea level rise has already impacted some refuge lands and threatens to inundate lands and/or change their water and soil characteristics (see response to Question f).

Red wolves readily used private agricultural lands to the west of the Alligator River and Pocosin NWRs. In fact, numerous studies reviewed by WMI indicated that wolves preferred agricultural lands due to the greater diversity and possibly abundance of prey found there. From an ecological perspective, there is abundant, potentially suitable habitat

on private and state land to the west of the current restoration area that could be occupied by red wolves. In fact, given the likely impacts of sea level rise on the current restoration area, it is unlikely this population will remain viable over the long term unless additional habitat to the west is made available and utilized.

WMI was not able to conclusively determine whether or not private and state landowners would support occupancy by red wolves. FWS staff reported they had positive working relationships and landowner agreements with a number of private landowners who were supportive of the recovery program. However, the online survey conducted by WMI and the public listening sessions held by WMI identified significant private landowner opposition to the recovery program and to red wolves on their property. These negative attitudes may have been intensified by the recent court injunction on coyote hunting in the 5 county area. WMI concluded that without a more thorough and scientific evaluation of public opinion and attitudes, FWS would not be able to assess the degree to which non-federal landowners would support use of their lands by red wolves. Further, regardless of the level of support among private landowners overall, the FWS would have to resolve the current opposition among many private landowners to ensure success of the recovery effort in the 5 county restoration area. Clark and Rutherford (2014) provide a framework for carnivore conservation decision-making that could be applied in this context.

d. The 1990 red wolf recovery plan identifies the need for 3 self-sustainable populations in at least 3 distinct locations. Is this assumption still valid? If so, what progress has been made to identify other sites? Does the recovery plan need to be revised?

WMI concluded that the 1990 red wolf recovery plan's identified need for 3 self-sustainable populations in 3 distinct locations was scientifically sound. The establishment of multiple, self-sustainable populations distributed across the historic range of red wolves would reduce the threats associated with stochastic events or long-term processes such as the likely impact of sea level rise on eastern North Carolina to the species as a whole.

WMI found the FWS attempted to establish reintroduced populations in the LBL and GSMNP without success. FWS staff explained to WMI that the LBL proposal was abandoned because the FWS was unable to secure the cooperation of the States of Kentucky or Tennessee. The GSMNP release was unsuccessful due to the lack of resources on the area, poor pup survival, and the dispersal patterns of red wolves released on site.

With the exception of the van Manen et al. (2000) article, WMI could find little information on site selection criteria. During interviews with FWS staff, the consensus was that cooperation and collaboration with state fish and wildlife agencies would be critical to the success of future programs. Likewise, building landowner and resident support for the program up front was a critical criterion for future reintroductions.

FWS informed WMI that their focus shifted from site selection to addressing hybridization around 1997-98. The 2009 Action Plan (USFWS 2009) proposed to initiate a process to

identify suitable geographic locations for further reintroductions. To date, WMI is unaware of substantive progress on the selection of suitable future sites.

WMI concluded that the recovery plan should be reviewed, updated and/or revised to incorporate the 27 years of knowledge and experience associated with the 5 county restoration area. This review would benefit from a thorough analysis of: the effectiveness of the placeholder strategy with respect to reducing hybridization, the population dynamics of the wild red wolf, the integrity of the red wolf genome in the wild and in captivity, the population size necessary to insure red wolf survival and genetic integrity, the restoration area size and resource availability necessary to support expanded red wolf populations, and the human dimension research and public outreach activity necessary to garner public support and tolerance for introduced predator populations. It may also be necessary to consider alternative strategies for red wolf recovery given the now ubiquitous distribution of coyotes.

e. What is the current role of the captive population? How is the Service incorporating it to the recovery efforts? Is the Species Survival Plan (SSP) still relevant and is it being followed? Does it need to be revised?

The captive population is essential for maintaining the integrity of the current red wolf genome. WMI recognized that this is an artificial situation but it allows further experimentation and debate regarding the appropriate classification and taxonomy of red wolves. Maintenance of the captive population would permit future decisions with respect to the desirability or appropriateness of maintaining the genome.

The captive population allows the introduction of "new" wolves into the wild population and improves the genetic diversity within the wild population. Further, it provides a buffer should a catastrophic event reduce the current wild population.

WMI was informed that the limiting factor for the expansion of the captive red wolf population is space in the existing 42-43 facilities and the rigorous criteria for SSP accreditation for additional facilities.

We concluded that the SSP was still relevant but currently insufficient funding and capacity hamper implementation of the plan. Further, the FWS should review the current status and project the future need for captive population facilities and cryogenic preservation of red wolf gametes.

f. How will sea level rise affect red wolf restoration in the recovery area in the foreseeable future?

WMI concluded that current sea level rise modeling indicates that significant portions of the Alligator River NWR and portions of the Albemarle Peninsula will be lost to sea level rise within the next 50–75 years. The inundation of this land will greatly reduce the

amount of federal land that remains suitable for red wolves. The loss of up to 1/3 of the currently available habitat could reduce the carrying capacity of the restoration zone to a similar extent. Such a reduction would increase the risk to the population from stochastic events or genetic swamping by coyotes, unless the lost acres can be replaced with habitat on state and private lands in upland areas to the west of the Albemarle Peninsula.

Current efforts to adapt to sea level rise, build resiliency, and restore hydrology are not directly complimentary to red wolf habitat needs at Alligator River or Pocosin Lakes NWRs.

(Excerpted from Appendix A. Literature Review)

Albemarle Peninsula and Red Wolf Vulnerability to Temperature and Precipitation Changes

Temperature increases and changes to precipitation regimes that may also lead to increased droughts may affect the Albemarle-Peninsula in various ways, but they will likely have a greater impact on specific species and water quality than necessarily on habitat factors that may affect red wolves. For example, in freshwater systems, increased drought and warmer temperatures coupled with changes in precipitation could lead to changes to water quality and chemistry affecting species that live there. Warmer temperatures may also contribute to warmer waters leading to increases in harmful algal blooms and disease presence within the system (Glick et al. 2007). Additionally, warmer temperatures may favor certain pest and disease species that may affect both red wolves and their prey (such as white tailed deer) or food of their prey.

Sea-Level Rise Impacts

Sea-level rise has been identified as another climate change-related issue along coastal North Carolina, which is the third lowest lying state in the U.S. and where much of the land is just above sea-level (below 1 meter) and is experiencing significant levels of erosion (Poulter et al. 2009, Feldman et al. 2009). Climate change is contributing to sea level rise increases through thermal expansion of ocean waters and glaciers and ice fields melting. Over the 20th century the average global (eustatic) sea level rose about 0.17 meters (6.7 inches), at an average rate of 0.017 meters (0.07 inches) per year. This was 10 times faster than the average rate of sea-level rise during the last 3,000 years (IPCC 2007). Sea-level rise is projected to increase from between 0.19 and 0.59 meters (7 and 23 inches) by the end of the century (2090 to 2099) (IPCC 2007, CCSP 2009). However, these projections do not account for the recent changes in the ice flows in Greenland and Antarctica, meaning that these values likely underestimate the future global rates of sea-level rise (NECIA 2006, CCSP, 2009).

North Carolina has experienced rates of relative sea-level rise (includes the global rate as well as localized factors such as land subsidence) based on geological data and tide gauge data. Several studies that indicate on average 1 millimeter of relative sea-level rise likely occurred per year for the last 2000 years (increased during certain warming times) and up until the 20th century. More recently, rates have ranged between 3.0 to 3.3 millimeters

(Kemp et al. 2009, Kemp 2009, Zervas 2004). The North Carolina Coastal Resources Commission Science Panel on Coastal Hazards used these estimates to determine that North Carolina will likely see an increase of 0.4 meters to 1.4 meters of sea-level rise by the end of the century, and the Panel recommends adopting a one meter rise scenario by 2100 for policy and decision-making purposes in the state (2010). The Panel also notes that two meters of rise is possible, but unlikely unless there are accelerated rates of ice sheet melting and warming (NCCRC 2010).

Various tools exist to visualize what sea-level rise may look like for the Albemarle-Pamlico Sound. Screen shots from NOAA's Digital Coast's Sea-Level Rise and Coastal Flooding Impacts Viewer (http://www.csc.noaa.gov/digitalcoast/) allow a user to see what a range of sea level rise may look like for the Peninsula (Figures 4 -7). The tool allows a user to look at 1, 2, 3, 4, or 5 feet of sea-level rise. The tools uses a simple "bathtub" sea-level rise model that shows areas vulnerable to inundation from sea-level rise based solely on elevation projection. It does not take into account factors such as erosion, marsh migration potential, or hydrology that could influence how sea-level rise may occur on the landscape. The three images shown below are for current, 1 foot of sea-level rise, 3 feet (approximately a 1 meter), and 5 feet of sea level rise (approximately 1.5 meters).

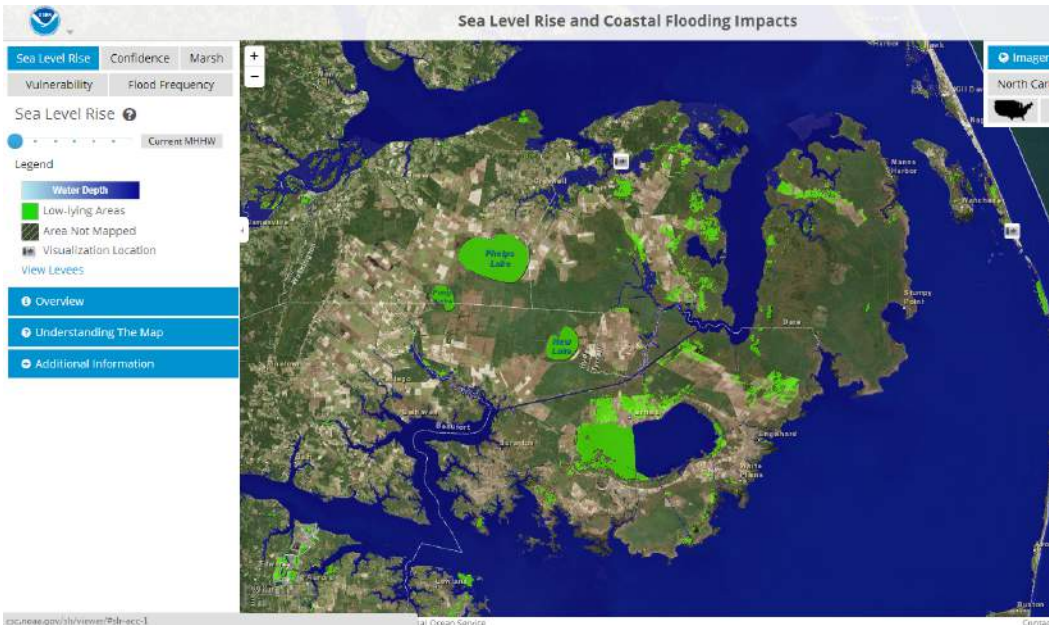


Figure 4. Albemarle Peninsula Current (Source: NOAA Digital Coast Sea-Level Rise and Coastal Flooding Impacts Viewer).

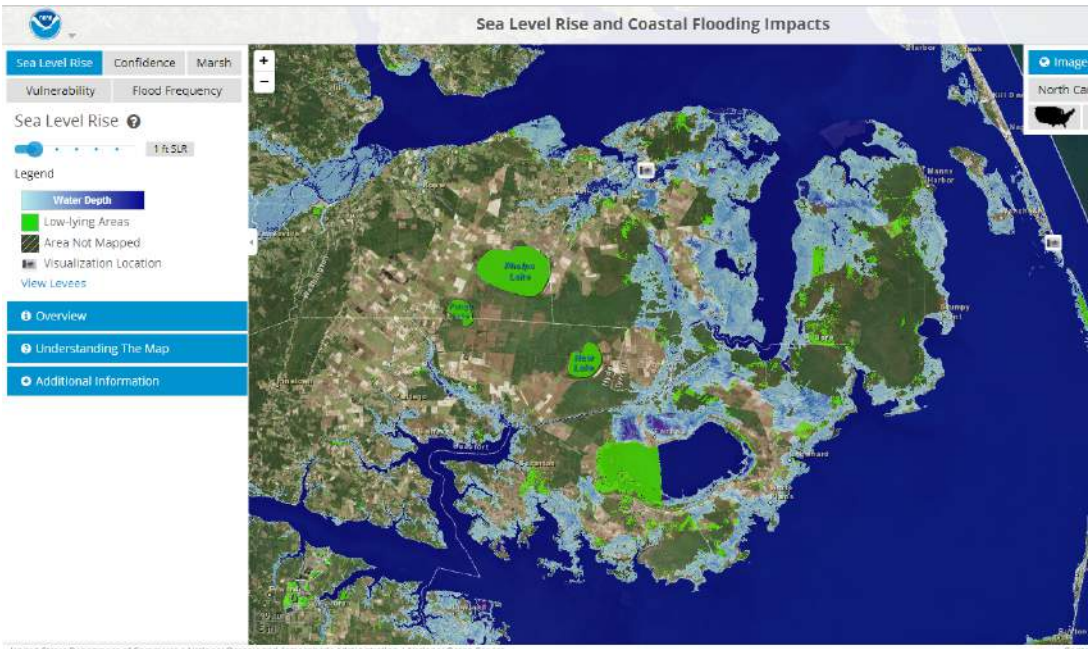


Figure 5. Albemarle Peninsula one foot of sea-level rise (Source: NOAA Digital Coast Sea-Level Rise and Coastal Flooding Impacts Viewer).

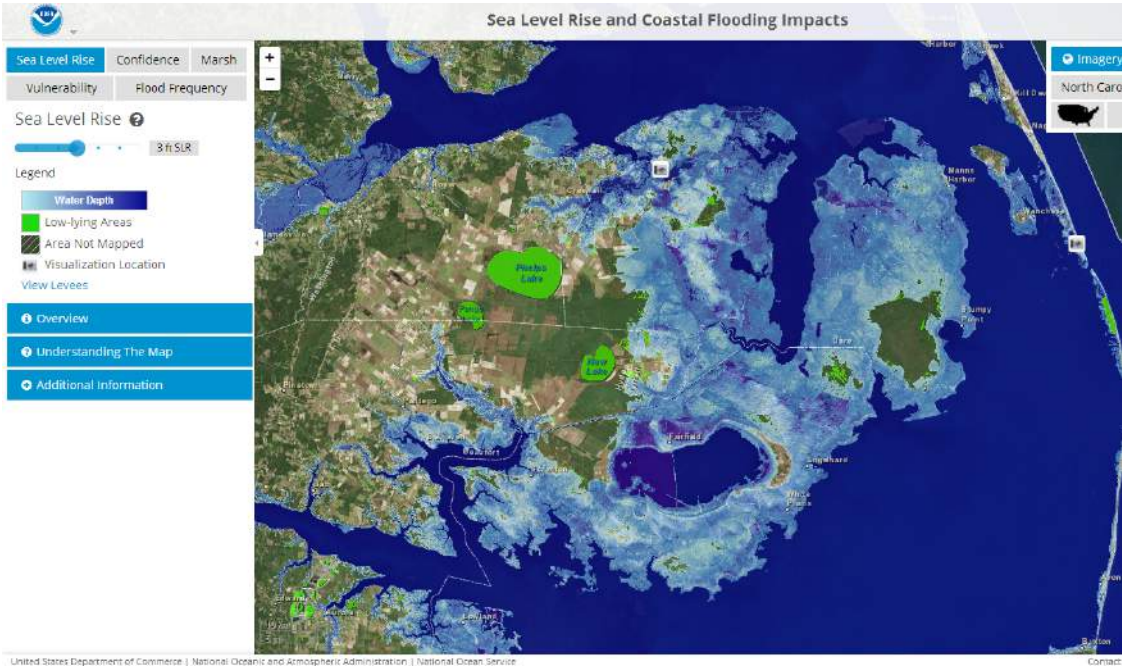


Figure 6. Albemarle Peninsula three feet of sea-level rise (Source: NOAA Digital Coast Sea-Level Rise and Coastal Flooding Impacts Viewer).

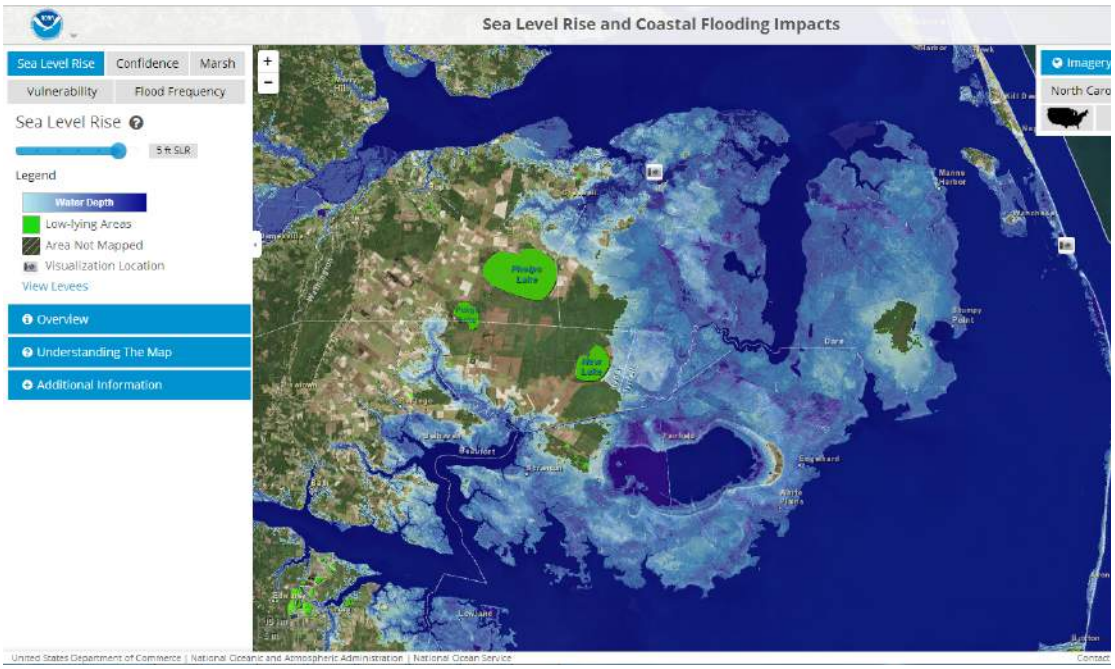


Figure 7. Albemarle Peninsula five feet of sea-level rise (Source: NOAA Digital Coast Sea-Level Rise and Coastal Flooding Impacts Viewer).

Albemarle Peninsula and Red Wolf Vulnerability to Sea-Level Rise

The Albemarle-Pamlico estuarine system covers approximately 6,000 km^2; and it is bordered by 275 kilometers of barrier islands (CCSP 2009, Poulter et al. 2009). To understand the impacts that sea-level rise may have on the area and the red wolves, it is important to understand features of the estuarine system. The Albemarle-Pamlico Sound system has relatively low salinity levels as it is protected from salt water exchange by the barrier islands. Its tides are also predominantly wind-driven as opposed to lunar, which also restricts tidal exchange (Poulter and Halpin 2007, Poulter et al. 2009, CCSP 2009). Two thirds of the Peninsula is less than 1.5 meters above sea level, while the other third is less than one meter above sea-level rise and experiences significant erosion rates. Based on data from the last 30 years, the estuarine shoreline in this system has an observed average retreat rate of slightly over one meter (over 3 feet). Given the already sediment poor and erosion prone system, the area is potentially extremely vulnerable to sea-level rise (Poulter 2005, Poulter and Halpin 2007, Feldman 2009). Poulter and Halpin (2007) used models to project impacts from sea-level rise on the Albemarle-Pamlico Peninsula and found that due to the drainage systems of canals and ditches the low near shore environment, flooding would actually be worse at lower levels of sea-level rise (less than 0.4 meters) due to the topographical complexity. This rate of sea-level rise will likely be reached by 2100 if not before.

Sea-level rise will likely result in a variety of impacts in the Albemarle Peninsula, including inundation and potential loss of wetlands and other coastal areas, significant changes in

salinity levels, and changes to system dynamics (Glick et al. 2007). Another consideration in terms of impacts from sea-level rise is whether or not wetlands will be able to accrete (build up sediment vertically) and keep pace with sea-level rise and persist over the long term. The Peninsula has been significantly altered with drainage ditches that appear to prevent vertical accretion (Pearsall and Poulter 2005). Additionally, as salinities increase the peat-based wetlands will likely not be able to keep pace as the peat, roots, and vegetation will die off with brackish and saltwater intrusion (Poulter 2005, Feldman et al. 2009). Within the Albemarle-Pamlico Peninsula, aerial photography has shown that wetlands have been able to offset some loss by accreting further inland, replacing forest systems; however, this accretion process is limited by the sediment poor environment (Poulter et al. 2009). Coastal tree line migration has averaged 1 to 12 meters per year, but is inhibited by erosion rates and inland land uses (Poulter et al. 2009). As sea-level rise rates increase, however, it is uncertain if these vegetative communities will keep pace (Feldman et al. 2009).

Additionally, to examine change and/ or loss of habitat types, a Sea-Level Rise Affecting Marshes Model (SLAMM) was applied to the Alligator River National Wildlife Refuge in 2013 (Clough 2013). This model takes into account accretion rates, erosion rates, inundation, overwash, and saturation (Clough 2013). The model uses 4 sea-level rise scenarios that correspond to four rates of sea-level rise by 2100: 0.39 meter, 0.69 meters, 1 meter, and 1.5 meters. The model analyzes how much area of specific habitat types will be lost at these various sea-level rise projections (Clough 2013). Understanding the changes to habitat may be important, because some areas are likely red wolf habitat such as wooded wetlands and likely dry lands (appear to be the agricultural lands), although they only makes up 6 percent of the refuge. However, as noted in the Habitat Section, red wolves tend to avoid coastal wetlands (saltmarsh, tidal wetland, etc.); thus, loss of wetlands may not be significant but conversion of dry land to coastal wetland/ tidal marsh may push wolves further west.

The analysis projects that even at the at the lowest level of sea-level rise, much of the swamp area and dry land are projected to be lost (62 percent and 90 percent respectively) and converted to salt marsh, tidal mudflats, and open water. At 1.5 meters of sea-level rise, 100 percent of swamplands would be lost, 99 percent of dry land, and 100 percent of brackish marsh (Clough 2013). Much of the Refuge is projected to transition to open water, mud flat, and saltmarsh – habitat less suitable to the red wolf.

Salinity changes and changes to water chemistry may also affect red wolf habitat. As sea-level potentially opens inlets and results in overwash of barrier islands, tidal range and exchange will increase, destroying freshwater wetlands by the increase in salinity and potentially changing the area to a more open water system (Feldman et al. 2009). The chemistry and make up of peat wetlands that comprise much of this area will also be affected, breaking it down and possibly resulting in subsidence (further exacerbating impacts from sea-level rise) (Feldman et al. 2009). Changes in system dynamics may also occur as barrier islands are overcome or segment. The tidal regime will likely go from wind driven to lunar tidal influence, increasing salinity levels. Loss of barrier island protection may also lead to increased erosion rates that will only accelerate the rate of loss

of the wetland system and conversion to open bay with higher salinity waters, lunar tides, and larger waves and wave action (Riggs and Ames 2003, Feldman et al. 2009). Changes to vegetation communities within the Alligator River NWR have already have been noted. Atlantic cedar is dying back, likely due to salt and brackish water coming in through the man-made ditches and canals (Feldman et al. 2009).

In terms of impacts more directly to red wolves, recent research shows that red wolves do not necessarily use the coastal wetland area along the Peninsula of the restoration area; however, dry areas within the SLAMM model appear to correspond to agricultural lands as noted in the NC GAP, which wolves do prefer at various points during the year (Hinton and Chamberlain 2010, Dellinger et al. 2012). Previous research documented pocosins being used by red wolves, which make up a significant portion of Zone 1 and Alligator River National Wildlife Refuge. Regardless, much of the swamp and pocosin area as well as the dry land are projected to be lost or converted to open water, mud flats, or salt marsh, habitat less desirable for wolves. Additionally, in just considering sea-level rise, much of the Albemarle Peninsula and the Red Wolf restoration area may be under water with 1 to 1.5 meters of sea-level rise (Figures 2 to 5).

Research shows that wolves appear to disperse west primarily, away from the coast, and onto agricultural fields and private lands (Hinton and Chamberlain, 2010). With the conversion and loss of much of the coastal areas, red wolves could be pressured to move in greater density and further distances to the west. Implications of this for their survival will be important given the negative impacts that have occurred with human interactions. Additionally, Feldman et al. (2009) note a 1995 report that states that even farmers on the Peninsula have already acknowledged that salt water intrusion and sea-level rise is affecting their agricultural fields (Feldman et al. 2009). Loss of agricultural lands or potential changes to the vegetation cover could be detrimental to the red wolf population given their importance to pup rearing and wolf preference for these areas (Hinton 2006; Hinton et al. 2010).

Storm Events (Hurricanes)

Storm Impacts

In terms of increases in storm intensity, there have been several studies that found a correlation between ocean temperature increases and more intense tropical storm and hurricane events as well as an increase in tropical cyclone activity over the last 40 years in the northern Atlantic Ocean (Emanuel 2005, Webster et al. 2005). Since the 1980's hurricanes also have been more intense, frequent, and lasted longer and there have been more Category 4 and 5 hurricanes; however, this also corresponds to better satellite data being available (Walsh et al. 2014). Model projections show that by the end of the century tropical cyclone events may be less frequent while strong hurricanes (Category 4 and 5) may be more frequent. There is some uncertainty around projecting frequency, but models are in closer agreement that these events will be more intense (Walsh et al. 2014).

Albemarle Peninsula and Red Wolf Vulnerability to Storms

Although storm events may or may not necessarily be more frequent, they are likely to be more intense has they have been in recent years. Impacts from hurricanes on the Albemarle Peninsula will be similar to some of those from sea-level rise such as increases in salinity levels and resulting changes to system dynamics. For example, hurricanes have already moved estuarine waters into naturally occurring freshwater areas, changing peat composition, vegetation, and water chemistry (Feldman et al. 2009). Increases in wave surge and scour will only exacerbate existing erosion problems and may result in barrier islands being breached in one event, leading to similar impacts noted above – change of Albemarle-Pamlico system from protected estuary to embayed system with higher salinity level, lunar tides, and more wave action (Riggs and Ames 2003).

Program Management

Questions posed by the FWS:

a. Have the rules/policies/guidance issued been followed by the Service?

WMI concluded that throughout much of the life of the red wolf recovery program, local program managers have received inadequate oversight and coordination from the regional office. In addition, the program was managed as a refuge activity rather than a national or regional Ecological Services' priority. We learned that program authority rested largely with local staff. Decisions made at the local level, although made with the best intentions and with the program's success in mind, did not always comply with the rules established for the reintroduction program. Recent changes in the program structure have improved the situation. A clear understanding of the need for rules and oversight of those rules will be necessary for future compliance.

FWS staff reported to WMI that some red wolves were released on private property with the permission of the landowner. These actions appear to conflict with the 10(j) Rule that stated red wolves would be released on the Alligator River NWR property. WMI was provided with a list of releases that indicated that of 132 releases of red wolves between 1987 and 2013, 64 were released on private property. WMI is unaware if agreements existed between the FWS and private landowners with respect to these releases; however, they appear to be in contradiction to the 1986, 1991, and 1995 10(j) final rules.

The 10(j) Rules also stated that, at the request of the landowner, wolves would be captured on private property and returned to the refuge property. WMI found that it was a common practice to inform landowners that wolves would not stay on the refuge and would probably return to private property. Some wolves captured on private property were released on private property rather than returned to the refuge lands. These activities were contradictory to the 10(j) Rules established at the onset of the recovery program. WMI concluded that the authors of the rules were either misinformed about red wolf

dispersal behavior or were unconcerned if the rules were violated. Local program staff was asked to comply with rules that were untenable. We concluded that local staff did their best to achieve program success and work with private landowners in spite of the rules because they realized the rules were not realistic for successful project implementation.

b. The Alligator River NWR and Pocosin Lakes NWR were established primarily for migratory birds. They are now in the primary cores areas for supporting red wolves. Are the lands within Alligator River NWR and Pocosin lakes NWR adequately managed for red wolves? If not, why? Can the management regime be changed to better support the population of red wolves and still support the original mission? If not, why?

Currently red wolves inhabit and travel through portions of a 1.7 million acre area within 5 counties in eastern North Carolina. WMI concluded that the NWRs (Alligator River, Pocosin, Mattamuskeet, Swan Quarter) and the Dare County Bombing Range (managed by the Navy and Air Force) within the current restoration area cannot be managed or restored in a manner that would provide sufficient habitat for the current population of red wolves. Experience indicated that movement off the refuge lands occurred almost immediately after the original release of red wolves in 1987. WMI was informed that there was only 1 breeding pair on the Alligator NWR at the time of our evaluation of the program. There is no theoretical or practical reason to believe that red wolves will constrain their activities or movements to a jurisdictional boundary, especially when red wolf density increases within that boundary. The numerical and spatial expansion of gray wolf packs and their ranges within the Greater Yellowstone ecosystem and across portions of the intermountain West demonstrates this conviction.

FWS refuge managers informed WMI that only about 5,000 acres of Alligator River NWR are managed for cooperative farming and Conservation Reserve Program lands. Pocosin Lakes NWR is managed primarily for waterfowl with about 1,250 acres of farmland, and Mattamuskeet contains only about 400 acres of farmland. Much of the habitat used by red wolves (particularly with pups) within the restoration area was associated with agricultural lands. Existing federal lands cannot be managed to replace the extensive private agricultural lands within the restoration area landscape.

WMI concluded that habitat restoration on the NWRs could not be accomplished at the scale necessary to support the current population of red wolves due to the geology, hydrology, soil, and habitat types found on the refuge lands. Further, sea level rise has already impacted some refuge lands and threatens to inundate lands and/or change their water and soil characteristics.

The juxtaposition of the NWRs, population growth, dispersal, and inter- and intra-specific competition for food and space preclude the containment of red wolves to these areas. The FWS has numerous agreements with private landowners in the restoration area to allow red wolf use of those lands. It is unclear if landowners in and adjacent to the restoration area would accept red wolf population growth in the long term. This is a particular concern given some of the current landowners' negative attitudes that presumably, and in part, resulted from the court ordered coyote hunting prohibition.

c. What level of management-related support has this project been given by the Service?

Budgetary support for the project has been consistent through the life of the project. It has been the highest budget priority within the Southeast Region since its inception. However, we concluded that the support has been inadequate given the promises made to the public via the 10(j) Rules. As the red wolf population has increased in number, existing staff has been challenged to respond to public requests for red wolf removal from private lands.

During the course of the recovery program, the supervisory oversight has changed from the Refuge program to the Ecological Services program. The change should better position the program from an oversight and supervisory perspective. Obviously, the close working cooperation between Refuges and Ecological Services must be maintained.

One of our discussions with a FWS staff member framed the management situation quite well in our opinion. Paraphrasing his remarks, the red wolf recovery program needs a better focus on mission, alignment, and execution. The program's mission should have clear and measurable goals that are shared and understood throughout the organization's structure and leadership at all levels. The program's mission must also be placed in the context of other organizational programs.

WMI concluded that the FWS should consider a new program management strategy that properly aligns its staff, time, and resources to accomplish the recovery program's goals. The FWS should provide the staff, time, and resources to execute the strategy in an efficient and effective manner to achieve the program's goals. Periodically, the FWS should evaluate the plan and progress to improve upon its execution. Although red wolves have been established in the 5 county restoration area, the FWS has not provided evidence that the program's objective to restore red wolves in 2 other areas has been addressed (with the exception of the failed attempt in the GSMNP). Local staff has not received adequate assistance to inform and educate local landowners about the program nor have they received the resources necessary to manage individual wolves in a timely fashion as described in the 10(j) Rules.

WMI concluded that throughout the life of the program, the red wolf recovery program management was relegated to the field level. Budget support for the program has been consistently high and relatively stable. The program appeared to have its own inertia – not moving forward but receiving sustainable organizational support at similar levels for years. We recognized the groundbreaking nature of the reintroduction of red wolves into the wild and the advances in science that accompanied the success of that reintroduction. Field staff has provided tremendous support for the program but have not had the multidisciplinary assistance to maintain public support for the program within the restoration area. WMI concluded that until recently, regional staff seemed to let the program operate on its own.

WMI expected greater oversight and support for a landmark recovery program involving one of the most imperiled canids in the world. Declining population growth without a scientific explanation, inadequate public outreach, insufficient captive facility capacity, lack of the identification of suitable alternative reintroduction sites, and the lack of a rigorous

adaptive management approach that includes evaluation and analysis, are signs of a program that is in need of additional review and course correction.

d. What is the total financial cost of the recovery effort (including costs from the regional office, field and Washington when appropriate)? Where does it fit in the overall priority system within the southeast and across the nation?

We were only able to document budget figures from 1999 to 2014. During that time period the Southeast Region budgeted a total of $17,018,422 for the red wolf recovery program. The average annual budget was $1,061,385 comprising an average of about 8 percent of the region's annual allocation (Table 3). We do note that the budget has been relatively stable through time and does not appear to be adjusted for inflation and increased staff expenses.

From a budgetary perspective, the red wolf recovery program is the highest priority within the Southeast Region. WMI requested budget information since the onset of the program. Due to changes in the accounting systems, we were only able to document budget figures from 1999 to 2014. Table 3 shows the budget amounts for that time period and the percentage of the total Southeast Region's budget allocations for recovery programs.

Table 3. Red wolf program budget and regional budget allocations for 1999-2014.

FISCAL YEAR	RED WOLF PROGRAM BUDGET	RECOVERY ALLOCATION	PERCENT REGIONAL ALLOCATION
1999	1,097,641	not available	
2000	735,421	11,369,503	6.5%
2001	955,104	10,815,850	8.8%
2002	937,526	12,434,886	7.5%
2003	946,923	12,392,193	7.6%
2004	1,023,279	12,540,597	8.2%
2005	987,832	13,424,449	7.4%
2006	1,284,287	14,332,960	9.0%
2007	927,477	14,142,622	6.6%
2008	1,049,841	14,405,976	7.3%
2009	1,097,641	15,245,384	7.2%
2010	1,146,224	16,173,302	7.1%
2011	1,170,351	15,320,012	7.6%
2012	1,201,851	14,998,960	8.0%
2013	1,208,637	16,065,754	7.5%
2014	1,248,387	14,989,146	8.3%
TOTAL	**$17,018,422**	**$208,651,594**	8.2%
2000-2014 Average	**$1,061,385**	**$13,910,106**	**8.2%**

During most of the recovery program (up until 2013), Ecological Services included the budget for the red wolf in their budget amounts. However, the NWRS actually administered the funds and conducted the oversight of daily recovery efforts. In 2013, program management was transferred to the Ecological Services staff within the regional office and the Raleigh office.

The red wolf recovery program was the top budgetary priority during that time period. We are unable to assess where the project ranks on a national scale because regions are allocated a set amount from the national office and then the region determined the actual allocation level independent of the national office.

Because the budget available to the project only supported one population (eastern NC), we must conclude that the budget was insufficient to meet the larger recovery plan goals. Further, the captive program has been financed, in part, by private donations to individual captive facilities. We were unable to determine those contributions to the program. We note that FWS staff informed WMI that the captive facility capacity was inadequate to support future growth of the captive population.

e. Has the project received adequate funding and institutional support to meet its goals?

Based on our review and evaluation of the red wolf recovery program's objectives (USFWS 1989) and the 2007 5-Year Status Review (USFWS 2007) the project has not received adequate funding and institutional support. According to the 2007 5-Year Status Review (in italics):

"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."

This objective has not been met due to a variety of reasons. These reasons include: lack of suitable or acceptable reintroduction sites, negative public opinion, uncertainties with respect to managing red wolf/coyote hybridization, mortality causes, and lack of suitable habitat on federal property. Funding and institutional support was inadequate to overcome the circumstances confronting the FWS.

"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)."

This objective has been achieved to date. Concerns exist about the captive facilities' capacity to hold additional red wolves and the future of the captive program.

"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)."

Currently the estimated wild red wolf population numbers around 112 wolves in the eastern NC restoration zone. The lack of redundant populations in at least two other distinct areas indicates that this objective has not been achieved. Captive populations are below objectives and the insufficent captive facility capacity further complicate achieving this objective.

"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."

WMI was informed that the embryo banking and cryogenic preservation of sperm has been on hiatus but plans are in place to resume this activity.

Further response to this question has been addressed in Question c (see above).

f. Based on science-based recovery recommendations, how much funding will be needed to achieve success within the current recovery area and with two additional population sites?

WMI cannot provide a precise answer to this question without additional information and decisions from the FWS that are not available at this time. However, based on the

accomplishments of the current wild red wolf recovery program with the current budget of approximately $1.3 million per year, WMI developed a budget scenario reflective of additional elements we believe necessary to more fully achieve the goals of the current recovery plan.

Extrapolation of past expenses for recovery will inform future funding needs. Additional funds would be needed for human dimensions research and public outreach and involvement prior to and during the recovery program (Clark and Rutherford 2014). Expenses could increase for the removal of wolves from private lands in new restoration areas. Currently wolves can only disperse in 3 directions due to the eastern boundary of the area (Atlantic Ocean). Wolves released in inland sites will have the opportunity to disperse in all 4 directions, leading to an increase in the geographic area available to wolves. More intensive monitoring of wolves will be required in order to respond to public concerns about their movement and habitat use. Alternatively, expenses could decrease if the FWS would adopt a different management strategy that would allow wolves to disperse throughput the restoration area. This action would likely be tolerated only if the FWS developed a landowner incentive program that would provide compensation for the presence of red wolves on private property within the restoration areas. Funding levels must consider the red wolf/coyote hybridization issue that is likely to occur in any selected reintroduction site unless the FWS adopts a "hands-off" approach to hybridization. Of course, future funding will have to address inflation in prices and increased staff salaries and benefits.

Table 4 presents an estimate of potential program management expenses for an enhanced management program in eastern North Carolina (NC), selection of 2 additional restoration sites, and on-going, annual program management expenses for 3 restoration sites. These estimates are for illustrative purposes only and are based solely on our experience and judgment not on actual expense details. They do not include administrative overhead expenses associated with necessary rule making or responding to legal challenges nor do they enumerate full-time equivalent positions. If the FWS would adopt a landowner incentive/compensation program within any or all restoration areas, those expenses would be in addition to our estimates.

Table 4. Estimates of program management funding needs under different management scenarios.

Activity	Budget
Current annual program management expenses (monitoring, research, captive population, planning, staff support)	**$1.3 million**
Additional monitoring (GPS telemetry for 50% of the population (n=50))	$300,000
Additional human dimensions research and conflict resolution process	$200,000
Enhanced annual program management expenses (eastern NC)	**$1.8 million**
Research on 2 potential restoration sites	$300,000
Human dimensions research and conflict resolution process for 2 additional restoration sites conducted in advance of red wolf releases	$500,000
Selection of and public outreach for 2 additional restoration sites	**$800,000**
Enhanced annual program management expenses for 2 additional restoration sites (at a population level of 100 red wolves)	**$3.6 million**
On-going annual program management expenses for 3 restoration sites	**$5.4 million**

g. In recent months, the Service has received an unprecedented number of red wolf removal requests from private landowners. Is the current management structure equipped to handle an increasing number of requests for red wolf removal from private property? Is the Service responding to these requests appropriately based on what is mandated in the 10j Rules? Does the Service have adequate facilities to handle captured wolves?

The 10(j) Rule states the FWS will remove wolves from private property and return those wolves to the refuge property at the request of landowners without questioning the rationale for the request. WMI concluded that the FWS' management structure is not equipped to handle the increasing number of requests to remove red wolves from private property. However, WMI is also aware of a concerted effort on the part of some individuals to motivate citizens in the red wolf restoration area to contact the FWS and request removal of wolves on their property. Further, WMI questions the nature of some requests over the past few years. Requests for removal of red wolves from numerous, small private land acreages, some with no evidence of red wolves, appeared to be more of a opposition to the recovery program than a desire or need for red wolf removal.

FWS staff informed WMI that as of the end of the week of September 27, 2014, the FWS had received 399 requests from landowners. Twenty-four requests were duplicate requests from the same landowner. Forty-three requests did not provide contact information for the FWS. The FWS attempted to contact 258 requestors but had received no response in return. Forty-seven requests were contacted but responded that they did not have a problem with wolves or had no wolves on their property. The FWS was working with 25

property owners to assess if wolves were present on their property and to do trapping to remove unwanted animals. As of that time, the FWS had yet to contact 2 landowners who made requests.

Although FWS staff appeared to be responsive to landowner requests, WMI concluded that these activities detract from regular duties and are expensive. The recent increase in landowner requests may continue into the future if red wolves increase in population size and disperse across the restoration area. We also concluded that GPS telemetry collars, although expensive, could provide real time locations of collared individuals that would assist FWS to respond to landowner requests and determine the legitimacy of those requests. Further, they would improve data collection and provide better information for managers and landowners within the restoration area.

h. If red wolves are removed from the core area where will they be placed? If some red wolves are identified as "repeat offenders" should they also identified as "nuisance wolves"? If so, how should this be defined and where will the service place these wolves? In zoos? Island populations? Others?

WMI believes that the designation and management of "repeat offenders" and "nuisance wolves" is a policy decision of the FWS that requires recommendations outside the scope of this report. However, we would note that the establishment of additional restoration areas may, under certain circumstances, allow the transfer of red wolves from one site to another possibly diminishing the concern about the disposition of "nuisance" wolves.

It is noteworthy that only 1 breeding pair inhabits the Alligator River NWR, captive facilities appear to be at or near capacity, and the island population of wolves on St. Vincent Island, FL is small and has been used to supplement wild red wolves in the area.

Human Dimensions

Questions posed by the FWS:

a. Is there institutional (e.g., State) and public (e.g., private landowners) support for this project? Do the public and private sector support the overall recovery plan?

As with most endangered species programs, public opinion regarding red wolves was mixed with respect to the recovery program. Expressed support or opposition was a function of the individual's worldview, values, life experiences and the degree to which they are or may be personally affected by the recovery program. Individuals living at some distance from the restoration area were generally more supportive of restoration than individuals who were or perceived to be affected by the presence of red wolves.

The timeline and budget for this review did not permit WMI to conduct a scientific or statistically generalizable evaluation of public support or opposition to the red wolf recovery program. The online survey and comments at public listening sessions surfaced

both strong support and strong opposition to the program. These results were neither unanticipated nor remarkable.

WMI did conclude, however, that the 2013 lawsuit that resulted in prohibition on all coyote hunting within the 5 county restoration area appeared to have lit a powder keg of public emotion. We heard this perception from the NCWRC and many of the participants in the public meetings. The reasons may be varied; however, we have concluded that some of the citizens in the area considered the prohibition as a violation of their private property rights and the right to defend livestock, family, and property. Others expressed concern about the level of predation on other wildlife caused by red wolves and coyotes. Many directly blame the red wolf recovery program for their concerns. The injunction has caused a major public relations issue for both the FWS and the NCWRC that further eroded support and tolerance for the program by some citizens residing in the restoration area.

We were also made aware of an underlying distrust of the federal government's presence in the restoration area. Dare County is predominantly federally owned. Other issues that added to the level of distrust within the restoration area were described to WMI as: beach closures to vehicles on Cape Hatteras National Park, management of the lake at Mattamuskeet NWR, wild horses, management of Pea Island NWR, and the relatively large presence of federal employees in the community. Drawing on this distrust and past activities of the FWS, some persons within the restoration area have become outspoken and influential opponents of the red wolf program. It was apparent to us at the public meetings that a concerted effort was underway to discredit the red wolf recovery program. Nearly half of the attendees at the second public meeting had attended the first public meeting the night before expressing similar prepared remarks. We do not draw any conclusions with respect to their sincerity; however, it was evident that some of the opinions expressed at the meetings included repeated story lines that were not accurate upon further investigation.

NCWRC support for the red wolf recovery program is tenuous. Although recent meetings between the leadership of the FWS Southeast Regional office and the NCWRC have been cordial and productive, the history of the red wolf program has created concerns on the part of the NCWRC. These concerns included: red wolf program management and research, project objectives, landowner relations, and the programs apparent focus on individuals rather than the population. The "Collaborative Conservation of Red Wolves and Other Canids on North Carolina's Albemarle Peninsula" memorandum of understanding (FWS/NCWRC MOU) signed by the FWS and NCWRC in 2013 detailed a substantial commitment for cooperation between the agencies to benefit canid management. We do note that the relationship between the FWS and NCWRC law enforcement staff was cooperative.

b. Is effective cooperation occurring with other agencies and the public? How has the red wolf recovery program affected the working relationship between the Service and the North Carolina Wildlife Commission and key public stakeholders?

WMI concluded that at the onset and throughout the life of the red wolf recovery program, that public outreach and education for private landowners within the restoration area was not a major component of the program. Private landowners were arguably the key stakeholders in this recovery program. Numerous public meetings were held in advance of the releases and the addition of Pocosin Lake NWR to the federal lands in the restoration area. However, we did not see a concerted effort to maintain these public outreach and education efforts. We are unaware of any public meetings in the last few years.

Unfortunately, WMI concluded that damage has been done to the relationship between the FWS and NCWRC. Steps have already been taken to repair that relationship. WMI understands that rebuilding trust and respect between agencies is difficult unless both parties address realities and perceptions. We believe that the following perceptions about the red wolf program must be discussed and addressed to improve the relationship in the future: lack of credibility with some of the public, unattainable project goals, insufficient conformance to rules, unilateral decisions made without consultation, misinformation provided to the public, and unresponsiveness to the public's requests.

During the last two years (2013-2014) deliberate and productive efforts have been made to strengthen the coordination and relationship between the FWS and NCWRC at top- and mid-level leadership. The "Collaborative Conservation of Red Wolves and Other Canids on North Carolina's Albemarle Peninsula" memorandum of understanding signed by the FWS and NCWRC in 2013 detailed a substantial commitment for cooperation between the agencies to benefit canid management. Both organizations expressed professional respect for leadership within the other organization. The NCWRC leadership also expressed the desire for a cooperative relationship with respect to resolving the coyote hunting injunction issue.

c. What information is available to assess public awareness of and support for the red wolf recovery program?

Prior to our recent efforts at public meetings in the area and the distribution of a public opinion survey, WMI could find no evidence of a human dimension research effort concerning the red wolf recovery program. We do note 17 press releases between the years of 2009 and 2013. However, 6 of those releases were focused on law enforcement investigations concerning red wolf mortality. WMI was particularly concerned about this lack of public outreach effort because the red wolf recovery program was arguably the highest priority within the Southeast Region of the FWS.

Public Meetings

To help identify and quantify the opinions of public meeting participants, WMI handed out a self-selected participant survey form. There were a total of 154 written survey responses from 114 (74%) males and 40 (26%) females. All respondents but one reported their race as white. Respondents' ages ranged from 16 to 83, with an average age of 54. Based on self-reported zip code of residence, the majority (86%) of respondents resided in the restoration area, while 22 respondents did not live in the restoration zone. Summary

responses from the survey are reported in Appendix G. **It is important to note that responses to this survey only represented the opinions of those individuals who attended the public meetings and choose to complete the survey; results may be biased and cannot be generalized to any larger population.**

When asked about the importance of restoring rare or imperiled animal species, responses were split. About half (53%) of respondents disagreed or slightly disagreed that restoring rare animal species was important, while the others (47%) agreed or slightly agreed that restoration was important. Almost three quarters (74%) of the sample disagreed or strongly disagreed that the general public was supportive of the restoration or recovery of red wolves. Similarly, 72 percent of respondents disagreed or strongly disagreed that the red wolf recovery program was a positive program for North Carolina, and 73 percent at least disagreed that red wolves should be restored to more locations to ensure their continued existence. Additionally, less than 20 percent of respondents agreed or strongly agreed that the red wolf recovery program had been successful at meeting its biological goals.

Of the respondents who were asked to complete Questions 7-16 of the survey (respondents that live in the 5 county restoration area), more than 80 percent of respondents disagreed or strongly disagreed that people who live in the restoration range were supportive of the red wolf recovery program. About a quarter of them agreed or strongly agreed that changes could be made to increase local public acceptance of the program, and 43 percent of them indicated they had suggestions for the program that would increase public acceptance.

Almost two thirds of respondents had serious concerns about having red wolves present in the area, and 66 percent reported that they had personally experienced or witnessed damage by red wolves on their property. Further, most respondents either disagreed or strongly disagreed that the USFWS had been a good partner during the planning (70%) and implementation (70%) of the red wolf recovery program, had meet or exceeded its commitment to residents of the restoration zone (81%), or had followed the rules and policies issued for the program (77%). Over a third (37%) of respondents at least slightly agreed that the Service was responding to requests to have wolves removed from private property appropriately based on what is mandated in the 10(j) Rules.

Comments (written and oral) were summarized topically into 4 categories: Biological, Management, Sociological, and Other. These comments could either be positive, negative, or neutral towards the Red Wolf Recovery Program and were presented in no particular order, in that aspect. Comments were identified as being “Actionable”, “Educational”, or “Informational” (Appendix G).

“Actionable” comments are those in which the USFWS could take immediate or short-term physical action in order to provide some possible mediation or mitigation. “Educational” comments are those in which the USFWS could develop educational materials or programs in order to clarify ambiguities or dispel misperceptions of the program. “Informational”

comments were simply to inform the USFWS of an issue or concern, but where no immediate action could be determined that would resolve the concern.

There were 24 generalized written comments within the "Biological" category, including seven that were Actionable, eight that were Educational, and nine that were Informational. In the "Management" category, there were 32 total comments, with 18 being Actionable, 10 being Educational, and four being Informational. In the "Sociological" category, there were 28 total comments with nine being Actionable, 11 being Educational, and eight being Informational. Finally in the "Other" category, there were 15 categorized comments with three being Actionable, five being Educational, and seven being Informational.

In our opinion, the development and implementation of an action plan to address the 37 actionable comments would decrease the concerns about the Red Wolf Recovery Program within the 5 county restoration area. Likewise, a hands-on, intensive public relations campaign, with "boots on the ground" public relations specialists or "Partners Biologists" within the restoration area, that focused on addressing the 34 Educational comments would also help resolve discrepancies, misunderstandings, rumors, and further explain the significance of the program. The remaining 28 Informational comments should be carefully evaluated and considered by the FWS to determine if additional actions or education efforts should be undertaken.

Online Survey

An online, self-selected survey was designed using Polldaddy™ to measure perceptions of the general public. It was advertised in a FWS press release on August 29, 2014. The survey was available to the public from August 29 at 12:00pm EDT until September 12, 2014 at 11:59pm EDT. Because the survey was open to anyone interested in completing it (self-selection of participants), no probability sampling techniques were used. **It is important to note that responses to this survey only represented the opinions of those individuals who choose to complete the survey; results may be biased and cannot be generalized to any larger population.**

The survey resulted in 13,456 responses. Based on self-reported zip codes, responses were divided into five groups for comparisons. The first group was comprised of all responses (n=13,456). The second group contained responses from all individuals living in North Carolina (n=1,798), while the third group consisted of only those people living within the 5 county red wolf restoration area in the state (n=286). Responses from residents of North Carolina who did not live in the restoration area made up the fourth group (n=1,512), and people living outside of North Carolina were in the last group (n=11,658) (Appendix G).

Respondents were asked how much they supported restoring endangered wildlife in places where it was feasible. The majority of all five groups were highly supportive of such restoration, although fewer individuals living in the restoration zone (56%) were highly supportive of such initiatives as compared to all other groups. At least 74 percent of all other groups highly supported restoration.

The next two questions on the survey focused specifically on red wolves. Most people in all groups were aware that red wolves once lived throughout most of the eastern United States, though a higher proportion of North Carolina residents (87%) were aware of this fact as compared to respondents outside the state (70%). Similarly, 80 percent of North Carolina residents were aware that red wolves have been restored to 5 counties in North Carolina, while only 43 percent of those outside the state were aware of the initiative. Interestingly, 7 percent of those living in the restoration area did not know about the recovery program.

All of the other items on the survey were intended only for respondents who were aware of the red wolf recovery program. Sample sizes for these items are 6,388 total respondents, 1,438 North Carolina residents, 265 restoration zone residents, 1,173 residents of North Carolina who do not live in the restoration area, and 4,950 respondents outside of North Carolina. Summary responses for these items are presented in Appendix G.

A review of responses indicated that survey respondents living in the restoration zone felt significantly ($p \leq .05$) different than other respondents regarding the red wolf recovery program. For example, when asked about the success of the red wolf recovery program, the highest proportion (31%) of residents of the restoration zone perceived that the program was highly unsuccessful. For all other groups, the greatest percentage thought the program was somewhat successful. The same pattern holds for perceptions of public acceptance concerning the red wolf recovery program. The most common response for restoration zone residents was highly unsupportive (37%), while somewhat supportive was the most commonly chosen category for all respondents (30%), all North Carolina residents (29%), and North Carolina residents not in the restoration area (29%). Respondents outside of North Carolina were more apt to think that the general public is highly supportive (33%) of the red wolf recovery program. Another item asked for a yes or no response concerning if respondents would support a red wolf restoration project located near them. More than 90 percent of all respondents (91%) and those outside of North Carolina (97%) said they would support a red wolf restoration project near them. These percentages dropped significantly for North Carolina residents in general (71%), North Carolina residents outside of the restoration zone (75%), and especially for those living in the restoration area (55%).

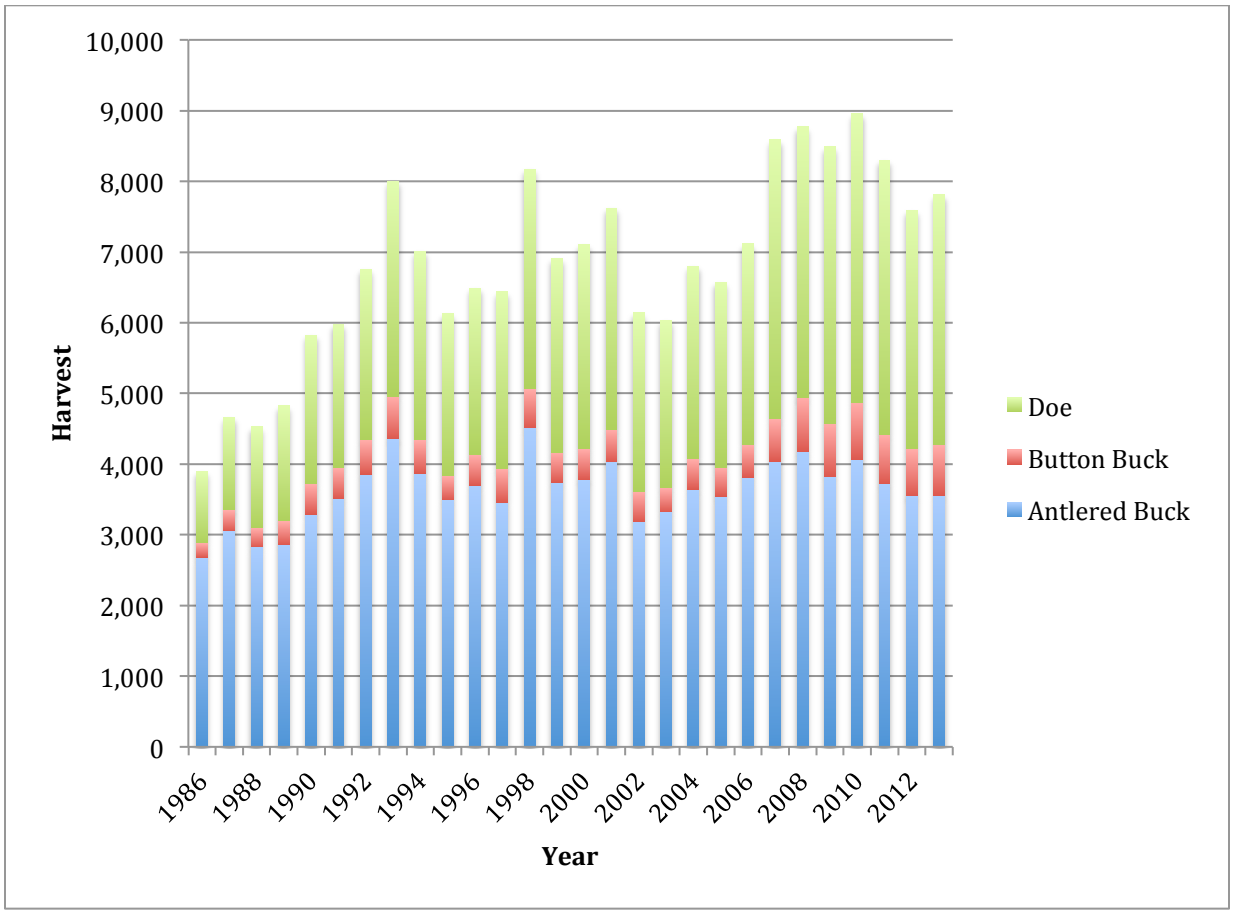
The next two items on the survey asked respondents to rank five possible benefits and threats of red wolf recovery. These summary results are also presented in Appendix G. Relative to benefits of the program, the highest percentage in all groups ranked "restoring a critically endangered species to the wild" as their highest priority. The second highest percentage for all groups ranked "red wolf recovery is part of the ecological balance" as their highest priority. The option least commonly ranked as number one for all of the groups, except those living outside of North Carolina, was "attracting money and tourists to the region". For the respondents living outside of North Carolina, the option least commonly ranked as the highest priority was "opportunity for research."

There was also consistency for the top threat of red wolf recovery. The greatest percentages in all groups were concerned about "further federal restrictions because red

wolves are endangered". "Damage to livestock or cropland" was the second most common threat for all groups except the restoration zone residents. For respondents in the restoration zone, the second most common threat was "decrease in the deer population". This concern was third for both other North Carolina groups, and was last for respondents outside of the state. The concern ranked highest by the fewest respondents in four of the groups was "people fearing for their safety". The exception was respondents outside of North Carolina; the fewest of those respondents ranked "decrease in the deer population" as the number one threat.

At the public meetings, we heard numerous statements of concern about the impact of red wolves and coyotes on the deer population in the restoration area. We asked the NCWRC for their deer harvest information for the 5 county restoration area. FWS staff provided deer-vehicle collision data for the same area. Neither of these data sets substitutes for scientific sampling of the deer population or population estimates; however, each provided an index to deer populations through time. Figures 8 and 9 display the trend of the indices that contradict some of the public perception.

Figure 8. Reported deer harvest for Beaufort, Dare, Hyde, Tyrrell, and Washington Counties for the years of 1986-2013.



Regulatory changes in the NCWRC deer season framework and bag limit changes have occurred during the 1986-2013 time period that may have affected harvest numbers. WMI requested that the NCWRC provide a summary of the changes that may have affected the deer harvest in the 5 county restoration area. That summary of changes appear below:

1987: Muzzle-loader hunters in Eastern deer season allowed to use antlerless-only deer tag in counties having established gun either-sex season

1989: Both hunter's choice and antlerless tags legal for use during muzzle-loader season in Eastern and Central deer seasons (3 antlerless deer)

1990: "Antlerless Deer" tag may be used anytime during the gun deer season in those areas having a 30-day either-sex season

1992: Statewide bag limit changed to daily-2; possession-5; and season-5, of which 1 must be antlerless. Tag structure changed to 4 "Deer" and 1 "Antlerless"

1993: "Bonus Antlerless Deer" tag created for use at anytime in those areas having a 30-day gun either-sex deer season "Antlerless Deer" tag use allowed in areas having a 10-day gun either-sex deer season

1997: Anytime "Antlerless Deer" tag eliminated. Statewide bag limit changed to daily-2; possession-6; and season-6, of which 2 must be antlerless

2004: Either-sex deer season on the Dare County mainland changed from 6 days to the 1-day
either-sex season.
Either-sex deer season on Dare Game Land changed from 6 days to the 1-day either-sex season.

2007: Bonus Antlerless Harvest Report Cards established. Two antlerless deer per card. Unlimited availability and no fee. Valid during the archery, muzzleloader, and gun season in those areas with a maximum either-sex gun season. Also valid in municipalities participating in the Urban Archery Season. Not valid on game lands.

2008: Dare County mainland (all of which was in the 1-day introductory either-sex season) and that part of Dare County on the Outer Banks that lies south of Whalebone in the 1-day either sex season was moved to the 6-day conservative either-sex season.

2010: Daily bag limit removed for deer.

Archery-only season shortened one week and muzzleloader season opened one week earlier to create a 2-week muzzleloader season.
All remaining private lands in the Eastern, Central, and Northwestern deer seasons not already in the maximum either-sex deer season (i.e., can harvest antlerless

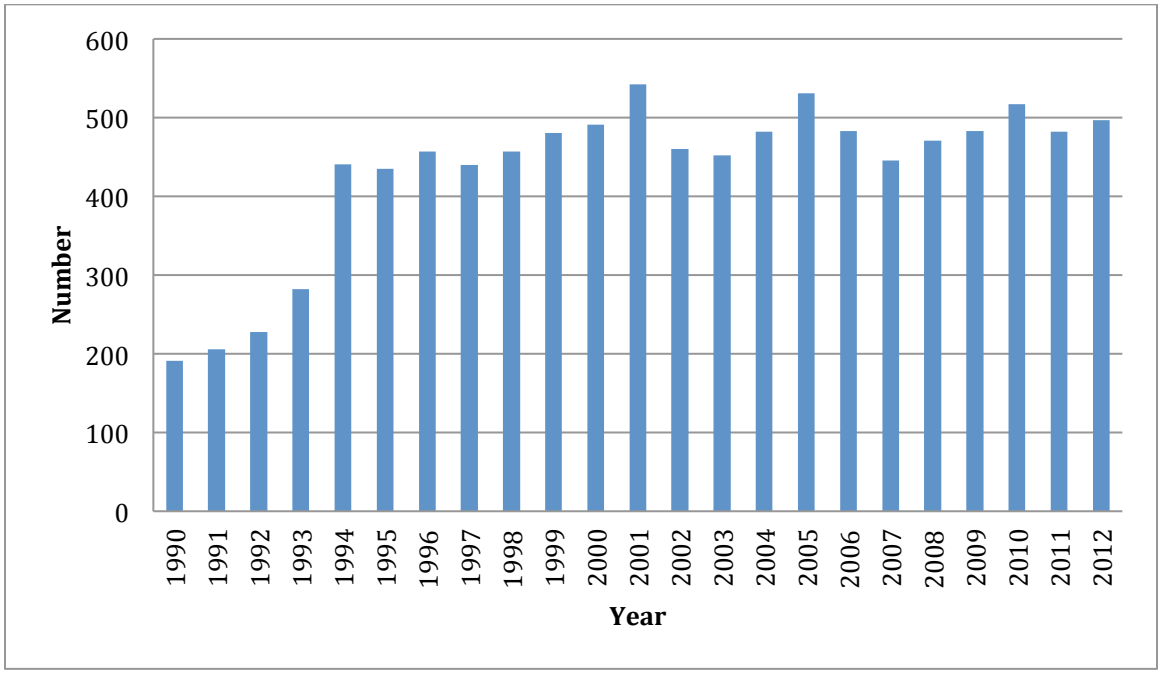
deer anytime during the season) are placed under that season (includes Dare County).

Archery hunting allowed on Sundays, except for migratory game birds.

Crossbows lawful for use, without a permit, anytime bows and arrows are lawful weapons.

It was not within the scope of this report to analyze the impact of canid predation or these regulatory changes on the deer harvest numbers; however, the sustained trend in deer harvest and deer-vehicle collisions (Figure 9) provide indices of a relatively stable deer population in the restoration area during the last 20 years. Further in-depth population surveys of deer and other game species and the transparent reporting of that information to the public may help to provide reassurance that wild canids (coyotes and red wolves) are having a minimal impact on the long term population trends of those species. Additionally, public outreach that disseminates scientific information on the impacts of the removal of territorial canids (i.e. that they are replaced by larger numbers of immigrants) may also alleviate public concerns about the restricted abilities to opportunistically remove canids that they perceive as a threat to game species.

Figure 9. Reported deer-vehicle collisions for Beaufort, Dare, Hyde, Tyrrell, and Washington Counties for the years of 1990-2012.



FWS Staff Surveys & Interviews

We surveyed and interviewed 20 FWS staff members regarding the Supporting Science, Program Management, and Human Dimensions aspects of the red wolf recovery program. Surveys were performed in an anonymous, written format just prior to or subsequent to

the oral interviews. Results from the written survey are reported in Appendix G. They were used to simply corroborate or clarify information received during the oral interview.

From the oral interviews, it was apparent that the red wolf recovery program suffers from multiple program management issues. For example, there appears to be a decoupling of input, oversight, and interest from staff the further they were geographically away from the project. While this is common in large organizations, the red wolf recovery program had the potential from the beginning to suffer from public relations problems. The early lack of oversight by regional and headquarters leadership allowed for miscommunication and speculation within the public. The majority of staff agreed (78%) that the red wolf recovery program was a priority of the FWS. However, the written survey data supported our understanding that decoupling between the region and local oversight occurred. The majority of staff agreed that the red wolf project had increased in priority over the past 20-30 years, even as public relations deteriorated during the same period. Furthermore, 61 percent slightly disagreed, disagreed, or strongly disagreed that there was sufficient institutional support for the red wolf recovery program.

Staff opinions of public perceptions of the red wolf recovery program indicated that they believe the public was generally supportive with 47 percent agreeing and 13 percent slightly agreeing. However, this was contrary to many of the comments and information collected during the public listening sessions, which according to the attendees indicated strong disagreement (78%) for public support of the project.

From a partnership perspective, the majority of staff perceived that FWS had been a good partner on planning (61%) and implementation (72%) of the red wolf recovery program. However, the majority of staff also felt that the USFWS was inadequately prepared to deal with wolf recapture on private land (78%) and holding captured wolves (78%). These opinions of FWS staff provide credence to some of the opinions expressed by attendees of the public meetings with respect to a "bad" partnership between the FWS and local landowners.

Finally, WMI has concluded that the red wolf recovery program has a strong biological focus but lacks an interdisciplinary approach to public outreach and engagement that would garner public support and acceptance of the red wolf recovery efforts in the 5 county area. WMI believes that the Collaborative Conservation Memorandum of Understanding between the FWS and the NCWRC is an ideal starting point for bringing resolution to the public relations conflicts that have arisen from issues such as the recent court decision to prohibit the killing of coyotes in the 5-county area. Nature abhors a vacuum, in the absence of public information and transparency; the public may be left to speculate and to, at times, conjure up misconceptions and controversies that may or may not be valid.

d. Are current agency funds and staff adequate to carry out needed management, monitoring, and research? Would success be possible if the Service worked with the North Carolina Wildlife Commission?

Agency funds are not adequate to carry out the entire recovery plan. FWS staff did comment that additional funds would be put to good use but the current funding levels were adequate for management, monitoring, and research in the 5 county restoration area. WMI concluded that additional funding for GPS telemetry collars would assist monitoring and research. In addition, these collars would provide additional information for staff and the public with respect to the management of wolves that travel across private property. We also believe that additional funding may be required for a rigorous analysis of the effectiveness of the placeholder strategy and for human dimensions research and conflict resolution efforts within the restoration area. However, if the FWS decides to terminate application of the placeholder strategy under the experimental approach described above, significant funds would be available to redirect to some of these needs.

A cooperative monitoring and research project between the FWS and NCWRC on canids within the restoration area would be beneficial from a science and program management perspective. Based on or discussions with NCWRC leadership, we believed that NCWRC welcomed the collaboration described in the FWS/NCWRC MOU.

e. Do the financial and institutional resources currently exist to meet the evolving environmental, social and management challenges that will be seen for recovery?

WMI concluded that the current level of resources available is inadequate to meet the evolving environmental, social, and management challenges that face the recovery plan. We do believe that the shift of program oversight from the NWRS to the Ecological Services program was a sound decision that better aligns expertise and resources with the program mission.

Further, WMI believes that the FWS has existing multidisciplinary staff available to improve the recovery program. To improve the recovery program management and increase public support for the program they must be aligned with the program mission. The following program elements need additional emphasis: regional review and oversight, private landowner relations, public education and outreach, and Congressional, state, and local government relations. The FWS's Partners for Fish and Wildlife program provides a good model for use in the restoration area. WMI is familiar with community engagement efforts of the FWS (e.g., Blackfoot Challenge) that could improve community relations in the restoration area.

The difficulty of threatened and endangered species management programs will not diminish. WMI concluded that a thorough look at selected recovery programs might be warranted. Policy makers may want to consider the following factors to prioritize their budget allocation decisions in a regional and national context (in no order of importance):

- Distribution across the historic range of the species
- Ecological function of the taxon
- Legal obligations (e.g., court ordered settlements)
- Organizational support required and available
- Recovery program expense

- Resources available through annual appropriations
- Return on investment from the recovery program activities
- Risk of extinction to the species
- Probability of program success or failure
- Staff capabilities required and available
- Suite of species with existing recovery plans
- Threats to species survival
- Uniqueness of the taxon

Further, recovery plans should be reviewed and updated on a routine schedule. Updates should incorporate lessons learned and an evaluation of program success to date.

f. What additional Human Dimensions information could be gathered to assist the Service in improving the red wolf recovery program?

Human dimensions information and a well-designed and executed conflict resolution process would assist in refining the recovery program management within the original restoration area and help inform management efforts in additional restoration areas. Rigorous scientific surveys would provide better information about public opinions and attitudes within and outside the restoration area regarding such things as landowner tolerance, public willingness to pay for additional efforts, and public awareness of the risk and consequences of hybridization. Economic impact (beneficial and negative) studies of the red wolf recovery program would help inform the FWS and the public about the program's impact to the community. Routine public information and education efforts, such as newsletters and/or the use of social media would help inform the public about the status and future of red wolf recovery plan efforts.

Given the current level of controversy associated with red wolf recovery, it may be necessary or advisable to implement a comprehensive conflict resolution process to sustain the program. Clark and Rutherford (2014) and others have outlined strategies that may allow the FWS and the stakeholders with deeply held and conflicting values and interests define a successful course of action.

Summary of Significant Conclusions

Supporting Science

Population Dynamics

- A detailed and robust analysis of red wolf population dynamics that is underway should assist in the understanding of the recent decline in population size and breeding pair numbers.
- FWS provided documentation of an improved and more robust population estimation model and we are confident that this effort will provide more accurate, precise, and timely information in the near future.
- Mortality causes and rates should be monitored throughout the year, especially to determine the impact of mortality on breeding behavior and reproduction.
- It is not just the loss of an individual that is of concern; it is the role that individual plays in the future reproduction and recruitment of red wolves into the population.
- Because of the small size of the existing wild red wolf population and potential future reintroductions, the impact of canid disease and parasites must be monitored and addressed.

Taxonomy/Hybridization

- The taxonomy of the red wolf remains unclear. The uncertainty surrounding red wolf taxonomy contributes to the current controversy. Regardless of the outcome of further analysis of red wolf taxonomy, the FWS faces extremely difficult decisions regarding the future direction of the recovery program.
- The dominant ecological challenge to red wolf recovery is hybridization with coyotes.
- Further analysis of the effectiveness and efficiency of the placeholder strategy is needed to determine the impact of the strategy on hybridization of red wolves and coyotes.
- Regardless of the effectiveness of the placeholder strategy, the high cost and indefinite duration over which it may be necessary to apply the strategy raise serious questions regarding the value of continuing this approach.
- The FWS may need to adopt an alternative to the placeholder strategy. One such alternative would be to allow red wolves and coyotes to interact without human intervention and monitor gene flow within the resulting hybrid swarm.
- At least two approaches exist that would allow the FWS to experimentally assess the ability of red wolf genes to persist in the absence of active efforts to preclude hybridizations.
    - One approach would be to reintroduce red wolves into one or more areas of suitable habitat within the historic range of the species without human intervention to suppress interbreeding.
    - The other approach would be to suspend application of the placeholder strategy in the recovery area.

- One of these approaches may be essential for the FWS to determine whether red wolves can ever be recovered as envisioned by the ESA or will remain "conservation-reliant" in perpetuity.

Habitat

- The original reintroduction area of 225 square miles (144,000 acres) was unrealistically small given the area's habitat quality.
- There is no theoretical or practical reason to believe that red wolves will constrain their activities or movements to a jurisdictional boundary, especially when red wolf density increases within that boundary and prey levels fluctuate through time.
- The Alligator River, Pocosin, Mattamuskeet, and Swan Quarter NWRs and the Dare County Bombing Range (managed by the Navy and Air Force) within the current restoration area cannot be managed or restored in a manner that would provide sufficient habitat for the current population of red wolves.
- Habitat restoration on the NWRs could not be accomplished at the scale necessary to support the current population of red wolves due to the geology, hydrology, soil, and habitat types found on the refuge lands.
- Current sea level rise modeling indicates that significant portions of the Alligator River NWR and portions of the Albemarle Peninsula will be lost to sea level rise within the next 50–75 years.
- Current efforts to adapt to sea level rise, build resiliency, and restore hydrology are not complimentary to red wolf habitat needs at Alligator River or Pocosin Lakes NWRs.

Recovery Plan

- The project has demonstrated that captive red wolves can be successfully reintroduced into the wild and rear offspring of their own in areas without coyotes. Given that coyotes now fully occupy former red wolf range, it is unclear whether red wolves can be successfully reintroduced and rear non-hybridized young without active human intervention.
- Reintroduction of red wolves to other areas would increase the program's representation, redundancy and resiliency.
- The primary challenges and impediments associated with the recovery program are fourfold: the need for redundancy in wild populations, genome integrity and the impact of interspecific breeding with coyotes, the necessary restoration area size, and land ownership patterns within restoration areas
- The recovery plan would benefit from a review, update and/or revision to incorporate the 27 years of knowledge and experience associated with the 5 county restoration area program.

Additional Reintroduction Sites

- Currently the estimated wild red wolf population numbers around 112 wolves (above the restoration area objective) in the eastern NC restoration area. This is above the initial objective of 35–50 wolves in this area, but is below the number necessary for a viable,

self-sustaining population in the face of sympatric coyotes. The lack of redundant populations in at least two other distinct areas indicates that the primary recovery objective has not been achieved.

- Future restoration areas should consider the opportunity for genetic exchange between the 3 populations.
- The selection of additional restoration areas may be hampered by the large size of the areas needed and land ownership patterns (federal, state, and private) within those areas.
- Jurisdictional, social, and political issues will need to be addressed prior to future reintroduction efforts.
- Extensive interagency and public relations efforts will be necessary to secure the broad-based social and political support necessary to create a suitable environment for reintroduction.
- Cooperation and collaboration with state fish and wildlife agencies would be critical to the success of future reintroduction programs.
- Building landowner and resident support for the program prior to reintroductions is a critical component of future reintroduction efforts.
- 10(j) Rules developed for any future reintroductions would benefit from a thorough analysis of the outcome of the current rule.
- Potential reintroduction sites would need to be assessed in advance for the abundance and distribution of suitable habitat and prey availability.
- Because coyotes are distributed across the historic range of red wolves, future releases will occur in the presence of coyotes. Releases would need to be informed by the reintroduction in eastern NC but will have to make management adaptations due to coyote interactions with red wolves.

Program Management

Program Management – oversight and coordination

- Throughout much of the life of the red wolf recovery program, local program managers received inadequate oversight and coordination from the regional office.
- The red wolf recovery program suffers from multiple program management issues. For example, there appears to be a decoupling of input, oversight, and interest from FWS staff the further they were stationed geographically from the project.
- The red wolf recovery program has a strong biological focus but lacks an interdisciplinary approach to public outreach and engagement that would garner public support and acceptance of the red wolf restoration efforts in the 5 county area.
- Decisions made at the local level, although made with the best intentions and with the program's success in mind, did not always conform to the rules established for the reintroduction program.

Program Management - resources

- Budgetary support for the program has been consistent through the life of the project and has been the highest budget priority within the Southeast Region since the project's inception.
- Because the budget available to the program only supported one population (eastern NC), the budget was insufficient to meet the larger recovery plan objectives.
- The current level of resources available is inadequate to meet the evolving environmental, social, and management challenges that face the recovery plan.
- Field staff has provided tremendous support for the program but have not had the multidisciplinary assistance necessary to maintain public support within the restoration area.
- The following program elements need additional emphasis: regional review and oversight, private landowner relations, public education and outreach, and Congressional, state, and local government relations.
- Captive populations are below objectives and the insufficient captive facility capacity further complicate achieving the captive population objective.
- The Species Survival Plan is still relevant but currently insufficient funding and capacity hamper implementation of the plan.
- The cryogenic preservation of red wolf gametes has been delayed and needs attention.
- The designation and management of "repeat offenders" and "nuisance wolves" is a policy decision of the FWS that requires recommendations outside the scope of this report.
- The establishment of additional restoration areas would allow the transfer of red wolves from one site to another possibly diminishing the concern about the disposition of "nuisance" wolves.

Program Management - rules

- The 10(j) Rule was deemed necessary to gain public acceptance for the reintroduction in the Alligator River and Pocosin Lakes NWRs.
- Authors of the 10(j) Rules were either misinformed about red wolf dispersal behavior or were uninformed about the practical administration of the rules.
- Poorly constructed rules resulted from a lack of adequate involvement of local program staff with rule-making staff.
- Local program staff was asked to comply with 10(j) Rules that were untenable leading to inconsistent or inappropriate application of the rules at the local level and/or miscommunication with the public.
- The amendments to the original 10(j) Rule, although intended to remedy management problems for FWS staff and the public, were not effective.

Human Dimensions

- At the onset and throughout the life of the red wolf recovery program, public outreach and education for private landowners within the restoration area was not a major component of the program.

- The inadequate public awareness and support efforts have lead to an atmosphere of distrust within some segments of the community.
- The 2013 lawsuit that resulted in prohibition on all coyote hunting within the 5 county restoration area increased some of the local residents' anti-wolf sentiment.
- The injunction caused a major public relations issue for both the FWS and the NCWRC that further eroded support and tolerance for the program by some citizens residing in the restoration area.
- Some of the citizens in the area consider the prohibition as a violation of their private property rights and the right to defend livestock, family, and property. Others expressed concern about the level of predation on other wildlife caused by red wolves and coyotes.
- The following red wolf program issues must be discussed and addressed to improve the relationship with the public and NCWRC: credibility with the public, project goals, conformance to program rules, consultation with NCWRC, information provided to the public, an apparent focus on individuals rather than entire red wolf population, and the perception of unresponsiveness to the public's requests.
- Rigorous scientific surveys to gather better information about public opinions and attitudes within and outside the restoration area would assist the FWS in addressing public concerns.
- Development and implementation of a comprehensive conflict resolution process involving the FWS and all stakeholders may be necessary to overcome current local opposition to the recovery program.
- Routine public information and education efforts, such as newsletters and/or the use of social media would help inform the public about the status and future of red wolf recovery plan efforts.
- During the last two years (2013-2014) deliberate and productive efforts have been made to strengthen the coordination and relationship between the FWS and NCWRC at top- and mid-level leadership.
- The "Collaborative Conservation of Red Wolves and Other Canids on North Carolina's Albemarle Peninsula" memorandum of understanding signed by the FWS and NCWRC in 2013 detailed a substantial commitment for cooperation between the agencies to benefit canid management.
- The NCWRC leadership expressed the desire for a cooperative relationship with respect to resolving the coyote hunting injunction issue.

Appendix A. Exhibit A of the FWS/WMI Contract

The Red Wolf program evaluation will be structured around three components: Supporting Biological Science, Program Management and Human Dimensions.

1. Supporting Science – Considerable science-based literature exists that is relevant to this project, and the Service has extensive data on the population dynamics of the experimental Red Wolf recovery effort. The following questions should be addressed:

a. What does current science tell us about this project? What are the challenges and impediments to the project? What are strategies to overcome them? What are the pros and cons of different strategies for moving forward?

b. What are the project goals outlined in the original Red Wolf Recovery Plan, 10j Rules and Environmental Assessments? Are they still feasible at this time?

c. Are the habitat conditions on federal lands within the recovery area conducive to holding viable self-sustaining red wolf populations for the long term? If not, can the NWR lands be restored or are there other lands outside federal lands (i.e., State, private) that could support populations and would landowners support those populations?

d. The 1990 red wolf recovery plan identifies the need for 3 self-sustainable populations in at least 3 distinct locations. Is this assumption still valid? If so, what progress has been made to identify other sites? Does the recovery plan need to be revised?

e. What is the current role of the captive population? How is the Service incorporating it to the recovery efforts? Is the Species Survival Plan (SSP) still relevant and is it being followed? Does it need to be revised?

f. How will sea level rise affect red wolf restoration in the recovery area in the foreseeable future?

2. Program Administration and Management – This part of the Program Evaluation should focus on how the Service has implemented and managed this project. It should focus solely on management decisions made by the Service, especially on relevant rules or other formal guidance or statements of policy issued by the Service. The following questions should be addressed:

a. Have the rules/policies/guidance issued been followed by the Service?

b. The Alligator River NWR and Pocosin Lakes NWR were established primarily for migratory birds. They are now in the primary cores areas for supporting red wolves. Are the lands within Alligator River NWR and Pocosin lakes NWR adequately managed for red wolves? If not, why? Can the management regime be changed to better support the population of red wolves and still support the original mission? If not, why?

c. What level of management-related support has this project been given by the Service?

d. What is the total financial cost of the recovery effort (including costs from the regional office, field and Washington when appropriate)? Where does it fit in the overall priority system within the southeast and across the nation?

e. Has the project received adequate funding and institutional support to meet its goals?

f. Based on science-based recovery recommendations, how much funding will be needed to achieve success within the current recovery area and with two additional population sites?

g. In recent months, the Service has received an unprecedented number of red wolf removal requests from private landowners. Is the current management structure equipped to handle an increasing number of requests for red wolf removal from private property? Is the Service responding to these requests appropriately based on what is mandated in the 10j Rules? Does the Service have adequate facilities to handle captured wolves?

h. If red wolves are removed from the core area where will they be placed? If some red wolves are identified as "repeat offenders" should they also identified as "nuisance wolves"? If so, how should this be defined and where will the service place these wolves? In zoos? Island populations? Others?

3. Human Dimensions – The Service's long-term relationship with the North Carolina Wildlife Commission, local governments, and private landowners, as well as the Governor's office, state legislature and Congressional delegation could be influenced by future management decisions on this project. The Service has legislated responsibilities to follow and its own conservation mission, goals, and strategies. The Service also recognizes the critical importance of public/private partnerships in reaching its conservation goals and respecting the rights of landowners who are affected by its actions. They also realize that working lands need to stay working. The impacts of this project on affected landowners in the 5 counties surrounding the Red Wolf recovery area should be explored along with landowner attitudes toward the project. The following questions should be addressed:

a. Is there institutional (e.g., State) and public (e.g., private landowners) support for this project? Do the public and private sector support the overall recovery plan?

b. Is effective cooperation occurring with other agencies and the public? How has the red wolf recovery program affected the working relationship between the Service and the North Carolina Wildlife Commission and key public stakeholders?

c. What information is available to assess public awareness of and support for the red wolf recovery program?

d. Are current agency funds and staff adequate to carry out needed management, monitoring, and research?

e. Do the financial and institutional resources currently exist to meet the evolving environmental, social and management challenges that will be seen for recovery?

f. What additional Human Dimensions information could be gathered to assist the Service in improving the red wolf recovery program?

Appendix B. Red Wolf Literature Review

Red Wolf Introduction

Red wolves were once found across the eastern United States (U.S.). Most accounts describe the historic range as from Texas and Louisiana to the Ohio River Valley and up the Atlantic Coast into northern Pennsylvania or southern New York, and perhaps further north (Hinton et al. 2013, USFWS 1989, Nowak 2002). The killing of wolves, land conversion and clearing, mineral extraction, logging, and road infrastructure decimated red wolf populations by the early 20th century (Riley and McBride 1972, USFWS 1989). The expansion of coyotes into the region during the mid-20th century led to increased interbreeding between these two closely related species, further threatening red wolf populations. By the 1970's the only identifiable population of red wolves was in the border coastal areas of southeastern Texas and southwestern Louisiana (Hinton et al. 2013, Paradiso and Nowak 1972, USFWS 1989, USFWS 1982).

The Red Wolf Recovery Program was established in 1975 and first focused on protecting these wolves in the wild. As concerns grew over the loss of genetic diversity due to the small number and inter-specific breeding with coyotes, the Program removed as many red wolves as possible from the wild and refocused on restoring the population through captive breeding and eventual reintroduction (USFWS 1989, Hinton et al. 2103). The first Red Wolf Recovery Plan was written in 1982 and revised in 1984, and the American Association of Zoological Parks and Aquariums accepted the captive breeding program as a Species Survival Plan in 1984 (USFWS 1989).

The first reintroduction experiment took place in 1976, when a wild caught pair was released onto Bulls Island at Cape Romain NWR in South Carolina. The pair was released into an acclimation pen for 40 days and then released on the island for nine days before being recaptured (USFWS 1989). The purpose of the release was to test management and public information approaches. Another pair was released on the island, first into a pen for six months, fed local prey species, and then released onto the NWR. They remained for eight months and were recaptured based on the original purpose of the experiments – to gain data to inform the reintroduction effort (USFWS 1989). The next few years were spent looking for mainland reintroduction sites. After a failed attempt to get support for reintroduction into a site in Kentucky and Tennessee, the Red Wolf Recovery Program began plans to reintroduce red wolves at a site that would become Alligator River National Wildlife Refuge (USFWS, 1989). From 1987 to 1992, 42 wolves were reintroduced over 15 different occasions (Phillips 1994). Of the 42, 22 died, 7 were returned to captivity, 11 were still free ranging in 1992, and one had lost contact (Phillips 1994). In addition to captive breeding sites across the U.S., island propagation sites were set up in South Carolina, Florida, and Mississippi to provide "wild-reared" wolves for reintroduction in North Carolina (van Manen et al. 2000) and potentially to other mainland restoration sites.

By the mid 1990's, the population was successfully breeding in the wild as well as establishing and protecting territories and forming packs. By 2002 all wolves were wild-born within the Red Wolf restoration area, which now covers 5 counties (Beaufort, Dare, Hyde, Tyrrell, and Washington) on the Albemarle Peninsula and includes federal, state, military, and private lands as well as four National Wildlife Refuges (Alligator River NWR, Pocosin Lakes NWR, Mattamuskeet NWR, Swan Quarter NWR) (USFWS 2007). The program continues today and has provided useful information for other captive breeding programs across the U.S.

To fully evaluate the success of the Red Wolf Recovery Program and the threats the Program and red wolves face today, it is necessary to understand the details of red wolf biology, taxonomy and genetics, and the threats and challenges to their survival. This review briefly summarizes foundational and seminal research and focuses on synthesizing key information from more recent research on red wolf life history traits, habitat characteristics and utilization, genetics/taxonomy, population dynamics, and current threats from issues such as hybridization with coyotes, sea-level rise and more intense storm events, and human-related issues. The information and details provided will assist in the evaluation of the Program's goals, objectives, and management actions as well as help to understand current threats to the restored population and how and if they may be overcome.

Life History and Habitat Characteristics

Evaluating the success and continued feasibility of the Red Wolf Recovery Program requires a thorough understanding of life history traits of red wolves such that managers can determine if the location, available food sources, and area for home range and denning, among other factors are adequate to ensure reproductive success and minimize loss and threats to the population. This section includes a review of red wolf food habits, breeding and reproductive characteristics, denning behavior, and social behavioral characteristics. Habitat needs, utilization, suitability, and availability are also described as these factors are extremely important in understanding if the current Red Wolf Recovery Program is sufficient in terms of size, location, prey availability, and for minimizing threats. The information provided in this section provides the foundation for which the other sections are built as well as for managers more generally to make decisions about the red wolf program.

In considering the red wolf life history and habitat needs, the red wolf was first described in the 1700's, but it was not well studied until it was already facing demise across its range in the 1960's (Phillips, et al. 2003). Given this, most information available is based on the remnant population that was extracted from eastern Texas and western Louisiana, red wolves in captivity, and the restored population in the Red Wolf restoration area. The information below will distinguish between that which is known based on the remnant population versus the restored population.

Food habits

The remnant red wolf population in Texas and Louisiana primarily ate small mammals such as swamp and cottontail rabbits, rodents (e.g., muskrat and cotton rat), and other small animals such as nutria (Paradiso and Nowak 1972, Riley and McBride 1972, and Shaw 1975). Although it is not likely red wolves often preyed on larger animals, they may have preyed on deer and wild hogs (Paradiso and Nowak 1972, Riley and McBride 1972). If they attacked livestock, it was often smaller or young animals (Howell 1921, Paradiso and Nowak 1972).

Red wolves are generalists and base their prey selection on what is available (Trani and Chapman 2007). Earlier research on prey selection demonstrates that 86 percent of red wolves' diet from 1987 to 1993 at the Alligator River National Wildlife Refuge (ARNWR) consisted of white-tail deer, raccoons, and marsh rabbits; however, prey type varied depending on pack location of the wolves (Phillips et al. 2003). Specifically, packs located near agricultural fields have a greater diversity of small prey available and tend towards rabbits and rodents, while the pack in the pine-hardwood swamps prey upon larger prey items such as raccoons and deer (Phillips, et al. 2003). Hunting typically occurs at night peaking at dawn and dusk (Kelly et al. 2004; Trani and Chapman 2007).

More recently, Dellinger et al. (2011) analyzed scat of six red wolf packs over a two-year period (2009 to 2010) to determine if food habits change during pup rearing and what their habits are year round. The authors found similar results to earlier studies. Approximately 66 percent of prey biomass consumed for the six packs consisted of adult white-tailed deer and fawns. Other prey species included: small rodents (hispid cotton rat, marsh rice rat, Eastern harvest mouse, and house mouse), large rodents, (nutria and muskrat), rabbits (marsh rabbits and eastern cottontails), raccoons, wild boars, anthropogenic material, and other incidental prey species. Prey did not vary between pup rearing and other seasons nor did it vary based on reproductive status (Dellinger et al. 2011). Variation did occur between the prey items consumed in smaller amounts. Variation is likely due to prey availability within a pack's territory or hunting and foraging skills rather than habitat type, as habitats do not vary greatly. Wolves also ate human food or trash, likely due to proximity to a dump (Dellinger et al. 2011).

McVey et al. (2103) also analyzed scat monthly from the restored red wolf population from January 2009 to February 2010, and found results similar to those of Dellinger et al. (2011). White-tailed deer, rabbits, and rodents were the primary food source for red wolves. White-tailed deer was the only prey species to show up in scat every month, and rodents were consumed more in the summer than the winter, likely due to changes in availability of prey species. Coyotes were also examined and found to eat similar prey over the same time periods as the red wolves (McVey et al. 2013).

Breeding and Reproduction

Little to no published documentation of reproductive and breeding habitats of red wolf exist prior to study of the remnant population in the 1970's (Paradiso and Nowak 1972). Using field observations from before 1930, researchers concluded that copulation occurred once a year from late December/early January to late February/early March, and young

were born from April to possibly the first part of June (Paradiso and Nowak 1972). Riley and McBride (1972) documented breeding at similar times, breeding in January and February with pups being born in March and April (1972). Litters averaged three pups, which were primarily reared in dens and both male and female wolves participate in rearing the young (Paradiso and Nowak 1972, Riley and McBride 1972). Pups typically bred just before they turned three and whelping occurred from April to early May (Paradiso and Nowak 1972).

Research on the restored wolf population shows that these wolves generally are sexually mature by two years of age (Phillips et al., 2003). Litters typically contain three pups, and wolves tend to stay in family units until they are sexually mature (Phillips et al. 2003). Research demonstrates that the youngest wild-born male to breed was 10 months old and the oldest was approximately 46 months, while the youngest wild-born female was 22 months and the oldest was 70 months. Although some earlier research notes that captive red wolves may mate with multiple male wolves if something happens to partner or separation occurs, more recent research notes that red wolves tend to be monogamous (USFWS, 1984, Phillips et al. 2003, Sparkman et al. 2011, Sparkman et al. 2012). Additionally, as of 2002 all red wolves were wild-born (not born in captivity or on the island) and without any intervention from the USFWS (USFWS 2007).

More recent research covering a longer span of reproductive data for the restored wolf population provides similar information on litter size and adds to the knowledge base on reproduction among red wolves. Based on this data, average litter size is 3.9 plus/ minus 0.1; however, the average litter size for the born-wild population in North Carolina was slightly higher than those bred in captivity (Locklear et al. 2009). Pup survival rates were also greater for free ranging pups than those born in captivity (Locklear et al. 2009). Age also affects reproductive success. As females age, breeding success, pup survival, and litter size decrease (Locklear et al., 2009, Rabon 2009).

In terms of inbreeding within the population, Rabon and Waddell (2009) determined that there is some observable inbreeding depression and effects on litter size, but that does not seem to be limiting factor on conservation of the red wolf. Sparkman et al. (2012) also investigated behaviors of red wolves to determine if there are specific actions or traits to prevent inbreeding. The authors found that like other cooperatively breeding species, red wolf breeding pairs were almost always two non-related wolves and thus experience limited inbreeding (Sparkman et al. 2012). This is likely due to pups dispersing separately and into different packs, based on the subordinate structure while within their natal pack. Additionally as mentioned previously, red wolves tend to be monogamous, making it less likely they would mate with another wolf from the pack (Phillips et al. 2003; Sparkman et al. 2011; Sparkman et al. 2012).

Additionally, Rabon (2014) studied the captive population of red wolves to determine factors that contribute to reproductive success. Rabon (2014) found that younger wolves are more likely to reproduce, the age of the female (older) negatively affects pup survival but age of the male and female both affect breeding success, which is different than the findings of Locklear et al. (2009) findings. Litter size decreases with increasing female age,

and reproductive capabilities likely start to decrease earlier for female wolves than previously thought (Rabon 2014). Finally, updated research shows a similar reproductive timeline to earlier efforts: pairing and breeding season is October to March, breeding is from February to March, whelping occurs in April and May, and pup rearing occurs in June through September (Rabon et al. 2013).

Denning

Remnant red wolf population in eastern Texas built dens in hollow logs, stumps, culverts, sand mounds, and along banks of reservoirs, canals, and ditches (Riley and McBride 1972, Paradiso and Nowak 1972). Most of what is known about denning habits is based on observation of the restored population of red wolves. Within the restored population, most dens are burrows in brush covered wind-rows in agricultural areas with a low water table and friable soils; however, dens also occurred as aboveground nests among thick vegetation (Phillips et al., 2003). Phillips et al. (2003) hypothesize that because of the proximity to the water table, red wolves could not put dens underground. Dens tend to be used from mid-April until mid-July, by breeding pairs and pups, but all wolves may use them. Wolves disperse in mid-July and use the dens rarely after this time (Phillips et al. 2003). In terms of reproduction and whelping pups, some females used the same den for several years, while others used a new den each year (Phillips et al. 2003). Adult wolves and pups often leave dens by mid-July to utilize agricultural fields likely due to availability of prey (Hinton 2006).

Social and Behavioral Characteristics

Early research on the remnant population in Texas demonstrates that red wolves are more social than coyotes but less so than grey wolves. They travel in packs throughout the year and maintain pack structure; however, they typically hunt alone (Riley and McBride 1972, Shaw 1975). Red wolves are built to run long distances, likely over open terrain. They carry their tails differently depending on the situation. For example, they carry it high over their backs during greetings and courting female wolves (Paradiso and Nowak 1972). When captured they are more aggressive than coyotes bearing their teeth and raising the fur on their neck and backs, often howling (Riley and McBride, 1972, Shaw 1975). As mentioned before, wolves are most active at night, hunting during dawn and dusk. Remnant populations would often rest during the day in fields, pastures, or other grass. They utilized dens or otherwise stopped traveling from April until mid-August, and they began hunting and traveling longer distances in September (Paradiso and Nowak 1972). Wolves tended to travel as families on established paths. Home ranges (discussed in more detail below) for the remnant Texas population ranged from 25 mi^2 to 50 mi^2 and likely averaged 44 mi^2 (Riley and McBride 1972, Shaw 1975, and Phillips et al. 2003).

Rearing Pups and Pack Dynamics

During pup rearing in the summer months, red wolves tend to use agriculture fields more than nearby wooded areas, and wolves and pups leave dens early to utilize these fields

(Hinton 2006). Pups are rarely left alone indicating both males and females rear the pups (Hinton 2006). Karlin and Chadwick (2011) examined non-breeding wolves in packs and determined that a non-breeding wolf typically is related to the female (offspring), which likely explains why he was allowed to stay in the pack. Sparkman et al. (2011b) found that non-breeding males delaying dispersal for two years had an increase in survivorship and reproductive fitness, given that reproductive maturity does not occur until two years of age. The relationship of non-breeding relative wolves staying in the pack and increasing survivorship and fitness is less clear for females (Sparkman et al. 2011b). Sparkman et al. (2011a) reviewed red wolf data from 1989 to 2007 to determine if having a non-breeding male in the pack serve as a "helper" increases size and survival of pups, could result in earlier reproductive ages, and/ or potentially increase reproductive success. The authors found that having helpers within the pack did increase survival and body mass of pups when the pack population density was low, but negatively affected pup body mass when pack population density was higher (Sparkman et al. 2011a). Reproductive age was not advanced in pups reared with helpers, but female pups did experience increased fitness in terms of having a later age at last reproductive event, and thus more reproductive events (Sparkman et al. 2011a).

Home Range

Reported home range sizes tend to vary and have been estimated from the remnant population as well as the restored population over the last 30 years (Table 1). Early research was based on remnant populations and thus small sample sizes, and research prior to Hinton (2006) was based on information gathered through monitoring for various management needs. Hinton (2006) represents the first systematic effort to determine red wolf home range. Phillips et al. (2003) hypothesize that home range size is based on prey availability – packs have smaller ranges where there is more abundant prey while packs need to cover more area when prey sources are less dense. Home range size is often larger for juvenile wolves than pups, and varies based on social rank for adult wolves (Hinton 2006). Additionally, adult and juvenile home ranges are larger at night than during the day, while pups constrict their home ranges at night (Hinton 2006).

Table B1. Reported home range sizes of red wolves.

Report	Home range size	Research parameters
Riley and McBride 1972	65 km^2 to 129.5 km^2 (25 mi^2 to 50 mi^2)	Telemetry study on remnant population – 3 males over 5 years
Shaw 1975	44 km^2 (17 mi^2)	Telemetry study on remnant population – 2 females and 5 males
Phillips et al. 2003	88.5 +/- 18.3 km^2 (35 +/- 7 mi^2) for individuals 123.4 +/- 53.5 km^2 (48 +/- 21 mi^2) for packs	Tracked location data for 13 reintroduced wolves from 3 packs
Hinton 2006	59 km^2 to 111 km^2 (23 mi^2 to 43 mi^2)	Two wolf packs (one breeding and one non-breeding) systematically sampled during pup rearing season

Habitat Utilization, Needs, and Availability

Red wolf observed and documented habitat use within the Red Wolf restoration area as well as provides managers with valuable information about both the suitability and availability of habitat within the current area. The information provided below also provides a foundation for better understanding the threats red wolves face and actions that may be needed to continue to manage and protect them. Having this understanding of the most current utilization patterns will help managers determine if management objectives and goals may need to change, if the all of the restoration area is still suitable for the red wolf population, and whether it will be able to continue to expand. Additionally, habitat information also potentially helps managers determine if and where other sites could be viable for reintroduction.

Existing Habitat Description

In 1987, the first red wolves were introduced into Alligator River National Wildlife Refuge, which then consisted of approximately 120,000 acres of coastal plain habitat, including brackish marsh, pocosin, and freshwater nonriverine swamp (USFWS 1989, Phillips et al. 2003). This area is adjacent to approximately 51,000 acres of non-inhabited Department of Defense lands (bombing range). In 1990, USFWS added another 110,000 acres with the establishment of Pocosin Lakes National Wildlife Refuge (Phillips et al. 2003). Today, the Red Wolf restoration area comprises 1.7 million acres on the Albemarle Peninsula in 5 counties in North Carolina (Beaufort, Dare, Hyde, Tyrrell, Washington) and includes four national wildlife refuges, the Department of Defense bombing range, state-owned lands, and private lands (Hinton and Chamberlain 2010, USFWS 2007). The restoration area is divided into three zones for management purposes (Hinton et al. 2013) (Figure 1). Natural habitat types within the area include agricultural field with bordering pine forests (30%), pine plantations (15%), pocosins (15%), pine hardwood forests, swamps (10%), and salt marsh or open water (10%) (Phillips et al. 2003, Hinton and Chamberlain 2010, and McVey et al. 2013).

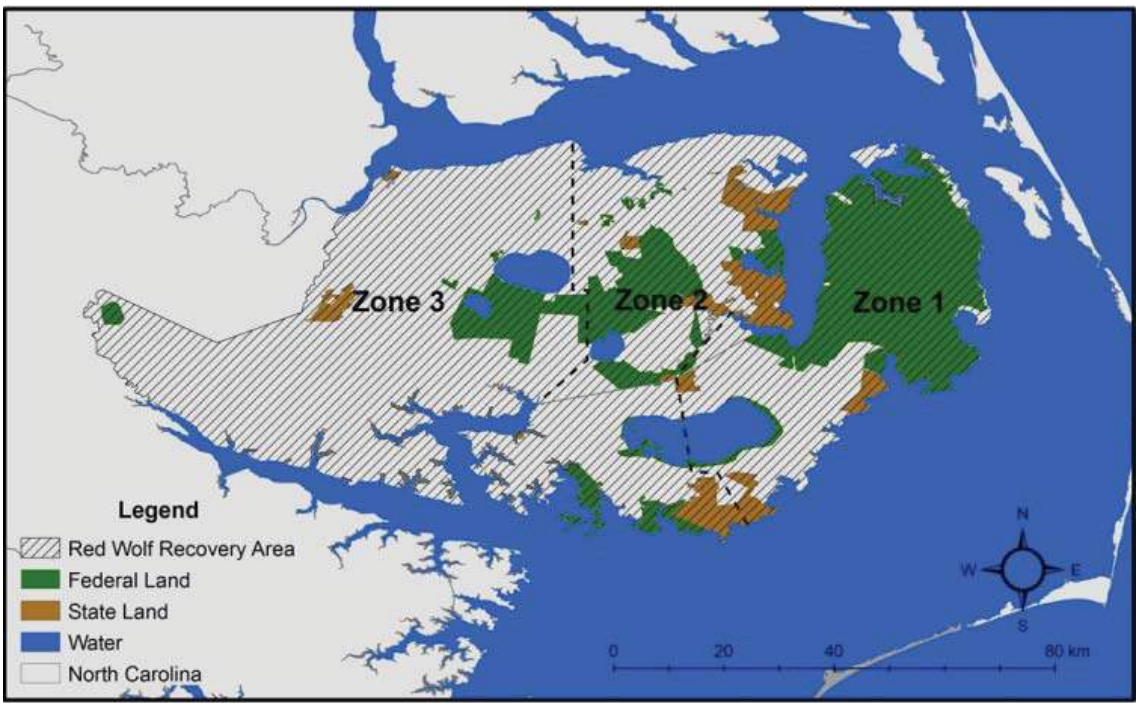


Figure B1. Current Red Wolf Recovery Program Area and Management Zones for the Red Wolf (Source: Hinton et al., 2013).

Current Habitat Use

Data gathered over the more than 25 years of red wolf restoration efforts in the Albemarle Peninsula provides the most information available on wolf habitat use. USFWS (2007) describes habitat requirements and utilization in its 5-year Status Review, noting red wolves have used wetlands, pocosins, pine forests, upland shrubs, and agricultural lands within the Red Wolf restoration area (Phillips et al. 2003, USFWS 2007). Additionally, this earlier research suggested that wolves prefer wooded areas for denning, whelping, and rearing pups and edge habitat and roadways for travel and hunting in areas of low population density (Hinton 2006, Kelly et al. 2004, USFWS 2007). More recent research, however, provides a more complete and slightly different understanding of habitat use throughout the year. Red wolves tend to prefer agricultural areas in the summer months as opposed to the nearby wooded areas, and they leave dens with pups early to utilize these agricultural areas, while wooded areas are preferred in fall and winter (Hinton 2006, Hinton and Chamberlain 2010, and Chadwick et al. 2010). During pup rearing, red wolves demonstrate a strong preference for agricultural lands, especially during the day. It is hypothesized that this is due to availability of prey and reducing exposure to insects and parasites that might be in more wooded areas (Hinton 2006, Hinton and Chamberlain 2010). Additionally, when pups disperse (more detail provided in the Population Dynamics Section below) they show an affinity to move westward (where agricultural lands are located) and not to settle on the edge of the peninsula in wetland area. Average

dispersal rates are approximately 37.1 +/- 33.3 days at distances of 36.6 +/- 27.0 km for males and 32.3 +/- 14.9 km for females (Karlin and Chadwick 2012).

Dellinger et al. (2011) studied the restored wolf population for three years over all seasons and also determined that the wolves tend to select human altered landscapes, specifically agricultural fields and cut over regenerating forests, over all natural habitat types if human density is low. This is likely due to the availability of white tail deer and overall concentration of prey species. Wolves also prefer secondary roads for travel and hunting but moved away from them as human density increased (Dellinger et al. 2011). This study demonstrates not only red wolf habitat preferences, but also that they can tolerate some human interaction. The authors conclude that if conservation of the red wolf is possible, it will not take place on protected natural landscapes alone but on a patchwork of natural, managed, and human altered areas (Dellinger et al. 2011). This is even more important given that USFWS notes 60 percent of red wolves are currently found on private lands and not public lands within the restoration area *(USFWS website http://www.fws.gov/redwolf/faq.html)*. Additionally, coyotes also tend to utilize agricultural lands, which could be an important consideration in terms of trying to determine when and where inter-specific breeding events most often occur as well as the potential for competition.

Habitat Availability within the Red Wolf Recovery Area and Beyond

As of 2006, red wolves were occupying approximately two-thirds of the Albemarle Peninsula restoration area, possibly leaving additional habitat area in the western area (Zone 3) available for expansion, although some areas are likely of poor quality and primarily in private ownership (USFWS 2007). An important consideration, however, is that research demonstrates that red wolves prefer agricultural lands to wooded areas for at least a portion of the year during pup rearing. Understanding this habitat need is important in relation to considering where and to what degree there is available habitat within the Red Wolf restoration area as much of the agricultural land is on private land within the western portion of project area, but the USFWS oversees the recovery efforts. In reviewing the National Wildlife Refuge (NWR) Comprehensive Conservation Plans (CCP), it appears that the only NWR with significant agriculture or cropland is Alligator River NWR. Additionally, Alligator River NWR does not have specific actions for managing the red wolf population on its property, although it does note protecting croplands will help red wolf among other species in its NWR. All four NWRs do note that they will work with the Red Wolf Recovery Team to provide access to the refuges and education and outreach assistance. Thus, in considering where available habitat may be within the restoration area, the Red Wolf Recovery Team will need to work with the refuges, state, and private property owners to consider what adequate and feasible management actions and needed public outreach efforts may be needed given the documented preference for agriculture land which are primarily on private lands. Additionally, what this may mean for human red wolf interactions should be considered.

Considering areas outside of the Albemarle Peninsula, Phillips et al. (2003) conclude that because red wolves can use a wide range of habitats and prey species, there is likely adequate habitat within the Southeastern U.S. to meet the population objectives set out in the Red Wolf Recovery Plan. This will depend, however, on addressing hybridization with coyotes and working with private landowners as much of the available land is in private ownership (Phillips et al. 2003). In 2000, van Manen et al. examined data from 320 releases using multiple models within the Red Wolf restoration area to determine success or failure to apply to 31 potential reintroduction sites identified by the USFWS. Like similar research, authors found that increased human density and number of roads negatively affected reintroductions. They also found that coyote density and time of year at release were important factors to success (van Manen et al. 2000). Of the 31 reintroduction sites analyzed the top five with highest potential or success include: Northwestern Alabama, Eastern West Virginia, Southwestern Mississippi, Northern Mississippi, and Southern Missouri. In looking at any area for reintroduction, it is likely that if the area is already fully colonized by coyotes, red wolves may have a harder time finding suitable area for territories in terms of quality and heterogeneity (Roth et al. 2008).

Examining red wolf life history, dynamics, and habitat characteristics and needs provides background to assist managers in being able to more comprehensively assess the current Recovery effort. These details also describe background to help consider and synthesize key issues related to the challenges of successful implementation of the Red Wolf Recovery Program. The following sections outline the key issues around taxonomy and population dynamics as well as the threats currently facing red wolves. These sections include information managers may need to overcome and address these challenges.

Taxonomy and Population Dynamics

Understanding the taxonomy and genetics is of particular interest for the red wolf given its endangered species status and the Recovery effort. Taxonomy also plays a role in considering population dynamics and the threat of hybridization of red wolves and coyotes and efforts to reduce that threat. This section synthesizes the most current research and thinking on red wolf taxonomy, hybridization with coyotes, and the sterilization/ adaptive management strategy to prevent hybridization.

Taxonomy

Significant debate on the phylogeny of North American canids has occurred in recent years, although there is some data that suggests historical existence of a large canid in the southeastern U.S. (Hinton et al. 2013). Much of this debate has been driven by interest in determining the existence of the eastern wolf (*Canis lycaon*) and its relatedness to other species; however, the ongoing discussion has direct implications as to whether the red wolf is a species as opposed to the product of recent hybridization between the gray wolf (*Canis lupus*) and coyote (*Canis latrans*). There are a number of competing interpretations surrounding the eastern wolf that are also relevant to the red wolf as identified by Thiel and Wydeven (2011). These interpretations include (Thiel and Wydeven 2011):

1. *Eastern wolves considered to be a full and distinct species from C. lupus and C. rufus (Wilson et al. 2000, 2009, Baker et al. 2003, Grewal et al. 2004, Fain et al. 2010, Chambers et al. 2012, Wheeldon and White 2009, Wheeldon et al. 2010a, Rutledge et al. 2010a,b);*
2. *Eastern wolf and red wolf considered to be a subspecies of gray wolf (Nowak 1979, 1983, 1995, 2002, 2003, 2009; Koblmüller et al. 2009, Leonard and Wayne 2008; vonHoldt et al. 2011);*
3. *Eastern wolf and red wolf found to be the same species (Wilson et al. 2000, Kyle et al. 2006, 2008); and*
4. *Eastern wolf presumed to be the product of hybridization between red wolf and gray wolf (Nowak 2002, 2003, 2009).*

In aggregate, two of these eastern wolf scenarios consider the red wolf to be a distinct species. Chambers et al. 2012 provides a comprehensive review of both morphological and genetic evidence for the relatedness between eastern and red wolf and concludes that the similarities between the two are the result of a common ancestor rather than admixture. It has been suggested that the red wolf is a relatively recent hybridization between gray wolf and coyote (vonHoldt et al 2011). This assertion was refuted by Rutledge et al (2012) who determined that conclusions by vonHoldt et al. (2011) related to a two-species origin hypothesis for eastern wolf

> *…are misconstrued due to flawed assumptions that bias the interpretation on various analytical levels, and because the authors fail to interpret their findings within the context of ecology, natural history, the fossil record, and other genetic markers.*

Chambers et al. (2012) also found the red wolf to be genetically different from the gray wolf and found it likely evolved from a common ancestor along with the coyote. Further, Chambers et al. (2012) while acknowledging there are limited samples for analysis, states that the available information supports retaining *Canis rufus* as a distinct species from the putative *Canis lycaon*. This work was reviewed by the National Center for Ecological Analysis and Synthesis and determined to be inconclusive with respect to the conclusion for a distinct eastern wolf species (NCEAS 2014). Although the NCEAS notes that issues included in Chambers et al. (2012) should be able to be answered relatively soon, no additional related peer-reviewed publications have been identified during this review.

Clearly the taxonomic debate surrounding the origins of eastern wolf species, including the red wolf will continue until molecular and morphometric information from both contemporary and historic specimens can be reconciled (Hinton et al. 2013).

Population Dynamics

Natality, Growth Rates, and Mortality/ Survival Rates

Despite the debate surrounding the taxonomy of the red wolf, for the purposes of the Red Wolf Recovery Program it is treated as its own species. There are several key population

dynamics related issues that have been researched for the reintroduced population. They include information on population size, population growth rates and natality, mortality, survival, and dispersal rates.

As of 2007, USFWS noted that the population can be between 100 and 130 (USFWS 2007). However, the USFWS estimates the current population for 2014 at 90-110 wild red wolves in the restoration area, but at the end of the second quarter of 2014, 69 wolves were actually known to occupy the area, including 9 wolf packs, 8 mixed packs (wolves and sterile coyotes), and 20 wolves not associated with a pack (Rabon et al. 2013). Since 1990 there has been a steady increase in the number of pups born in the wild (3 in 1990 and 51 in 2007), while the yearly number of litters has also increased (2 to 11) (USFWS 2007). The 2007 5-year Status Review included research that calculated an intrinsic rate of increase as 0.346 (0.037, 0.655; 95% CI), which is comparable to other wolf species (USFWS 2007). However, using this rate of increase, carrying capacity would be approximately 139 wolves, which could mean that the species reached capacity in 2001, but this is a qualitative exercise and as of 2001, only 60 percent of the entire restoration area was being used by red wolves (USFWS 2007).

Annual survival rates also are included in the 2007 5-year Status Review Summary and Evaluation for the reintroduced population. The annual overall survival rate is documented as 78.2 percent, with adults at 80.6 percent, pups at 67.8 percent, and yearlings at 79.3 percent. Survival rates for males is 76.8 percent, females 79.6 percent, wild born 83.6 percent, island-reared 67.3 percent, and captive- reared 56.8 percent (USFWS 2007). This demonstrates high survivability that likely means the wolf population is stationary or increasing (USFWS 2007). Sparkman et al. (2011b) analyzed reintroduced wolf data from 1990 to 2005 and found mortality attributed to the following: 61 percent due to anthropogenic causes, 20 percent to natural causes, and 19 percent to unknown causes. The authors also found that mortality due to human induced causes was additive to natural causes and affected the preservation of wolf breeding pairs. These additive effects also resulted in lower growth rates, thus, affecting red wolf population growth (Sparkman et al. 2011b).

Population Dispersal

Research on the restored red wolf population has revealed more information about dispersal patterns, which are important to ensure genetic diversity and maintaining the health of the population (Phillips et al. 2003). Dispersal appears to correlate to onset of sexual maturity, around two years of age (Phillips et al. 2003). Sparkman et al. (2012) found that the propensity towards late dispersal is actually due to genetic variation as they also examined red wolf-coyote hybrids and found hybrids had inter-specific variation with earlier dispersal. Dispersal also can occur after some type of disturbance to pack structure. Dispersal direction typically correlates to new areas that have sufficient prey and no other wolf packs.

Dispersal rates were studied on wolves from 1987 to 1994 (Phillips et al. 2003) and 1999 to 2007 (Karlin and Chadwick, 2012). Phillips et al. (2003) estimated an average dispersal

rate of 9 days (range 1-44 days) with an average distance of 36 +/- 22 km for males and 45 +/- 58 km for females. Karlin and Chadwick (2012) estimates are based on more recent red wolf data (2000-2007), and they find an average dispersal rate of 37.1 +/- 33.3 days, which is statistically different from Phillips et al. (2003). Distance traveled, however, was similar, although slightly less for females (36.6 +/- 27.0 km for males and 32.3 +/- 14.9 km for females) (Karlin and Chadwick 2012). The shorter dispersal duration or rate for wolves introduced earlier is likely due to the fact that when wolves were first introduced there was more area available, while later wolves had less area and likely had to travel further to settle and establish territories (Karlin and Chadwick 2012). These data possibly represent saturation in the management area, which could lead to more competition for resources and aggression between animals (Karlin and Chadwick 2012). Previous studies found direction of dispersal depended on a variety of factors, including prey availability, wolf density, human density, and topography; however, Karlin and Chadwick (2012) found dispersal direction to be solely based on habitat type.

Threats to Red Wolves

Hybridization

Hybridization with coyotes is the one of the largest threats facing red wolves. Coyotes are likely found within 100 percent of the red wolf historic range, are pervasive within the Red Wolf restoration area, and are too difficult to eradicate from the area (USFWS 1989, Moore and Parker 1992, Mastro et al. 2012, Hinton et al. 2013). Red wolves tend to be more likely to breed with a coyote when a wolf pack has been broken apart or a mate is lost (Hinton et al. 2013]. The USFWS is attempting to address this issue by implementing an Adaptive Management Program, whereby sterilized coyotes are introduced into the red wolf population to pair with a red wolf that lost a mate to help hold a place for another red wolf to come into the pack, while not being able to reproduce (Hinton et al. 2013).

Interspecific Breeding

Hybridization among North American canids is well documented. Generally speaking, interspecific breeding occurs when intra-specific breeding opportunities are few due to low population. Direct persecution and habitat changes in the eastern United States led to drastic declines in red wolf populations across its historic range, which increased the rate of hybridization with western coyotes. This factor was a major contributor in the decision to remove the red wolf from the wild in order to preserve the species (USFWS 1984).

The issue of hybridization has been particularly important to the Red Wolf Recovery Program. The original breeding stock of red wolves was heavily scrutinized in an attempt to reduce the genetic impacts from long-term hybridization between *C. rufus gregoryii* and western coyotes. These impacts were described as "irreversible dilution" by Carley (1975) as documented in the Recovery Plan (USFWS 1984). Initial recovery work involved careful selection of captured individuals for characteristics representing the purest red wolf genome (USFWS 1984). Only these founder animals were permitted to breed as part of the recovery breeding program and Species Survival Plan. Subsequent breeding has maximized

and maintained the heterozygosity of the population. The present population contains nearly 90% of the red wolf genome (USFWS 2007).

The threat of genetic introgression of coyotes into the wild population of red wolves increased with the eastward expansion of this species into the restoration area during the 1990's. By 1999, the threat of coyote hybridization was identified as the primary threat to the recovery of the red wolf (Kelly et al. 1999). In response to this threat, the USFWS developed a strategy to research and monitor coyote-red wolf hybridization in the restoration area resulting in the Adaptive Management Strategy (Fazio et al. 2005).

Adaptive Management Plan

The Red Wolf Adaptive Management Plan (RWAMP) requires a management strategy aimed at the control and management of the hybridization occurring between red wolves and coyotes (Fazio et al. 2005). Attempts to limit coyote populations commonly involve removing as many coyotes as possible, but this approach often proves to be ineffective in the long term. In areas of high-intensity control efforts, coyote litter size can increase as population density decreases and reductions in local populations are often offset by immigration from adjacent areas (Knowlton 1973). Current red wolf management strategy involves surgical sterilization within proximate coyote populations, using methods that leave individuals hormonally intact (vasectomy/tubal ligation) but unable to reproduce. Without the need to provide for litters of pups, Bromley and Gese (2001a) found that this technique not only reduced the occurrence of livestock predation, but also that coyotes sterilized in this manner continued to form pair bonds and defend territories, thus creating a buffer of "placeholder" animals to help prevent immigration of fertile coyotes from other areas (Bromley and Gese 2001b). Available data suggests that these various mechanisms as described in the 2005 RWAMP are working to reduce interbreeding and coyote gene introgression (USFWS 2007). This approach has enabled managers to reduce the proximity of reproductively capable coyotes around the recovering red wolf population. Stoskopf et al. (2005) noted that as of 2005, coyote gene introgression had been minimized and coyotes and hybrids had been eliminated from half of the restoration area. Biologists are also actively working to encourage red wolf pair-bonding through captive acclimation and by killing coyotes that pair with red wolves (USFWS 2007).

The FY2013 to FY2015 Adaptive Management Plan notes that if 75 percent of coyotes or hybrids are sterilized, then there will likely be a 90 percent retention rates and that removing hybrids would not be as effective. Additionally, their modeling shows sterilized hybrids are successful placeholders (Rabon et al. 2013). Mahoney (2011) examined the population model used originally by Kelly et al. (1999) and developed an updated population model to consider effects of sterilization. He found sterilization more effective than euthanizing coyotes when it could only be done in specific timeframe and probably of capturing coyotes is low, while euthanasia was found to be more effective when the probability of capturing coyotes is high (Mahoney 2011). Beyond this, however, little to no additional research including USFWS quarterly reports provide additional detail on success of the program to date. The 2013 RWAMP does not include specific details on the effectiveness of the program to date, the amount of funding spent, or the duration of the

program. It does note that sterilization efforts will be a priority first in Zone 1, then Zone 2, and finally Zone 3 (Rabon et al. 2013).

Modeling has shown that over time the sterilization approach has the potential to reduce coyote gene introgression and thus, reduce the likelihood of loss of red wolves due to hybridization (Fredrickson and Hedrick 2006, USFWS 2007). Fredrickson and Hedrick (2006) emphasize that the probability of the persistence of red wolf genes in their model is primarily driven by (1) the likelihood that red wolves would challenge and replace non-wolf pairs (wolf/coyote hybrid pairs), and that (2) preferential mating would result in a preference for red wolf/red wolf pair bonds over red wolf/non-wolf pair-bonds. Support for this has been documented by red wolf biologists who have noted 32 events of red wolves displacing or killing non-wolves between 1993 and 2007, while biologists and the Red Wolf Recovery Implementation Team had found no evidence of coyotes or hybrids displacing or killing red wolves (USFWS 2007). Dellinger (2011) indicates that red wolves already paired with a coyote will leave their mate if the opportunity arises to pair with a red wolf. The adherence of observed behaviors in the wild to the modeled parameters suggests that over time, and with sufficient population size to support preferential mate selection (e.g., a population with a sufficient proportion of "pure" red wolves), that the place-holder strategy foundation is likely sound; however, more up to date research is needed to determine the effectiveness of this strategy.

Interaction with Coyotes – Food and Habitat

The interaction between coyotes and red wolves is not only important to understanding the hybridization threat, but also how coyotes affect red wolf survival in terms of competition for prey and habitat/ territory. Little research has been conducted on this specific aspect, although coyotes likely occupy the red wolves historic range, given they are found across the U.S. (USFWS 1989, Moore and Parker 1992, Mastro et al. 2012). Pack structure is similar between red wolves and coyotes with a breeding pair, pups, and offspring from a previous year (Roth et al. 2008). Home ranges between coyotes and red wolves may have some overlap at the edges, but there is typically no overlap in the central core areas. As noted previously, home range size for red wolves in North Carolina vary (44 km^2 to 176km^2 (Table B1)). Coyote home range sizes are typically smaller (2 to 20 km^2) (Roth et al. 2008). Coyotes tend to have a higher reproductive rate (80 percent) than the red wolves in North Carolina (58 percent), and they also produce on average more pups (6 versus 3.9). However, both species only reproduce once a year (Roth et al. 2008). Roth et al. (2008) modeled potential impacts of coyotes on red wolves in terms of competition for prey species and for space on the landscape. The model projects that the presence of coyotes decreases red wolf viability, but in the model, red wolves were most sensitive to coyotes' impact on prey availability, which in theory would affect their ability to reproduce and have viable offspring (Roth et al. 2008). They also have very similar prey preferences as McVey et al. (2013) found that coyote and red wolves have very similar food preferences throughout the year, including white-tail deer, rabbits, and rodents, and both consume more rodents in the summer. More research could help provide information on whether and to what degree resource competition exists between the two species. However, if they

are utilizing similar habitats and prey species, this may mean there are increased opportunities for hybridization.

Red Wolf Diseases

Although there are few studies specifically on diseases and the remnant wolf population, it is documented that hookworm and distemper often resulted in mortality (Paradiso and Nowak 1972, Shaw 1975). More recently as noted in the USFWS 5-year Status Review Summary and Evaluation, canid viruses are of extreme concern (USFWS 2007). One specific virus, CPV2 parvovirus, can greatly affect ability of pups to survive if contracted and was a primary reason for failure and termination of the reintroduction of a red wolf population in the Great Smoky Mountains; thus, parvovirus is clearly a potential threat to the reintroduced population (Acton et al. 2000, Acton 2007, USFWS 2007).

The diseases of most concern include canine distemper (*Morbillivirus*; CDV), canine parvovirus (*Parvovirus*; CPV1, CPV2), leptospirosis (*Leptospira*), hemobartonellosis (*Haemobartonella canis*), borrelliosis (Lyme disease, *Borrelia* sp.), demodectic mange (*Demodex canis* mites), sarcoptic mange (*Sarcoptes scabiei* mites), heartworm (*Dirofilaria immitis*), and rabies (*Lyssavirus*, rabies virus) (USFWS 2007). These diseases are of concern both to the captive and reintroduced wolves, and there is an extensive vaccination program for both groups of wolves. However, the vaccination program does not necessarily mean wolves are not at threat from these viruses (Bartel and Rabon 2013). None of these diseases are at high enough levels within the reintroduced population to cause an epidemic, but there are concerns that outside canids could bring in viruses to the Albemarle Peninsula (USFWS 2007). However, mange and heartworm have been documented as sources of mortality in the reintroduced population (Bartel and Rabon 2013). Other health related concerns include tick borne diseases that can cause significant problems, such as Lyme disease, abdominal diseases, dematosis, and neoplasia as well as trauma from other red wolves (Acton et al. 2000, USFWS 2007). Neonatal deaths have also been attributed to parental trauma, parasitic pneumonia, and septicemia (Acton et al. 2000). Although research does not show widespread mortality among the reintroduced population, disease is a threat that needs to be considered.

Human Based Threats (Interactions and Public Perceptions)

Red wolves are threatened by interactions with humans. The two significant sources of human-caused mortality are by gunshot and collisions with vehicles. As with the hybridization issue, this is a large challenge for the Red Wolf Recovery Program. Relatedly, but a somewhat different aspect of human dimensions are people's perceptions of the Red Wolf Recovery Program and the existence of red wolves themselves. This factor relates more to community and landowner outreach about the program, but it is an important component to the Recovery Program, especially as red wolves are demonstrating a preference for agricultural lands that are concentrated on private lands. This section will synthesize information on human interactions with wolves as well as provide information on red wolf public outreach efforts.

Human Interactions

Successful management of natural resources must incorporate the public. The actions and attitudes of the people engaged with any effort, directly or indirectly, should be considered to mitigate, and wherever possible avoid, conflicts that diminish effectiveness. In terms of the red wolf, anthropogenic stressors have had a direct impact on the success of the red wolf recovery effort. Humans are the leading cause of mortality by shooting wolves, or by collisions with automobiles (USFWS 2007). Breeding pairs are lost more frequently to shooting and disappearance, while non-breeding wolves were lost more to vehicle collisions, likely due to the fact that they do not maintain a specific territory and travel more (USFWS 2007).

Of the deaths that occurred from 1990 to 2005, 61 percent are human-induced, and as mentioned previously, due to the additive nature of this type of mortality and its effects on breeding pairs, population growth is likely affected (Sparkman et al. 2011a). A more recent analysis of mortality from 1987 to 2012 for 364 wolves demonstrates the following causes (Bartel and Rabon 2013):

- Suspected illegal activities, involving gunshot, poisoning, and other suspected illegal take (30%)
- Vehicle collisions (20%)
- Health-related causes (16%)
- Intraspecific competition (6.5%)
- Management actions (5.0%)
- Private trapping (3.5%)
- Unknown causes (19%)

Additionally, of the observed mortalities during this time frame, 57 percent were due to human caused events. From 2004 to 2013, mortality from gunshots has increased approximately 375 percent from gunshot mortalities from 1988-2003 (Bartel and Rabon 2013). To help address these significant and seemingly increasing human-induced impacts to red wolves, it is necessary to understand why they occur. While vehicle collisions are likely episodic and accidental, shooting is a direct result of public perceptions and negative attitudes related to red wolf reintroduction.

Public Perception

Historically, the general public attitude towards wolves has been strongly negative (Mech 2012). The sanctioned persecution through bounties and other targeted extermination programs is well-documented and lead to drastic population declines by the early 20th century. Since the passage of the Endangered Species Act in 1967, the general perception of wolves has seemed to improve driven largely by the popular media; however, negative media coverage has been shown to affect public opinion as well (Mech 2012, Williams et al. 2002, Enck and Brown 2002).

The importance of considering and managing public concerns along with at-risk species has been demonstrated. Black-footed ferret (*Mustela nigripes*) recovery efforts were

hampered by prairie dog control practices such as poisoning and shooting. The USFWS engaged landowners through a "Safe-Harbor" program to facilitate cooperation while addressing landowner concerns (USFWS 2013). Thus, establishing partnerships across a range of groups from local to state to federal and with private landowners, universities, and other interest groups is critical to a successful reintroduction program (Bartel and Rabon 2013). The use of the "non-essential-experimental designation per the 10(j) rule of the ESA also facilitates the establishment of partnerships, particularly with private landowners, when attempting to restore endangered species, but with the added benefit of not requiring landowners to provide additional conservation benefits. This designation is probably favorable for the recovery of controversial species such as the red wolf.

The public perception of wolves and wolf recovery is important to understand as well (Bruskotter et al. 2007). Some studies have shown that the attitudes of residents found in close proximity to active wolf recovery programs also have a negative opinion of them (Williams et al. 2002, Karlsson and Sjöström 2007). There is some indication that although community members may have neutral attitudes at the onset of such program, their attitudes can shift negatively with negative experience (Heberlein and Ericsson 2008, Karlsson and Sjöström 2007, and Williams et al. 2002), but also occurs when no direct negative experience has occurred (Karlsson and Sjöström 2007, Treves et al. 2013). These attitudes may be affected by indirect experiences from peers (Karlsson and Sjöström 2007) or from negative expressions of wolves in the popular media (Houston et al. 2010, Enck and Brown 2002, Karlsson and Sjöström 2007). Further, Houston et al. (2010) found that the number negative media coverage of wolves and wolf reintroductions increased in areas considering introductions and that this may negatively affect public opinion.

Studies have indicated that public opinion of wolves and the Red Wolf Recovery Program is generally positive; however, subgroups can have different levels of support (Bruskotter et al. 2007, Williams et al. 2002). Agricultural producers have a lower rate of positive opinion relative to more urban groups or the public at-large (Kansky et al. 2014, Williams et al. 2002, Karlsson and Sjöström 2007, Bruskotter et al. 2007). Similarly, hunters have been shown to have a lower positive response as well (Williams et al. 2002, Karlsson and Sjöström 2007, Bruskotter et al. 2007). For both groups, concerns related to wolf predation on either livestock or game populations appear to be the primary issue driving this lower opinion.

Kramer and Jenkins (2009) surveyed agricultural producers in the Red Wolf restoration area and documented considerable negative opinions related to red wolves. Further, this study found that while wildlife habitat was important to producers in these counties, their attitudes were negative if payment for ecosystem services programs targeted red wolves. This is not unique to the red wolf landscape. Treves et al. (2013) found that the favorable attitudes towards wolves decreased for people living within the range of increasing wolf abundance in Wisconsin. This was accompanied by an increase in agreement with statements related to fear of wolves, increased competition (with hunters) for deer, and inclination to poach a wolf (Treves et al. 2013). This suggests there is potential for decreasing support for wolf conservation within the red wolf restoration area and continued negative population impacts from poaching. Other studies have suggested that

human intolerance for wolves can result in lower simulated mean population size (Stronen et al. 2007).

Divisions of perception among stakeholder groups should be recognized as part of recovery operations as they could lead to erosion of support for such activities (Bruksotter et al. 2007). Understanding the underlying perspectives of stakeholders is important before attempting to modify attitudes (Mazur and Asah 2013, Lute and Gore 2014).

Climate Change and the Red Wolf

Climate change is a variable that was not considered in the 1980's and 1990's to be a threat to the reintroduction of red wolves in North Carolina. However, research demonstrates that climate change, specifically sea-level rise and more intense storm events will likely have significant impact to coastal North Carolina. The information below summarizes current research on climate change and its impacts for the state and the Albemarle-Pamlico Peninsula. Much of the emphasis is on sea-level rise as most of the research has focused on that aspect. Having an understanding of climate change impacts at the state and local scale will help provide a more complete picture of how climate impacts could affect red wolves and the success of the Recovery Program.

Temperature and Precipitation Impacts

In 2010, Defenders of Wildlife conducted an assessment of projected temperature and precipitation changes for North Carolina using The Nature Conservancy's Climate Wizard Tool (www.climatewizard.org). Climate Wizard allows users to view historical climate patterns globally as well as projections for future temperature and precipitation changes. The tool uses climate models developed for the Intergovernmental Panel on Climate Change's 2007 assessment that were repackaged by Maurer et al. (2007) to focus on the U.S. and Mexico and provide the ability to select various climate models and time frames to project changes in climate. The climate projections for North Carolina generated using Climate Wizard project that average annual temperatures in North Carolina could rise by approximately 3.5°F to 4.7°F by the mid-21st century and by 5°F to 6°F at the end of the century (DeWan et al. 2010). Averages are important for understanding trends, but extremes are often more useful in interpreting how climate change may affect species survival, such as duration of extreme cold or warm temperatures in a year. Climate Wizard projections also show that the largest projected increase in temperature will likely be in the summer months (average increase of 7.8°F by 2100) (DeWan et al. 2010).

Precipitation models are more difficult to interpret than models projecting temperatures, which may vary in degree of increase, but agree temperatures will increase. Precipitation models often vary in direction; some models may project wetter conditions while others project drier conditions. Climate Wizard projections predict both increases and decreases in precipitation for North Carolina by the end of the century (DeWan et al. 2010). If precipitation does increase in the state, it will likely be in more intense storm events, not necessarily equally distributed throughout the year. Even if precipitation does increase it likely will not counterbalance evapotranspiration and water loss. Coupled with an increase

in temperature, the frequency and severity of droughts will likely increase (Karl et al. 2009).

Albemarle Peninsula and Red Wolf Vulnerability to Temperature and Precipitation Changes

Temperature increases and changes to precipitation regimes that may also lead to increased droughts may affect the Albemarle-Peninsula in various ways, but they will likely have a greater impact on specific species and water quality than necessarily on habitat factors that may affect red wolves. For example, in freshwater systems, increased drought and warmer temperatures coupled with changes in precipitation could lead to changes to water quality and chemistry affecting species that live there. Warmer temperatures may also contribute to warmer waters leading to increases in harmful algal blooms and disease presence within the system (Glick et al. 2007). Additionally, warmer temperatures may favor certain pest and disease species that may affect both red wolves and their prey (such as white tailed deer) or food of their prey (citation).

Sea-Level Rise Impacts

Sea-level rise has been identified as another climate change-related issue along coastal North Carolina, which is the third lowest lying state in the U.S. and where much of the land is just above sea-level (below 1 meter) and is experiencing significant levels of erosion (Poulter et al. 2009, Feldman et al. 2009). Climate change is contributing to sea level rise increases through thermal expansion of ocean waters and glaciers and ice fields melting. Over the 20th century the average global (eustatic) sea level rose about 0.17 meters (6.7 inches), at an average rate of 0.017 meters (0.07 inches) per year. This was 10 times faster than the average rate of sea-level rise during the last 3,000 years (IPCC 2007). Sea-level rise is projected to increase from between 0.19 and 0.59 meters (7 and 23 inches) by the end of the century (2090 to 2099) (IPCC 2007, CCSP 2009). However, these projections do not account for the recent changes in the ice flows in Greenland and Antarctica, meaning that these values likely underestimate the future global rates of sea-level rise (NECIA 2006, CCSP, 2009).

North Carolina has experienced rates of relative sea-level rise (includes the global rate as well as localized factors such as land subsidence) based on geological data and tide gauge data. Several studies that indicate on average 1 millimeter of relative sea-level rise likely occurred per year for the last 2000 years (increased during certain warming times) and up until the 20th century. More recently, rates have ranged between 3.0 to 3.3 millimeters (Kemp et al. 2009, Kemp 2009, Zervas et al. 2004). The North Carolina Coastal Resources Commission (NCCRC) Science Panel on Coastal Hazards used these estimates to determine that North Carolina will likely see an increase of 0.4 meters to 1.4 meters of sea-level rise by the end of the century, and the Panel recommends adopting a one meter rise scenario by 2100 for policy and decision-making purposes in the state (NCCRC 2010). The Panel also notes that two meters of rise is possible, but unlikely unless there are accelerated rates of ice sheet melting and warming (NCCRC 2010).

Various tools exist to visualize what sea-level rise may look like for the Albemarle-Pamlico Sound. Screen shots from NOAA's Digital Coast's Sea-Level Rise and Coastal Flooding Impacts Viewer (http://www.csc.noaa.gov/digitalcoast/) allow a user to see what a range of sea level rise may look like for the Peninsula (Figures 2 -5). The tool allows a user to look at 1, 2, 3, 4, or 5 feet of sea-level rise. The tools uses a simple "bathtub" sea-level rise model that shows areas vulnerable to inundation from sea-level rise based solely on elevation projection. It does not take into account factors such as erosion, marsh migration potential, or hydrology that could influence how sea-level rise may occur on the landscape. The three images shown below are for current, 1 foot of sea-level rise, 3 feet (approximately a 1 meter), and 5 feet of sea level rise (approximately 1.5 meters).

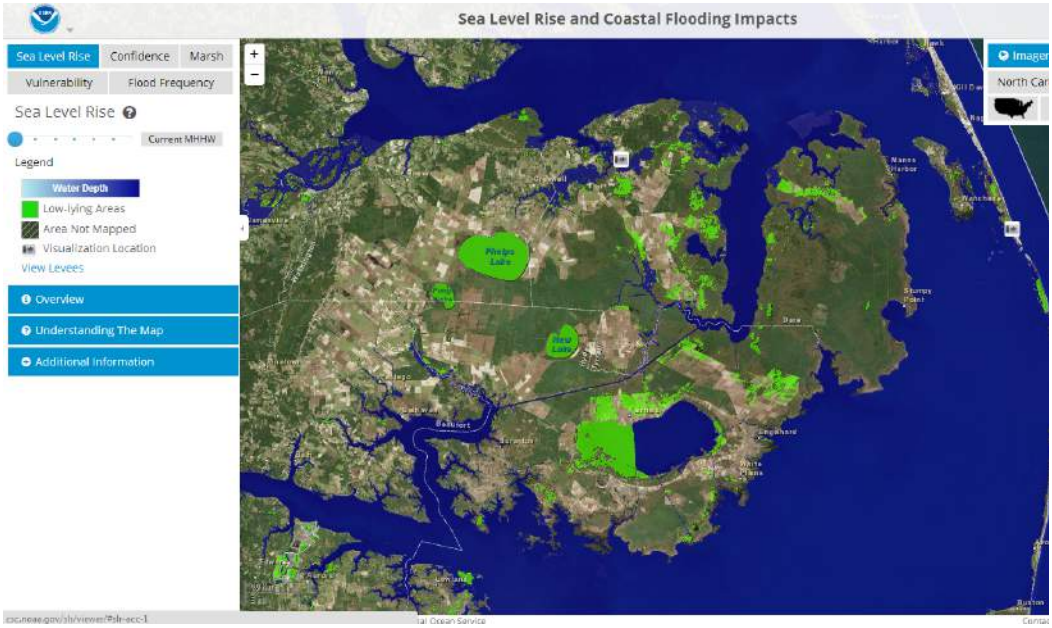


Figure B2. Albemarle Peninsula Current (Source: NOAA Digital Coast Sea-Level Rise and Coastal Flooding Impacts Viewer).

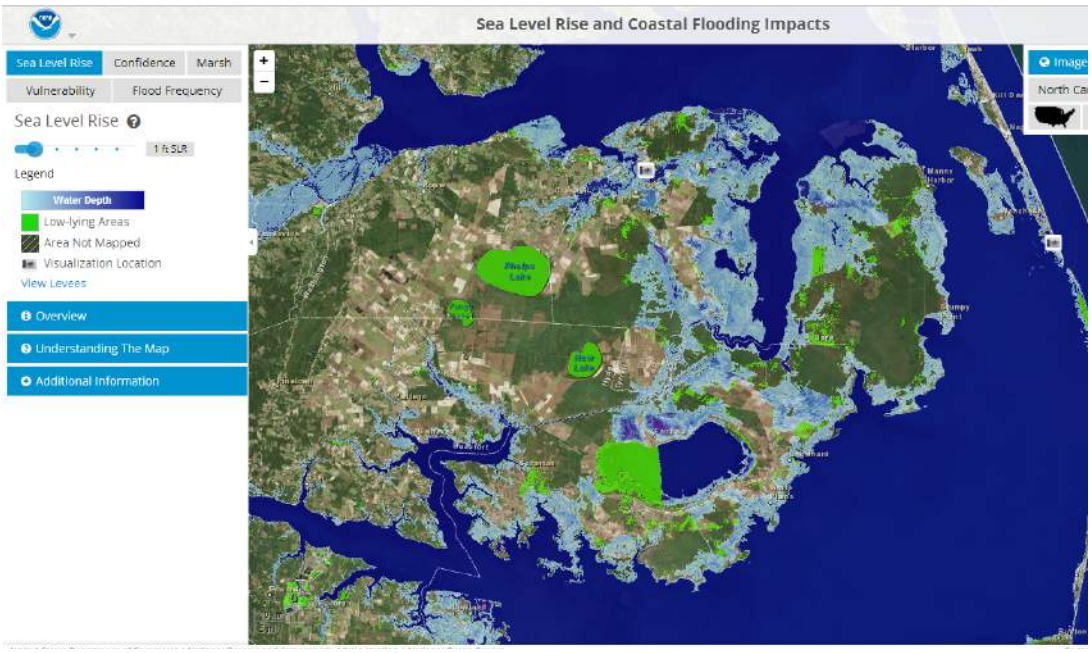


Figure B3. Albemarle Peninsula one foot of sea-level rise (Source: NOAA Digital Coast Sea-Level Rise and Coastal Flooding Impacts Viewer).

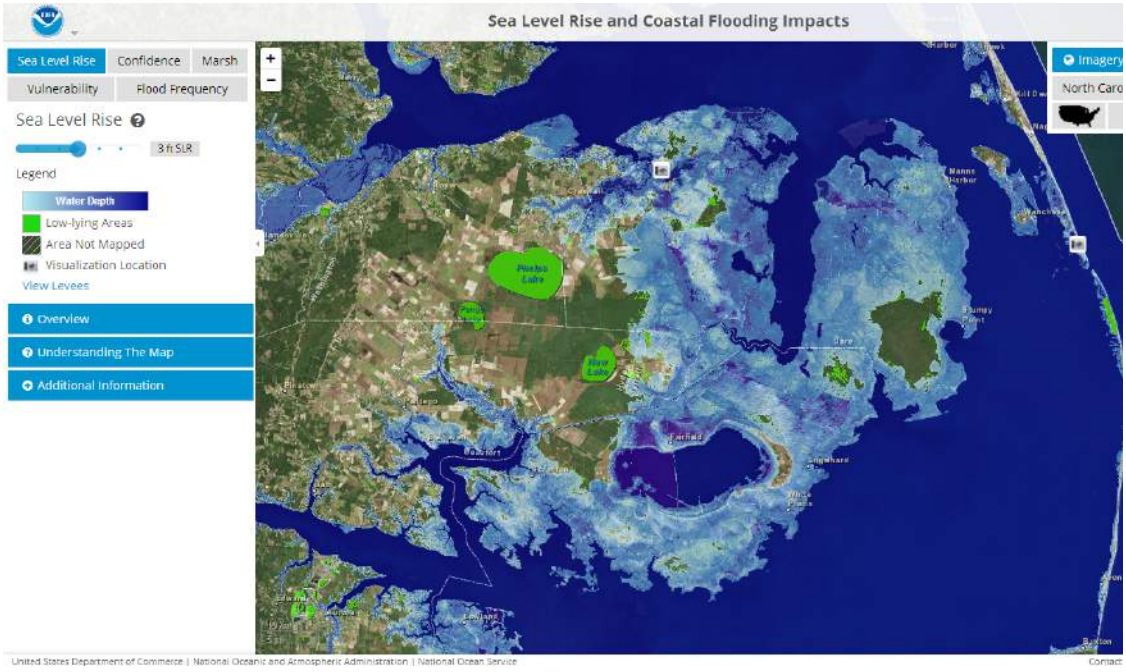


Figure B4. Albemarle Peninsula three feet of sea-level rise (Source: NOAA Digital Coast Sea-Level Rise and Coastal Flooding Impacts Viewer).

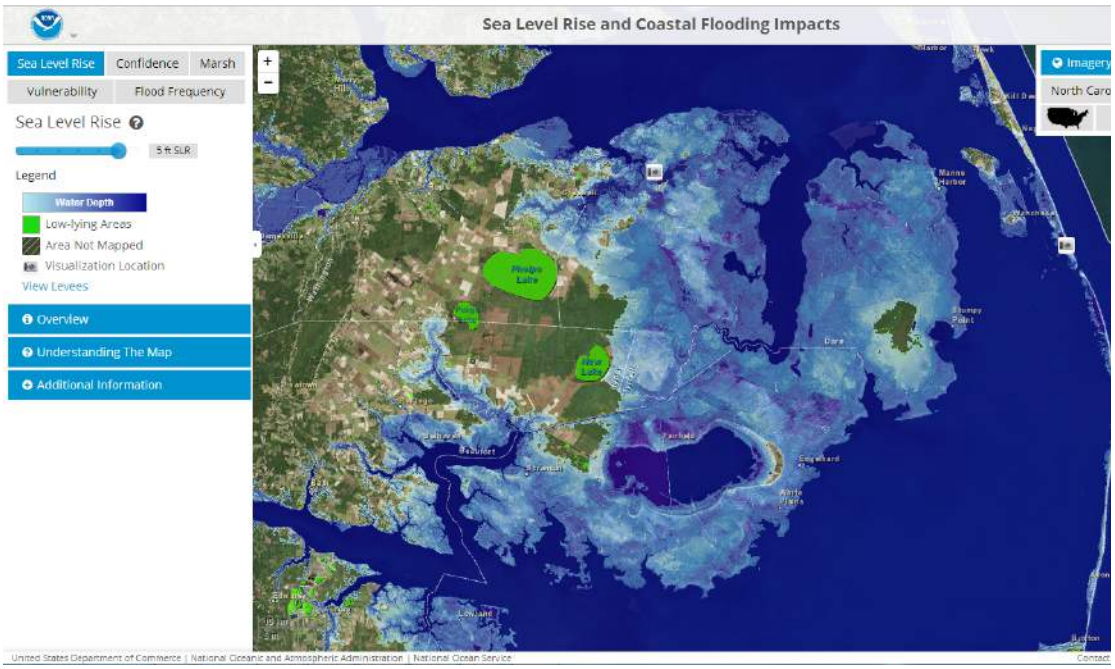


Figure B5. Albemarle Peninsula five feet of sea-level rise (Source: NOAA Digital Coast Sea-Level Rise and Coastal Flooding Impacts Viewer).

Albemarle Peninsula and Red Wolf Vulnerability to Sea-Level Rise

The Albemarle-Pamlico estuarine system covers approximately 6,000 km^2; and it is bordered by 275 kilometers of barrier islands (CCSP 2009, Poulter et al. 2009). To understand the impacts that sea-level rise may have on the area and the red wolves, it is important to understand features of the estuarine system. The Albemarle-Pamlico Sound system has relatively low salinity levels as it is protected from salt-water exchange by the barrier islands. Its tides are also predominantly wind-driven as opposed to lunar, which also restricts tidal exchange (Poulter and Halpin 2007, Poulter et al. 2009, CCSP 2009). Two thirds of the Peninsula is less than 1.5 meters above sea level, while the other third is less than one meter above sea-level rise and experiences significant erosion rates. Based on data from the last 30 years, the estuarine shoreline in this system has an observed average retreat rate of slightly over one meter (over 3 feet). Given the already sediment poor and erosion prone system, the area is potentially extremely vulnerable to sea-level rise (Poulter 2005, Poulter and Halpin 2007, Feldman et al. 2009). Poulter and Halpin (2007) used models to project impacts from sea-level rise on the Albemarle-Pamlico Peninsula and found that due to the drainage systems of canals and ditches the low near shore environment, flooding would actually be worse at lower levels of sea-level rise (less than 0.4 meters) due to the topographical complexity. This rate of sea-level rise will likely be reached by 2100 if not before.

Sea-level rise will likely result in a variety of impacts in the Albemarle Peninsula, including inundation and potential loss of wetlands and other coastal areas, significant changes in salinity levels, and changes to system dynamics (Glick et al. 2007). Another consideration in terms of impacts from sea-level rise is whether or not wetlands will be able to accrete (build up sediment vertically) and keep pace with sea-level rise and persist over the long term. The Peninsula has been significantly altered with drainage ditches that appear to prevent vertical accretion (Pearsall and Poulter 2005). Additionally, as salinities increase the peat-based wetlands will likely not be able to keep pace as the peat, roots, and vegetation will die off with brackish and saltwater intrusion (Poulter 2005, Feldman et al. 2009). Within the Albemarle-Pamlico Peninsula, aerial photography has shown that wetlands have been able to offset some loss by accreting further inland, replacing forest systems; however, this accretion process is limited by the sediment poor environment (Poulter et al. 2009). Coastal tree line migration has averaged 1 to 12 meters per year, but is inhibited by erosion rates and inland land uses (Poulter et al. 2009). As sea-level rise rates increase, however, it is uncertain if these vegetative communities will keep pace (Feldman et al. 2009).

Additionally, to examine change and/ or loss of habitat types, a Sea-Level Rise Affecting Marshes Model (SLAMM) was applied to the Alligator River National Wildlife Refuge in 2013 (Clough 2013). This model takes into account accretion rates, erosion rates, inundation, overwash, and saturation (Clough 2013). The model uses 4 sea-level rise scenarios that correspond to four rates of sea-level rise by 2100: 0.39 meter, 0.69 meters, 1 meter, and 1.5 meters. The model analyzes how much area of specific habitat types will be lost at these various sea-level rise projections (Clough 2013). Understanding the changes to habitat may be important, because some areas are likely red wolf habitat such as wooded wetlands and likely dry lands (appear to be the agricultural lands), although they only makes up 6 percent of the refuge. However, as noted in the Habitat Section, red wolves tend to avoid coastal wetlands (saltmarsh, tidal wetland, etc.); thus, loss of wetlands may not be significant but conversion of dry land to coastal wetland/ tidal marsh may push wolves further west.

The analysis projects that even at the at the lowest level of sea-level rise, much of the swamp area and dry land are projected to be lost (62 percent and 90 percent respectively) and converted to salt marsh, tidal mudflats, and open water. At 1.5 meters of sea-level rise, 100 percent of swamp lands would be lost, 99 percent of dry land, and 100 percent of brackish marsh (Clough 2013). Much of the Refuge is projected to transition to open water, mud flat, and saltmarsh – habitat less suitable to the red wolf.

Salinity changes and changes to water chemistry may also affect red wolf habitat. As sea-level potentially opens inlets and results in overwash of barrier islands, tidal range and exchange will increase, destroying freshwater wetlands by the increase in salinity and potentially changing the area to a more open water system (Feldman et al. 2009). The chemistry and make up of peat wetlands that comprise much of this area will also be affected, breaking it down and possibly resulting in subsidence (further exacerbating impacts from sea-level rise) (Feldman et al. 2009). Changes in system dynamics may also occur as barrier islands are overcome or segment. The tidal regime will likely go from

wind driven to lunar tidal influence, increasing salinity levels. Loss of barrier island protection may also lead to increased erosion rates that will only accelerate the rate of loss of the wetland system and conversion to open bay with higher salinity waters, lunar tides, and larger waves and wave action (Riggs and Ames 2003, Feldman et al. 2009). Changes to vegetation communities within the Alligator River NWR have already have been noted. Atlantic cedar is dying back, likely due to salt and brackish water coming in through the man-made ditches and canals (Feldman et al. 2009).

In terms of impacts more directly to red wolves, recent research shows that red wolves do not necessarily use the coastal wetland area along the Peninsula of the restoration area; however, dry areas within the SLAMM model appear to correspond to agricultural lands as noted in the NC GAP, which wolves do prefer at various points during the year (Hinton and Chamberlain 2010, Dellinger et al. 2012). Previous research documented pocosins were not being used by red wolves (Dellinger et al. 2012), which make up a significant portion of Zone 1 and Alligator River National Wildlife Refuge. Regardless, much of the swamp and pocosin area as well as the dry land are projected to be lost or converted to open water, mud flats, or salt marsh, habitat less desirable for wolves. Additionally, in just considering sea-level rise, much of the Albemarle Peninsula and the Red Wolf restoration area may be under water with 1 to 1.5 meters of sea-level rise (Figures B2 to B5).

Research shows that wolves appear to disperse west primarily, away from the coast, and onto agricultural fields and private lands (Hinton and Chamberlain, 2010). With the conversion and loss of much of the coastal areas, red wolves could be pressured to move in greater density and further distances to the west. Implications of this for their survival will be important given the negative impacts that have occurred with human interactions. Additionally, Feldman et al. (2009) note a 1995 report that states that even farmers on the Peninsula have already acknowledged that salt water intrusion and sea-level rise is affecting their agricultural fields (Feldman et al. 2009). Loss of agricultural lands or potential changes to the vegetation cover could be detrimental to the red wolf population given their importance to pup rearing and wolf preference for these areas (Hinton 2006; Hinton et al. 2013).

Storm Events (Hurricanes)

Storm Impacts

In terms of increases in storm intensity, there have been several studies that found a correlation between ocean temperature increases and more intense tropical storm and hurricane events as well as an increase in tropical cyclone activity over the last 40 years in the northern Atlantic Ocean (Emanuel 2005, Webster et al. 2005). Since the 1980's hurricanes also have been more intense, frequent, and lasted longer and there have been more Category 4 and 5 hurricanes; however, this also corresponds to better satellite data being available (Walsh et al. 2014). Model projections show that by the end of the century tropical cyclone events may be less frequent while strong hurricanes (Category 4 and 5)

may be more frequent. There is some uncertainty around projecting frequency, but models are in closer agreement that these events will be more intense (Walsh et al. 2014).

Albemarle Peninsula and Red Wolf Vulnerability to Storms

Although storm events may or may not necessarily be more frequent, they are likely to be more intense has they have been in recent years. Impacts from hurricanes on the Albemarle Peninsula will be similar to some of those from sea-level rise such as increases in salinity levels and resulting changes to system dynamics. For example, hurricanes have already moved estuarine waters into naturally occurring freshwater areas, changing peat composition, vegetation, and water chemistry (Feldman et al. 2009). Increases in wave surge and scour will only exacerbate existing erosion problems and may result in barrier islands being breached in one event, leading to similar impacts noted above – change of Albemarle- Pamlico system from protected estuary to embayed system with higher salinity level, lunar tides, and more wave action (Riggs and Ames 2003).

Summary of Threats to Red Wolf Recovery

One of the most significant stressors noted in the literature for the reintroduced population of red wolves is hybridization with coyotes. The Adaptive Management Plan is in place to help address this issue, and literature has noted its success, at least through 2007. Additional analysis needs to be completed to determine its current effectiveness. Another major threat to red wolf survival is mortality due to interactions with humans (i.e., shootings, vehicle strikes, etc.). Diseases also represent a threat, although there is an active vaccination campaign and based on quarterly reports a disease monitoring program is being established. There is little understanding of competition between wolves and coyotes for resources, but it appears likely interspecific competition for resources could also be a source of stress for red wolves. These stressors likely have an additive effect on the wolf population.

In addition to these threats, climate change and its impacts are likely to affect red wolves negatively and potentially exacerbate the above threats. If, as projected, much of Zone 1 is inundated due to sea-level rise (or potentially earlier from due to hurricanes), wolves will be pushed into Zones 2 and 3 and potentially the mainland. As described previously, human-interactions and more densely populated areas can be unsuitable for red wolves.

Little research has been conducted looking at all of these stressors together and their impacts on red wolves cumulatively. Including additional studies on climate change and how it may affect the other stressors will be important. The cumulative effect of all these stressors on red wolves will depend on whether they happen in concert or not and/ or in what sequence and the degree to which they occur.

Appendix C. Literature Cited

Acton, A., L. Munson, and W. Waddell. 2000. Survey of necropsy results in captive red wolves (*Canis rufus*). 1992–1996. Journal of Zoo and Wildlife Medicine, 30:2-8.

Acton, A. 2007. Evaluation of Noninvasive Molecular Monitoring for Fecal Pathogens Among Free-ranging Carnivores. North Carolina State University.

Baker, R. J. and R. D. Bradley. 2006. Speciation in mammals and the genetic species concept. Journal of Mammalogy, 87:643–662.

Baker, R. J., L. C. Bradley, R. D. Bradley, J. W. Dragoo, M. D. Engstrom, F. S. Hoffman, C. A. Jones, F. Reid, D. W. Rice, and C. Jones. 2003. Revised Checklist of North American Mammals North of Mexico. Museum of Texas Tech University.

Bartel, R. and D. Rabon. 2013. Re-introduction and recovery of the red wolf in the southeastern USA. IUCN/ SSC Re-introduction Specialist Group and Environment Agency-Abu Dhabi, Gland, Switzerland and Abu Dhabi, UAE.

Benson, J. F., B. R. Patterson, and T. J. Wheeldon. 2012. Spatial genetic and morphologic structure of wolves and coyotes in relation to environmental heterogeneity in a *Canis* hybrid zone. Molecular Ecology, 21:5934–5954.

Bergstrom, B.J., S. Vignieri, S.R. Sheffield, W. Sechrest, and A.A. Carlson. 2009. The Northern Rocky Mountain gray wolf is not yet recovered. BioScience. 59: 991-999.

Bohling, J. H. and L. P. Waits. 2011. Assessing the prevalence of hybridization between sympatric *Canis* species surrounding the red wolf (*Canis rufus*) recovery area in North Carolina. Molecular Ecology, 20:2142–2156.

Bromley, C. and E. M. Gese. 2001a. Surgical sterilization as a method for reducing coyote predation on domestic sheep. Journal of Wildlife Management, 65:510-519.

Bromley, C. and E. M. Gese. 2001b. Effects of sterilization on territorial fidelity and maintenance of pair bonds, and survival of free-ranging coyotes. Canadian Journal of Zoology, 79:386-392.

Bruskotter, J. T., R. H. Schmidt, and T.L. Teel. 2007. Are attitudes toward wolves changing? A case study in Utah. Biological Conservation, 139:211-218.

Brzeski, K. E., D. R. Rabon, Jr., M. J. Chamberlain, L. P. Waits, and S. S. Taylor. 2014. Inbreeding and inbreeding depression in endangered red wolves (*Canis rufus*). Molecular Ecology, 23:4241–4255.

Burnham, K. P. 1993. A theory for combined analysis of ring recovery and recapture data. Pages 199-213 in J. D. Lebreton and P. M. North, editors. Marked individuals in the study of bird population. Birkhauser Verlag, Basel, Switzerland.

Cahill, J. A., R. E. Green, T. L. Fulton, M. Stiller, F. Jay, N. Ovsyanikov, R. Salamzade, J. St. John, I. Stirling, M. Slatkin, and B. Shapiro. 2013. Genomic evidence for island population conversion resolves conflicting theories of polar bear evolution. PLoS Genetics, 9(3): e1003345. doi:10.1371/journal.pgen.1003345.

Carley, C. J. 1975. Activities and findings of the red wolf recovery program from late 1973 to July 1,1975. USFWS, Albuquerque, New Mexico.

Chambers, S. M., S. R. Fain, B. Fazio, and M. Amaral. 2012. An account of the taxonomy of North American wolves from morphological and genetic analyses. North American Fauna, 77:1–67.

Chadwick, J., B. Fazio, and M. Karlin. 2010. Effectiveness of GPS-Based Telemetry to Determine Temporal Changes in Habitat use and Home-Range Sizes of Red Wolves. Southeastern Naturalist, 9:303-316.

Clark, S.G. and M.B. Rutherford (eds). 2014. Large Carnivore Conservation – Integrating Science and Policy in the North American West. Univ. of Chicago Press. Chicago. 407 pp.

Clough, J. 2013. Application of the Sea-Level Affecting Marshes Model (SLAMM 5.0) to Alligator River National Wildlife Refuge. Warren Pinnacle Consulting, Inc., Warren, Vermont.

Climate Change Science Program (CCSP). 2009. Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region. A report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. U.S. Environmental Protection Agency, Washington, D,C., 320pp.

Cronin, M. A., S. C. Amstrup, G. W. Garner, and E. R. Vyse. 1991. Interspecific and intraspecific mitochondrial DNA variation in North American bears (*Ursus*). Canadian Journal of Zoology, 69:2985–2992.

Dellinger, J.A. 2011. Foraging and Spatial Ecology of Red Wolves (*Canis rufus*) in Northeastern North Carolina. Masters Thesis. Auburn University.

Dellinger , J. A., B. Ortman, T. Steury, J. Bohling, and L. Waits. 2011. Food Habits of Red Wolves during Pup-Rearing Season. Southeastern Naturalist, 10:731-740.

Dellinger, J. A., C. Proctor, T. D. Steury, M. J. Kelly, and M. R. Vaughn. 2013. Habitat selection of a large carnivore, the red wolf, in a human-altered landscape. Biological Conservation, 157:324-330.

DeWan, A., N. Dubois, K. Theoharides, and J. Boshoven. 2010. Understanding the impacts of climate change on fish and wildlife in North Carolina. Defenders of Wildlife, Washington, D.C.

Emanuel, K. 2005. Increasing destructiveness of tropical cyclones over the past 30 years. Nature, 436:686-688.

Enck, J. and T. L. Brown. 2002. New Yorkers' Attitudes toward Restoring Wolves to the Adirondack Park. Wildlife Society Bulletin, 30:16-28.

Fain, S. R., D. J. Straughan, and B. F. Taylor. 2010. Genetic outcome of wolf recovery in the western Great Lakes states. Conservation Genetics, 11:1747-1765.

Fazio, B., C. Lucash, and A. Beyer. 2005. Red Wolf Recovery Program Adaptive Work Plan. USFWS. Manteo, North Carolina.

Feldman, R., J. G. Titus, and B. Poulter. 2009. North Carolina. U.S. Environmental Protection Agency, Washington, D.C.

Frederickson, R. and P. W. Hedrick. 2006. Dynamics of hybridization and introgression in red wolves and coyotes. Conservation Biology, 20:1272-1283.

Glick, P., A. Staudt, and D. Inkley. 2007. The Chesapeake Bay and Global Warming: A Paradise Lost for Hunters, Anglers, and Outdoor Enthusiasts? , National Wildlife Federation, Washington, D.C.

Grewal, S. K., P. J. Wilson, T. K. Kung, K. Shami, M. T. Theberge, J. B. Theberge and B. N. White. 2004. A genetic assessment of the eastern wolf (*Canis lycaon*) in Algonquin Provincial Park. Journal of Mammalogy, 85:625-632.

Heberlein, T. A. and G. Ericsson. 2008. Public attitudes and the future of wolves *Canis lupus* in Sweden. Wildlife Biology, 14:391-394.

Hedrick, P. W., R. N. Lee, and D. Garrigan. 2002. Major histocompatibility complex variation in red wolves: evidence for common ancestry with coyotes and balancing selection. Molecular Ecology, 11:1905–1913.

Hinton, J. 2006. Home range, habitat use, and pup attendance of red wolves (*Canis rufus*) during the pup rearing season. Rice University, Houston, Texas.

Hinton, J. and M. J. Chamberlain. 2010. Space and Habitat Use by a Red Wolf Pack and Their Pups during Pup-Rearing. Journal of Wildlife Management, 74:55-58.

Hinton, J. H., M. J. Chamberlain, and D. R. Rabon Jr. 2013. Red Wolf (*Canis rufus*) Recovery: A Review with Suggestions for Future Research. Animals, 3:722-744.

Houston, M., J. T. Bruskotter, and D. Fan. 2010. Attitudes toward Wolves in the United States and Canada: A Content Analysis of the Print News Media, 1999–2008. Human Dimensions of Wildlife, 15:389–403.

Howell, A. 1921. A biological survey of Alabama. North American Fauna no. 45. Page 88 *in* USFWS, editor. Washington, D.C.

Intergovernmental Panel on Climate Change (IPCC). 2007. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 976pp.

Kansky, R., M. Kidd, and A. T. Knight. 2014. Meta-Analysis of Attitudes toward Damage-Causing Mammalian Wildlife. Conservation Biology, 28:924–938.

Karl, T., J. M. Melillo, and T. C. Peterson (eds.). 2009. Global Climate Change Impacts in the United States. Cambridge University Press.

Karlin, M. and J. Chadwick. 2011. Measures of space use and association of two unrelated male red wolves in a shaded area. Mammal Study, 36:147-153.

Karlin, M. and J. Chadwick. 2012. Red wolf natal dispersal characteristics: comparing periods of population increase and stability. Journal of Zoology, 286:266–276.

Karlsson, K. and M. Sjöström. 2007. Human attitudes towards wolves, a matter of distance. Biological Conservation, 137:610–616.

Kelly, B. T., P. S. Miller, and U. S. Seal (eds.). 1999. Population and Habitat Viability Assessment Workshop for the Red Wolf (*Canis rufus*). Conservation Breeding Specialist Group (SSC/IUCN), Apple Valley, MN.

Kelly, B. T., A. Beyer, and M. Phillips. 2004. Red wolf *Canis rufus* Audubon and Bachman, 1851 Critically Endangered – CR: D (2004). IUCN/SSC Canid Specialist Group IUCN World Conservation Union, Gland Switzerland and Cambridge, UK.

Kemp, A. 2009. High resolution studies of late Holocene relative sea-level change (North Carolina). University of Pennsylvania.

Kemp, A., B. P. Horton, S. J. Culver, R. D. Corbett, O. van de Plassche, W. R. Gehrels, B. C. Douglas, and A. C. Parnell. 2009. Timing and magnitude of recent accelerated sea-level rise (North Carolina, United States). Geological Society of America, 39:1035–1038.

Knowlton, F. 1973. Preliminary Interpretations of Coyote Population Mechanics with

Some Management Implications, *in* Great Plains Wildlife Damage Control Workshop Proceedings.

Koblmüller, S., M. Nord, R. K. Wayne, and J. A. Leonard. 2009. Origin and status of the Great Lakes wolf. Molecular Ecology **18**:2313 – 2326.

Kramer, R. and A. Jenkins. 2009. Ecosystem Services, Markets, and Red Wolf Habitat: Results from a Farm Operator Survey. Defenders of Wildlife, Washington, D.C.

Kyle, C., A. R. Johnson, B. R. Patterson, P. J. Wilson, K. Shami, S. K. Grewel, and B. N. White. 2006. Genetic nature of eastern wolves: Past, present and future. Conservation Genetics, 7:273-287.

Kyle, C., A. R. Johnson, B. R. Patterson, P. J. Wilson, and B. N. White. 2008. The conspecific nature of eastern and red wolves; conservation and management implications. Conservation Genetics, 9:699-701.

Leonard, J. and R. Wayne. 2008. Native Great Lakes wolves were not restored. Biology Letters, 4:94 – 98.

Locklear, K., W. T. Waddell, K. L. Goodrowe, and S. E. MacDonald. 2009. Retrospective investigation of captive red wolf reproductive success in relation to age and inbreeding. Zoo Biology, 28:214-229.

Lute, M. and M. L. Gore. 2014. Stewardship as a Path to Cooperation? Exploring the Role of Identity in Intergroup Conflict Among Michigan Wolf Stakeholders. Human Dimensions of Wildlife: An International Journal 19:267-279.

Mahoney, P. 2011. An assessment of red wolf (*Canis rufus*) population persistence using classical and individual based modeling approaches. MS Thesis. Auburn University.

Mastro,L. L., E. M. Gese, J. K. Young, and J. A. Shivik. 2012. What do we know? A literature review of the eastern coyote. Proceedings of the 14th Wildlife Damage Management Conference.

Maurer, E., L. Brekke, T. Pruitt, and P. B. Duffy. 2007. Fine-resolution climate projections enhance regional climate change impact studies. Eos, Transactions American Geophysical Union, 88:504.

Mazur, K. and S. T. Asaha. 2013. Clarifying standpoints in the gray wolf recovery conflict: Procuring management and policy forethought. Biological Conservation, 167:79–89.

McVey, J. D. C., R. Powell, M. Stoskopf, J. Bohling, L. Waits, and C. Moorman. 2013. Diets of sympatric red wolves and coyotes in northeastern North Carolina. Journal of Mammalogy, 94:1141-1148.

Mech, L. D. 1970. The wolf: the ecology and behavior of an endangered species. Natural History Press, Garden City, New York. 384pp.

Mech, L. D. 2012. Is science in danger of sanctifying the wolf? Biological Conservation, 150:143–149.

Mech, L. D., B. W. Christensen, C. S. Asa, M. Callahan, and J. K. Young. 2014. Production of hybrids between western gray wolves and western coyotes. PLoS ONE, 9(2): e88861. doi:10.1371/journal.pone.0088861.

Miller, C. R., J. R. Adams, and L. P. Waits. 2003. Pedigree-based assignment tests for reversing coyote (*Canis latrans*) introgression into the red wolf (*Canis rufus*) population. Molecular Ecology, 12:3287–3301.

Miller, W., S. C. Schuster, A. J. Welch, A. Ratan, O. C. Bedoya-Reina, F. Zhao, H. L. Kim, R. C. Burhans, D. I. Drautz, N. E. Wittekindt, L. P. Tomsho, E. Ibarra-Laclette, L. Herrera-Estrella, E. Peacock, S. Farley, G. K. Sage, K. Rode, M. Obbard, R. Montiel, L. Bachmann, Ó. Ingólfsson, J. Aars, T. Mailund, Ø. Wiig, S. L. Talbot, and C. Lindqvist. 2012. Polar and brown bear genomes reveal ancient admixture and demographic footprints of past climate change. Proceedings of the National Academy of Sciences of the USA, 109:E2382–E2390, doi:10.1073/pnas.1210506109.

Monzon, J., R. Kays, and D. E. Dykhuizen. 2014. Assessment of coyote–wolf–dog admixture using ancestry-informative diagnostic SNPs. Molecular Ecology, 23:182–197.

Moore G.C. and G. R. Parker. 1992. Colonization by the eastern coyote (*Canis latrans*) *in* A. H. Boer (editor). Ecology and Management of the Eastern Coyote. Wildlife Research Unit, University of New Brunswick, Fredericton, New Brunswick, Canada, pp. 23–37.

National Center for Ecological Analysis and Synthesis (NCEAS). 2014. Review of Proposed Rule Regarding Status of the Wolf Under the Endangered Species Act. University of California, Santa Barbara, California.

North Carolina Coastal Resources Commission's Science Panel on Coastal Hazards (NCCRC). 2010. North Carolina sea-level rise assessment report. Division of Coastal Management. North Carolina Department of Environment and Natural Resources. Raleigh, NC.

Northeast Climate Impacts Assessment (NECIA). 2006. Climate change in the U.S. Northeast. A report of the Northeast climate impacts assessment. Union of Concerned Scientists (UCS), Cambridge, MA

Nowak, R. 1979. North American Quaternary Canis. Monograph of the Museum of Natural History, 6:1-154.

Nowak, R. 1983. A perspective on the taxonomy of wolves in North America. Pages 10-19

in L. E. Carbyn, editor. Wolves in Canada and Alaska, Ottawa, Canada.

Nowak, R. 1995. Another Look at Wolf Taxonomy *in* L. Carbyn, S. H. Fritts, and D. R. Seip (eds.). Ecology and Conservation of Wolves in a Changing World. Canadian Circumpolar Institute, Edmonton, Alberta.

Nowak, R. 2002. The original status of wolves in eastern North America. Southeastern Naturalist, 1:95-130.

Nowak, R. 2003. Wolf evolution and taxonomy. Pages 239 – 258 *in* L. D. and L. B. Mech, (eds). Wolves: Behavior, ecology, and conservation. University of Chicago Press.

Nowak, R. 2009. Taxonomy, morphology, and genetics of wolves in the Great Lakes region *in* A. P. Wydeven, T. Van Deelen, and E. J. Heske (eds.). Recovery of gray wolves in the Great Lakes region of the United States. Springer, New York, New York.

Paradiso, J. and R. Nowak. 1972. *Canis rufus*. Mammalian Species, 22:1-4.

Pearsall III, S. H. and B. Poulter. 2005. Adapting coastal lowlands to rising seas. Principles of conservation biology, 3:366-370.

Phillips, M. 1994. Reestablishment of Red Wolves Alligator River National Wildlife North Carolina. USFWS. Southeast Region. Manteo, NC.

Phillips, M. K., V. G. Henry, and B. T. Kelly. 2003. Restoration of the Red Wolf. Pages 272-288 *in*. L. D. and L. B. Mech, (eds), Wolves: behavior, ecology, and conservation. University of Chicago Press, Chicago, Illinois.

Poulter, B. 2005. Interactions between landscape disturbance and gradual environmental change: Plant community migration in response to fire and sea level rise. Duke University, Durham, North Carolina.

Poulter, B., R. L. Feldman, M. M. Brinson, B. P. Horton, M. K. Orbach, S. H. Pearsall, E. Reyes, S. R. Riggs, and J. C. Whitehead. 2009. Sea-level rise research and dialogue in North Carolina: Creating windows for policy change. Ocean and Coastal Management, 52:147–153.

Poulter, B. and P. Halpin. 2007. Raster modeling of coastal flooding from sea-level rise. International Journal of Geographical Information Science, 22:167-182.

Rabon, D. 2009. Factors affecting reproduction in the red wolf (*Canis rufus*). North Carolina State University, Raleigh, N.C.

Rabon, D. 2014. Effects of age and experience on reproductive performance of captive red wolves (*Canis rufus*). Canadian Journal of Zoology, 92:251-258.

Rabon, D., R. Bartel, and A. Beyer. 2013. Red Wolf Adaptive Management Plan FY13-FY15. USFWS. Manteo, NC.

Rabon, D. and W. Waddell. 2009. Effects of inbreeding on reproductive success, performance, litter size, and survival in captive red wolves (*Canis rufus*). Zoo Biology, 28:1-14.

Reich, D. E., R. K. Wayne, and D. B. Goldstein. 1999. Genetic evidence for a recent origin by hybridization of red wolves. Molecular Ecology, 8:139–144.

Riggs, S. and D. Ames. 2003. Drowning the North Carolina coast: Sea-level rise and estuarine dynamics. North Carolina Sea Grant, North Carolina State University, Raleigh, North Carolina.

Riley, G. A., and R. T. McBride. 1972. A survey of the red wolf (*Canis rufus*). USFWS. Washington, D.C.

Roth, J., D. L. Murray, and T. D. Steury. 2008. Spatial dynamics of sympatric canids: Modeling the impact of coyotes on red wolf recovery. Ecological Modeling, 214:391-403.

Roy, M. S., E. Geffen, D. Ostrander, and R. K. Wayne. 1994. Patterns of differentiation and hybridization in North American wolf-like canids, revealed by analysis of microsatellite loci. Molecular Biology and evolution, 11:533–570.

Rutledge, L. Y., B. R. Patterson, and B. N. White. 2010a. Analysis of *Canis* mitochondrial DNA demonstrates high concordance between the control region and ATPase genes. BMC Evolutionary Biology, 10:215.

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

Rutledge, L. Y., B. R. Patterson, K. J. Mills, K. M. Loveless, D. L. Murray, and B. N. White. 2010c. Protection from harvesting restores the natural social structure of eastern wolf packs. Biological Conservation, 143:332–339.

Rutledge, L. Y., K. I. Bos, R. J. Pearce, and B. N. White. 2010d. Genetic and morphometric analysis of sixteenth century *Canis* skull fragments: implications for historic eastern and gray wolf distribution in North America. Conservation Genetics, 11:1273–1281.

Rutledge, L. Y., B. N. White, J. R. Row, and B. R. Patterson. 2011. Intense harvesting of eastern wolves facilitated hybridization with coyotes. Ecology and Evolution, 2:19–33.

Rutledge, L. Y., P. J. Wilson, C. F. C. Klütsch, B. R. Patterson, and B. N. White. 2012. Conservation genomics in perspective: A holistic approach to understanding *Canis* evolution in North America. Biological Conservation, 155:186–192.

Shafer, J. 2007. Analyzing a Prospective Red Wolf (*Canis rufus*) Reintroduction Site for Suitable Habitat. Duke University, Duke University.

Shaw, J. H. 1975. Ecology, Behavior, and Systematics of the Red Wolf (*Canis Rufus*). Yale University.

Sparkman, A., J. Adams, A. Beyer, T. Steury, L. Waits, and D. L. Murray. 2011a. Helper effects on pup lifetime fitness in the cooperatively breeding red wolf (*Canis rufus*). Proceedings of the Royal Society, 278:1381–1389.

Sparkman, A., J. Adams, T. Steury, L. Waits, and D. L. Murray. 2011b. Direct fitness benefits of delayed dispersal in the cooperatively breeding red wolf (*Canis rufus*). Behavioral Ecology, 22:199-205.

Sparkman, A., J. R. Adams, T. D. Steury, L. P. Waits, and D. L. Murray. 2012. Pack social dynamics and inbreeding avoidance in the cooperatively breeding red wolf. Behavioral Ecology, 23:1186-1194.

Stoskopf, M. K., K. Beck, B. B. Fazio, T. K. Fuller, E. M. Gese, B. T. Kelly, F. F. Knowlton, D. L. Murray, W. Waddell, and L. Waits. 2005. Implementing recovery of the red wolf-integrating research scientists and managers. Wildlife Society Bulletin, *33* :1145-1152.

Stronen A. V., R. K. Brook, P. C. Paquet, and S. McLachlan. 2007. Farmer attitudes toward wolves: Implications for the role of predators in managing disease. Biological Conservation, 135:1-10.

Thiel, R. and A. P. Wydeven. 2011. Eastern Wolf (*Canis lycaon*) Status Assessment Report Covering East-Central North America. Wisconsin Department of Natural Resources.

Trani, M. and B. R. Chapman. 2007. Red Wolf, *Canis rufus*. Pages 441-445 *in* M. Trani, W. M. Ford, and B. R. Chapman, editor. The land manager's guide to mammals of the South. The Nature Conservancy; U.S. Forest Service, Durham, NC; Atlanta, GA.

Treves, A., L. Naughton-Treves, and V. Shelley. 2013. Longitudinal Analysis of Attitudes Toward Wolves. Conservation Biology, 27:315–323.

U.S. Fish and Wildlife Service. 1982. Red Wolf Recovery Plan. Atlanta, GA. 28pp.

U.S. Fish and Wildlife Service. 1984. Red Wolf Recovery Plan. Atlanta. GA 37pp.

U.S. Fish and Wildlife Service. 1989. Red Wolf Recovery Plan. Atlanta, GA. 110pp.

U.S. Fish and Wildlife Service. 2007. Red Wolf (*Canis rufus*) 5-Year Status Review: Summary and Evaluation. Manteo, NC. 58pp.

U.S. Fish and Wildlife Service. 2009. Red Wolf Action Plan. Manteo, NC. 6pp.

U. S. Fish and Wildlife Service. 2013. Black-Footed Ferret Programmatic Safe Harbor Agreement. Denver, CO. 54pp.

van Manen, F., B. A. Crawford, and J. D. Clark. 2000. Predicting Red Wolf Release Success in the Southeastern United States. Journal of Wildlife Management, 64:895-902.

vonHoldt, B. M., J. P. Pollinger, D. A. Earl, J. C. Knowles, A. R. Boyko, H. Parker, E. Geffen, M. Pilot, W. Jedrzejewski, B. Jedrzejewska, V. Sidorovich, C. Greco, E. Randi, M. Musani, R. Kays, C. D. Bustamante, E. A. Ostrander, J. Novembre, and R. K. Wayne. 2011. A genome-wide perspective on the evolutionary history of enigmatic wolf-like canids. Genome Research, 21:1294–1305.

Walsh, J., D. Wuebbles, K. Hayhoe, J. Kossin, K. Kunkel, G. Stephens, P. Thorne, R. Vose, M. Wehner, J. Willis, D. Anderson, S. Doney, R. Feely, P. Hennon, V. Kharin, T. Knutson, F. Landerer, T. Lenton, J. Kennedy, and R. Somerville. 2104. Ch. 2: Our Changing Climate. Pages 19-67 *in* T. R. J. M. Melillo, and G. W. Yohe (eds.), Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program.

Wayne, R. K., and S. M. Jenks. 1991. Mitochondrial DNA analysis implying the extensive hybridization of endangered red wolf *Canis rufus*. Nature, 351:565–568.

Webster, P., G. J. Holland, J. A. Curry, and H. R. Change. 2005. Changes in tropical cyclone number, duration, and intensity in a warming environment. Science, 309:1844-1846.

Wheeldon, T. and B. N. White. 2009. Genetic analysis of historic western Great Lakes region wolf samples reveals early *Canis lupus*/*lycaon* hybridization. Biology Letters, 5:101–104.

Wheeldon, T. J., B. R. Patterson, and B. N. White. 2010. Sympatric wolf and coyote populations of the western Great Lakes region are reproductively isolated. Molecular Ecology, 19:4428-4440.

White, G.C. and K. P. Burnham. 1999. Program MARK: Survival estimation from populations of marked animals. Bird Study 46 Supplement, 120-138.

Williams, C., G. Ericsson, and T. A. Heberlein. 2002. A Quantitative Summary of Attitudes toward Wolves and Their Reintroduction (1972-2000). Wildlife Society Bulletin, 30:575-584.

Wilson, P., S. Grewal, D. I. Lawford, J. N. M. Heal, A. G. Granacki, D. Pennock, J. B. Theberge, M. T. Theberge, D. R. Voigt, W. Waddell, R.E. Chambers, P.C. Paquet, G. Gulet, D. Cluff and B. N. White. 2000. DNA profiles of the eastern Canadian wolf and the red wolf provide evidence for a common evolutionary history independent of the gray wolf. Canadian Journal of Zoology, 78:2156 – 2166.

Wilson, P., S. Grewal, F. F. Malory and B. N. White. 2009. Genetic characterization of hybrid wolves across Ontario. Journal of Heredity, 100:S80-S89.

Wilson, P. J., S. Grewal, T. McFadden, R. C. Chambers, and B. N. White. 2003. Mitochondrial DNA extracted from eastern North American wolves killed in the 1800s is not of gray wolf origin. Canadian Journal of Zoology, 81:936–940.

Wilson, P. J., L. Y. Rutledge, T. J. Wheeldon, B. R. Patterson, and B. N. White. 2012. Y-chromosome evidence supports widespread signatures of three-species *Canis* hybridization in eastern North America. Ecology and Evolution, 2:2325–2332.

Zervas, C. 2004. North Carolina bathymetry/topography sea level rise project: determination of sea level trends. NOAA.

Appendix D. List of FWS Documents Reviewed

YEAR	DOCUMENT
1973	Endangered Species Act
1967	Federal Register (32) 4001
1984	Federal Register (49) 33885-33894
1986	Federal Register (51) 26564-26569
1986	Federal Register (51) 41790-41797
1991	Federal Register (56) 56325-56334
1992	Federal Register (57) 1246-1250
1995	Federal Register (60) 18940-18948
1997	Federal Register (62) 64799-64800
1998	Federal Register (63) 54151-54153
1999	Federal Register (64) 60454
1984	Federal Register (49) 4402
1982	Conference report 1982 amendments
1986	Environmental Assessment – Alligator River NWR 9_1986
1990	Environmental Assessment – Pocosin Lakes NWR 5_1990
1993	Environmental Assessment – Alligator River & Pocosin Lakes NWR 9_1993
1986	Determination of Effect of Rules 6_1986
1982	Red Wolf Recovery Plan 07_12_1982
1984	Red Wolf Recovery Plan 9_1984
1986	Reintroduction Proposal 3_1986
1986	Section 7 Consult. – Alligator River NWR 4_1986
1990	Species Survival Plan 10_1990
1993	Red Wolf Release Plan – Pocosin Lakes NWR 6_1993
1999	1999 Outreach Plan
1999	Red Wolf Pop. & Habitat Viability Assessment 4_1999
2000	Red Wolf Adaptive Management Plan FY00-FY02
2005	Red Wolf Adaptive Management Plan FY05-FY08
2007	Red Wolf 5-Year Status Review 9_2007
2009	Red Wolf Recovery Action Plan 2009
2013-2015	Red Wolf Adaptive Management Plan FY13-FY15
2014	Red Wolf Program Recovery Timeline
Undated	Red Wolf Rules and Federal Rules Highlights
2013	Red Wolf Recovery Implementation Team Appointments
1999-2014	Red Wolf Budget
1991	Ecological Services Expenditures 12_17_1991
1999-2014	Red Wolf Budget Allocations
2014	Mortality Table website 8_28_2014

YEAR	DOCUMENT
1987-2014	Red Wolf Demographics
2013	Red Wolf Studbook 2013
2014	Columbia - recording of NCWRC public meeting 06_19_2014
1999	Correspondence - Jackson to Director 02_23_1999
1999	Correspondence - Henry to Cole 03_15_1999
1999	Correspondence - King to Kelly 07_24_1999
1998	Correspondence - Kelly to RWRP staff 11_23_1998
1998	Correspondence - Kelly to Henry 12_01_1998
2005	Correspondence - Defenders of Wildlife to USFWS 11_21_2005
2013	Correspondence - Cindy Dohner & Gordon Meyers 11_13_2013
2014	Correspondence - NC Wildlife Resources Commission 6_2014
2014	Correspondence - Cindy Dohner to Gordon Meyers 6_2014
2014	Correspondence - Miner to Leo Miranda
2014	Correspondence – DOI Solicitor to Leo Miranda
1999	Correspondence – Staff thoughts regarding take regulations
1993	Correspondence - Phillips 02_10_1993
1993	Correspondence – Correspondence from Phillips 02_10_1993
1993	Correspondence – Phillips to Askew 03_23_1993
1993	Correspondence - Phillips to GSM 04_28_1993
2013	Organizational Chart – Alligator River NWR 4_2013
2013	Organizational Chart – Alligator River NWR 6_19_2013
2012	Organizational Chart – Alligator River NWR 10_2012
2007-2010	Organizational Chart – Alligator River NWR 2007-2010
2014	Organizational Chart – Raleigh Field Office 2014
1986	Annual Narrative - Alligator River NWR
1987	Annual Narrative - Alligator River NWR
1988	Annual Narrative - Alligator River NWR
1989	Annual Narrative - Alligator River NWR
1990	Annual Narrative - Alligator River NWR
1991	Annual Narrative - Alligator River NWR
1992	Annual Narrative - Alligator River NWR
1993	Annual Narrative - Alligator River NWR
1994	Annual Narrative - Alligator River NWR
1995	Annual Narrative - Alligator River NWR
1996	Annual Narrative - Alligator River NWR
1997-1998	Annual Narrative - Alligator River NWR
1999-2001	Annual Narrative - Alligator River NWR
2002	Annual Narrative - Alligator River NWR
2003	Annual Narrative - Alligator River NWR
2004	Annual Narrative - Alligator River NWR

YEAR	DOCUMENT
2005	Annual Narrative - Alligator River NWR
2006	Annual Narrative - Alligator River NWR
2007	Annual Narrative - Alligator River NWR
1986-2014	Red wolf restoration area deer populations 1986-2014
Undated	Deer-vehicle collision data
2013	Point Defiance Zoo & Aquarium Conservation Committee Red Wolf Disease Plan
2013	Point Defiance Zoo & Aquarium Con. Com. progress report - red wolf disease
1999	Discussion Paper - Red Wolf Regulations 01_21_1999
1999	Guidelines - Removing Wolves from Private Lands 01_28_1999
1989	Durant Island Lease Agreement
1990-1995	MOU John Hancock Life Insurance Company
1990	Durant Island Lease Agreement
1991	Durant Island Lease Agreement
1997	Durant Island Agreements
1993-1998	AgriEast Agreement
1993	Landowner/Partner Agreement
1994	Landowner Agreements
1997-2001	Landowner/Partner Agreements
1997	Landowner Agreements
1998	Landowner/Partner Agreement
1998	Landowner Agreements
1993	19930523 Lux Agreement
1993	19930927 Letter from Phillips
1995	19950424 Hancock MOU
1997	19971029 Bluestone Agreement
1998	19980304 Ventures Agreement
1999	AgriEast Invoice
2000	20001212 AgriEast Invoice
2002	20020802 Ventures Agreement
2002	20021114 Lux Agreement
2000	Landowner Agreements
2001	Landowner Agreements
2002	Landowner Agreements
2003	Landowner Agreements
1998	Gilbreath & Henry 1998 Regulations and Private Lands
1994	Phillips 1994 Red Wolf Tech. Report 10 (Summary 1987-92)
1995	19950601 Reestablishment of RW in ENC Annual Summary 1994
1996	19960401 Reestablishment of RW in ENC Annual Summary 1995
1997	19970601 Reestablishment of RW in ENC Annual Summary 1996
1991	19910812 July - Red Wolf Monthly Report

YEAR	DOCUMENT
1991	19910905 August - Red Wolf Monthly Report
1991	19911010 September - Red Wolf Monthly Report
1991	19911101 October - Red Wolf Monthly Report
1991	19911211 November - Red Wolf Monthly Report
1992	19920117 December (91) - Red Wolf Monthly Report
1992	19920206 January - Red Wolf Monthly Report
1992	19920303 February - Red Wolf Monthly Report
1992	19920403 March - Red Wolf Monthly Report
1992	19920511 April - Red Wolf Monthly Report
1992	19920612 May - Red Wolf Monthly Report
1992	19920707 June - Red Wolf Monthly Report
1992	19920811 July - Red Wolf Monthly Report
1992	19920911 August - Red Wolf Monthly Report
1992	19921005 September - Red Wolf Monthly Report
1992	19921208 November - Red Wolf Monthly Report
1993	19930108 December (92) - Red Wolf Monthly Report
1993	19930204 January - Red Wolf Monthly Report
1993	19930308 February - Red Wolf Monthly Report
1993	19930406 March - Red Wolf Monthly Report
1993	19930511 April - Red Wolf Monthly Report
1993	19930608 May - Red Wolf Monthly Report
1993	19930713 June - Red Wolf Monthly Report
1993	19930810 July - Red Wolf Monthly Report
1993	19930910 August - Red Wolf Monthly Report
1993	19931105 October - Red Wolf Monthly Report
1993	19931213 November - Red Wolf Monthly Report
1994	19940113 December (93) - Red Wolf Monthly Report
1994	19940215 January - Red Wolf Monthly Report
1994	19940303 February - Red Wolf Monthly Report
1994	19940418 March - Red Wolf Monthly Report
1994	19940516 April - Red Wolf Monthly Report
1994	19940609 May - Red Wolf Monthly Report
1994	19940721 August - Red Wolf Monthly Report
1994	19940721 June - Red Wolf Monthly Report
1994	19940809 July - Red Wolf Monthly Report
1994	19940908 August - Red Wolf Monthly Report
1994	19941004 September - Red Wolf Monthly Report
1994	19941104 October - Red Wolf Monthly Report
1994	19941116 October - Red Wolf Monthly Report
1994	19941206 November - Red Wolf Monthly Report

YEAR	DOCUMENT
1995	19950111 December (94) - Red Wolf Monthly Report
1995	19950215 January - Red Wolf Monthly Report
1995	19950321 February - Red Wolf Monthly Report
1995	19950411 March - Red Wolf Monthly Report
1995	19950518 April - Red Wolf Monthly Report
1995	19950616 May - Red Wolf Monthly Report
1996	19960723 June - Red Wolf Monthly Report
1996	19960813 July - Red Wolf Monthly Report
1996	19960813 July - Red Wolf Monthly Report
1996	19960813 July - Red Wolf Monthly Report
1996	19960924 August - Red Wolf Monthly Report
1996	19961023 September - Red Wolf Monthly Report
1996	19961113 October - Red Wolf Monthly Report
1996	19961212 November - Red Wolf Monthly Report
1997	19970116 December (96) - Red Wolf Monthly Report
1999	19991014 Red Wolf Quarterly report FY99-04
2000	20000125 Red Wolf Quarterly report FY00-01
2000	20000601 Red Wolf Quarterly report FY00-02
2010	20100119 Red Wolf Quarterly report FY10-01
2010	20100416 Red Wolf Quarterly report FY10-02
2010	20100714 Red Wolf Quarterly report FY10-03
2010	20101122 Red Wolf Quarterly report FY10-04
2011	20110121 Red Wolf Quarterly report FY11-01
2011	20110428 Red Wolf Quarterly report FY11-02
2011	20110718 Red Wolf Quarterly report FY11-03
2011	20111116 Red Wolf Quarterly report FY11-04
2012	20120203 Red Wolf Quarterly report FY12-01
2012	20120419 Red Wolf Quarterly report FY12-02
2012	20120816 Red Wolf Quarterly report FY12-03
2012	20121029 Red Wolf Quarterly report FY12-04
2013	20130110 Red Wolf Quarterly report FY13-01
2013	20130416 Red Wolf Quarterly report FY13-02
2013	20130709 Red Wolf Quarterly report FY13-03
2013	20131112 Red Wolf Quarterly report FY13-04
2014	20140128 Red Wolf Quarterly report FY14-01
2014	20140522 Red Wolf Quarterly report FY14-02
2008	Red Wolf Program Report 2008
2003	Red Wolf Quarterly report 2003-4
2004	Red Wolf Quarterly report 2004-2
2004	Red Wolf Quarterly report 2004-4

YEAR	DOCUMENT
2011	NYS Museum Press Release - Wolves, Coyotes
2003	Restoration of the Red Wolf 1_2003
2012	Taxonomy of North American Wolves

Appendix E. Written survey instruments

Red Wolf Survey
USFWS Regional Staff

This survey is an important component or the Red Wolf Recovery Program Review that WMI has been asked to complete for the U.S. Fish and Wildlife Service. Please indicate the extent to which you agree or disagree with the following statements. All answers will remain anonymous.

	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	Don't Know
1. The Red Wolf Recovery Program is a priority of the Service.	☐	☐	☐	☐	☐	☐	☐
2. The Red Wolf Recovery Program has become more of a priority for the Service during the last 20-30 years.	☐	☐	☐	☐	☐	☐	☐
3. Funding for the Red Wolf Recovery Program has increased since the Program's implementation.	☐	☐	☐	☐	☐	☐	☐
4. The budgetary needs of the Red Wolf Recovery Program have increased since the Program's implementation.	☐	☐	☐	☐	☐	☐	☐
5. The Red Wolf Recovery Program has received adequate funding to meet its goals.	☐	☐	☐	☐	☐	☐	☐
6. The Red Wolf Recovery Program has received adequate institutional support to meet its goals.	☐	☐	☐	☐	☐	☐	☐
7. The Red Wolf Recovery Program has been successful at meeting its biological goals.	☐	☐	☐	☐	☐	☐	☐
8. I feel that I can voice my suggestions to increase the chances of success of the Red Wolf Recovery Program.	☐	☐	☐	☐	☐	☐	☐
9. The public is supportive of the Red Wolf Recovery Program.	☐	☐	☐	☐	☐	☐	☐
10. The USFWS has been a good partner during the planning of the Red Wolf Recovery Program.	☐	☐	☐	☐	☐	☐	☐
11. The USFWS has been a good partner during the implementation of the Red Wolf Recovery Program.	☐	☐	☐	☐	☐	☐	☐

Thank you for participating in this important survey.

Red Wolf Survey
USFWS Local Staff

This survey is an important component or the Red Wolf Recovery Program Review that WMI has been asked to complete for the U.S. Fish and Wildlife Service. Please indicate the extent to which you agree or disagree with the following statements. All answers will remain anonymous.

	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	Don't Know
1. The Red Wolf Recovery Program is a priority of the Service.	☐	☐	☐	☐	☐	☐	☐
2. The Red Wolf Recovery Program has become more of a priority for the Service during the last 20-30 years.	☐	☐	☐	☐	☐	☐	☐
3. Funding for the Red Wolf Recovery Program has increased since the Program's implementation.	☐	☐	☐	☐	☐	☐	☐
4. The budgetary needs of the Red Wolf Recovery Program have increased since the Program's implementation.	☐	☐	☐	☐	☐	☐	☐
5. The Red Wolf Recovery Program has received adequate funding to meet its goals.	☐	☐	☐	☐	☐	☐	☐
6. The Red Wolf Recovery Program has received adequate institutional support to meet its goals.	☐	☐	☐	☐	☐	☐	☐
7. The Red Wolf Recovery Program has been successful at meeting its biological goals.	☐	☐	☐	☐	☐	☐	☐
8. I feel that I can voice my suggestions to increase the chances of success of the Red Wolf Recovery Program.	☐	☐	☐	☐	☐	☐	☐
9. The public is supportive of the Red Wolf Recovery Program.	☐	☐	☐	☐	☐	☐	☐
10. The USFWS has been a good partner during the planning of the Red Wolf Recovery Program.	☐	☐	☐	☐	☐	☐	☐
11. The USFWS has been a good partner during the implementation of the Red Wolf Recovery Program.	☐	☐	☐	☐	☐	☐	☐
12. The lands within Alligator River NWR and Pocosin Lakes NWR are adequately managed for red wolves.	☐	☐	☐	☐	☐	☐	☐

	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	Don't Know
13. If a red wolf is identified as a "repeat offender," it should also be identified as a "nuisance wolf."	☐	☐	☐	☐	☐	☐	☐
14. The current management structure is equipped to handle an increasing number requests for red wolf removal from private property.	☐	☐	☐	☐	☐	☐	☐
15. The Service has adequate facilities to handle captured wolves.	☐	☐	☐	☐	☐	☐	☐

Thank you for participating in this important survey.

Red Wolf Survey
NCWRC Staff

This survey is an important component or the Red Wolf Recovery Program Review that WMI has been asked to complete for the U.S. Fish and Wildlife Service. Please indicate the extent to which you agree or disagree with the following statements. All answers will remain anonymous.

	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	Don't Know
1. The Red Wolf Recovery Program is a positive program for North Carolina.	☐	☐	☐	☐	☐	☐	☐
2. The Red Wolf Recovery Program has been successful at meeting its biological goals.	☐	☐	☐	☐	☐	☐	☐
3. I have suggestions to increase the chances of success of the Red Wolf Recovery Program.	☐	☐	☐	☐	☐	☐	☐
4. The general public is supportive of the Red Wolf Recovery Program.	☐	☐	☐	☐	☐	☐	☐
5. The people that live in the recovery range are supportive of the Red wolf Recovery Program.	☐	☐	☐	☐	☐	☐	☐
6. There is institutional (e.g., state) support for the Red Wolf Recovery Program.	☐	☐	☐	☐	☐	☐	☐
7. The public sector supports the overall recovery plan.	☐	☐	☐	☐	☐	☐	☐
8. Changes can be made to increase public acceptance of the program.	☐	☐	☐	☐	☐	☐	☐
9. The USFWS has been a good partner during the implementation of the Red Wolf Recovery Program.	☐	☐	☐	☐	☐	☐	☐
10. There is effective cooperation occurring with other agencies and the public.	☐	☐	☐	☐	☐	☐	☐
11. The Red Wolf Recovery Program has negatively affected the working relationship between the Service and the North Carolina Wildlife Commission.	☐	☐	☐	☐	☐	☐	☐
12. The Red Wolf Recovery Program has negatively affected the working relationship between the Service and key public stakeholders	☐	☐	☐	☐	☐	☐	☐

	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	
13. The rules and policies issued for the program have been followed by the Service.	☐	☐	☐	☐	☐	☐	☐
14. The Service is responding to the request to have wolves removed from private property appropriately based on what is mandated in the 10j rules.	☐	☐	☐	☐	☐	☐	☐

Thank you for participating in this important survey.

Red Wolf Survey
General Public Focus Groups

This survey is an important component or the Red Wolf Recovery Program Review that WMI has been asked to complete for the U.S. Fish and Wildlife Service. After providing some basic demographic information, please indicate the extent to which you agree or disagree with the following statements. All answers will remain anonymous.

Demographic Questions

Gender: ☐ Male ☐ Female

Race: ☐ White ☐ Black ☐ Hispanic ☐ Other

Age: _____

County _____

City, State _____

Zip _____

General Questions:

	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	Don't Know
1. It is important to attempt to restore rare or imperiled animal species.	☐	☐	☐	☐	☐	☐	☐
2. The general public is supportive of the restoration/recovery of imperiled species.	☐	☐	☐	☐	☐	☐	☐
3. The general public is supportive of the restoration/recovery of red wolves.	☐	☐	☐	☐	☐	☐	☐
4. The Red Wolf Recovery Program is a positive program for North Carolina.	☐	☐	☐	☐	☐	☐	☐
5. Red wolves should be restored to more locations to ensure their continued existence.	☐	☐	☐	☐	☐	☐	☐
6. The Red Wolf Recovery Program has been successful at meeting its biological goals.	☐	☐	☐	☐	☐	☐	☐

Answer these questions only if you live within the five county Red Wolf restoration area.

	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	Don't Know
7. The people that live in the recovery range are supportive of the Red wolf Recovery Program.	☐	☐	☐	☐	☐	☐	☐
8. The USFWS has met or exceeded its commitment to residents of the five county recovery zone.	☐	☐	☐	☐	☐	☐	☐
9. The rules and policies issued for the program have been followed by the Service.	☐	☐	☐	☐	☐	☐	☐
10. Changes can be made to increase local public acceptance of the program.	☐	☐	☐	☐	☐	☐	☐
11. The USFWS has been a good partner during the planning of the Red Wolf Recovery Program.	☐	☐	☐	☐	☐	☐	☐
12. The USFWS has been a good partner during the implementation of the Red Wolf Recovery Program.	☐	☐	☐	☐	☐	☐	☐
13. I have some serious concerns about having red wolves present in my area.	☐	☐	☐	☐	☐	☐	☐
14. I have suggestions for the Red Wolf Recovery Program that would increase public acceptance of the program.	☐	☐	☐	☐	☐	☐	☐
15. I have personally experienced or witnessed damage by red wolves on my property.	☐	☐	☐	☐	☐	☐	☐
16. The Service is responding to requests to have wolves removed from private property appropriately based on what is mandated in the 10j rules.	☐	☐	☐	☐	☐	☐	☐

Please provide any additional comments here. These should include specific concerns that your might have with the wolves, actual damage that you have sustained, or ways to improved the program, increase local support, how the Service can improve it relationship with local landowner, etc.

1. _____

_____

_____

_____

_____

2. _____

_____

_____

_____

_____

3. _____

_____

_____

_____

_____

4. _____

_____

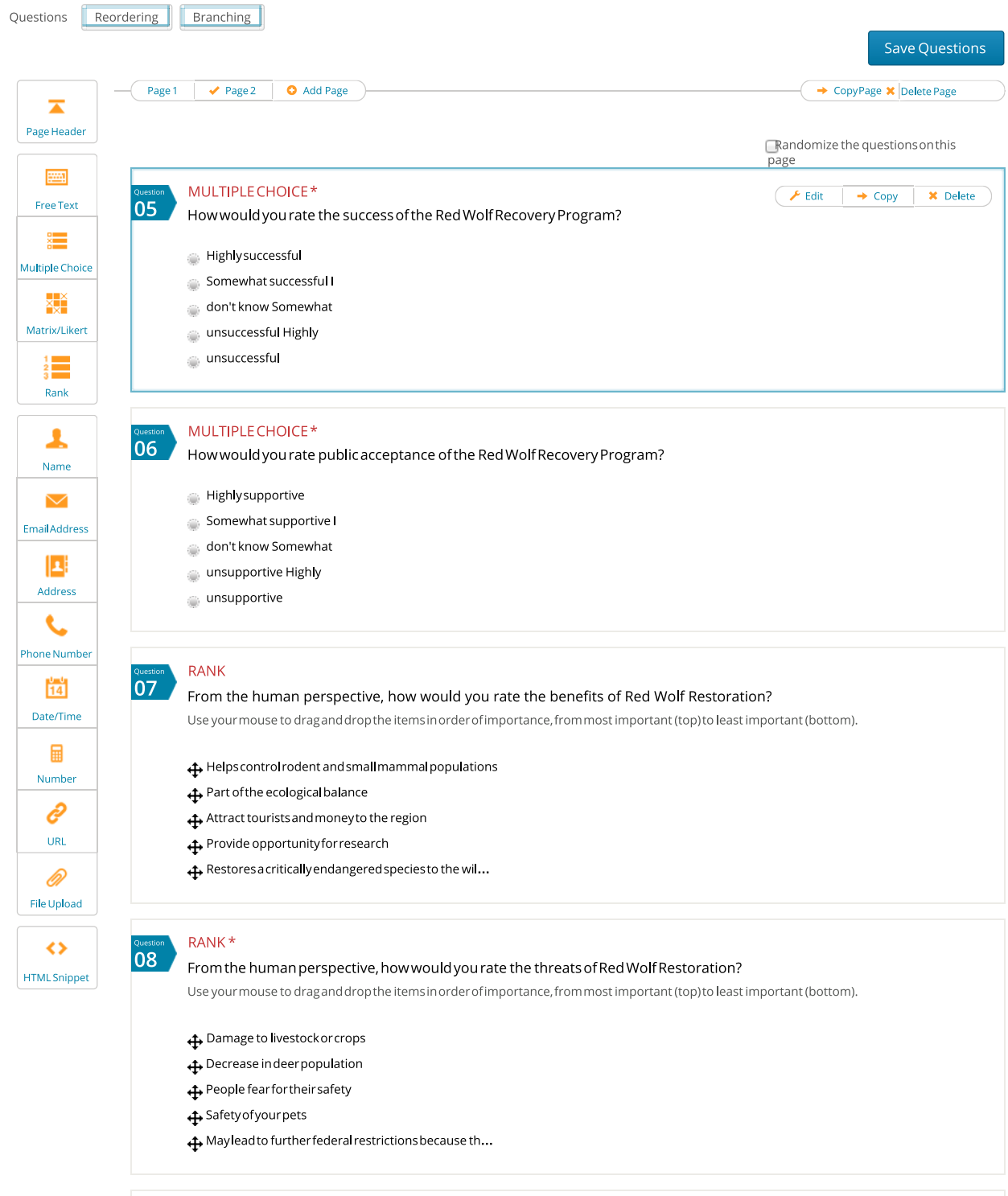
_____

_____

_____

Thank you for participating in this important survey.

Appendix F. WMI's online survey instrument



Question 09

MULTIPLE CHOICE *

If the habitat was available, would you support a Red Wolf Restoration project that was located near you?

- yes
- no
- Other

Please help us understand why you selected this answer

Question 10

FREE TEXT

How do you think the Red Wolf Recovery Program could be improved?

Question 11

FREE TEXT

Please provide any additional comments that you may have on the Red wolf Restoration.

Save Questions

Appendix G. Responses to WMI public meeting surveys, interview surveys, and WMI's online survey

Table G1. General Questions about endangered species and red wolf recovery.

(n=154)	Strongly Disagree n (%)	Disagree n (%)	Slightly Disagree n (%)	Slightly Agree n (%)	Agree n (%)	Strongly Agree n (%)	Don't Know n (%)
It is important to attempt to restore rare or imperiled animal species.	53 (34.6)	18 (11.8)	10 (6.5)	19 (12.4)	18 (11.8)	35 (22.9)	0 (0.0)
The general public is supportive of the restoration/recovery of imperiled species.	53 (34.6)	31 (20.3)	10 (6.5)	16 (10.5)	24 (15.7)	13 (8.5)	6 (3.9)
The general public is supportive of the restoration/recovery of red wolves.	83 (53.9)	31 (20.1)	6 (3.9)	6 (3.9)	12 (7.8)	13 (8.4)	3 (1.9)
The Red Wolf Recovery Program is a positive program for North Carolina.	92 (60.1)	19 (12.4)	4 (2.6)	1 (0.7)	5 (3.3)	31 (20.3)	1 (0.7)
Red wolves should be restored to more locations to ensure their continued existence.	92 (59.7)	20 (13.0)	4 (2.6)	0 (0.0)	8 (5.2)	30 (19.5)	0 (0.0)
The Red Wolf Recovery Program has been successful at meeting its biological goals.	94 (61.0)	13 (8.4)	8 (5.2)	4 (2.6)	15 (9.7)	15 (9.7)	5 (3.2)

Table G2. Specific questions for residents of the five county red wolf restoration area.

(n=132)	Strongly Disagree n (%)	Disagree n (%)	Slightly Disagree n (%)	Slightly Agree n (%)	Agree n (%)	Strongly Agree n (%)	Don't Know n (%)
The people that live in the recovery range are supportive of the Red wolf Recovery Program.	76 (68.5)	16 (14.4)	3 (2.7)	6 (5.4)	2 (1.8)	3 (2.7)	5 (4.5)
The USFWS has met or exceeded its commitment to residents of the five county recovery zone.	88 (66.2)	20 (15.0)	3 (2.3)	0 (0.0)	14 (10.5)	4 (3.0)	4 (3.0)
The rules and policies issued for the program have been followed by the Service.	77 (58.3)	25 (18.9)	4 (3.0)	2 (1.5)	9 (6.8)	5 (3.8)	10 (7.6)
Changes can be made to increase local acceptance of the program.	61 (46.9)	20 (15.4)	4 (3.1)	5 (3.8)	27 (20.8)	9 (6.9)	4 (3.1)
The USFWS has been a good partner during the planning of the Red Wolf Recovery Program.	70 (52.2)	24 (17.9)	9 (6.7)	4 (3.0)	9 (6.7)	10 (7.5)	8 (6.0)
The USFWS has been a good partner during the implementation of the Red Wolf Recovery Program.	74 (55.6)	19 (14.3)	7 (5.3)	4 (3.0)	10 (7.5)	9 (6.8)	10 (7.5)
I have some serious concerns about red wolves present in my area.	38 (29.0)	5 (3.8)	1 (0.8)	4 (3.1)	22 (16.8)	58 (44.3)	3 (2.3)
I have suggestions for the Red Wolf Recovery Program that would increase public acceptance of the program.	35 (28.2)	16 (12.9)	4 (3.2)	5 (4.0)	22 (17.7)	26 (21.0)	16 (12.9)
I have personally experienced or witnessed damage by red wolves on my property.	27 (21.4)	5 (4.0)	1 (0.8)	7 (5.6)	30 (23.8)	46 (36.5)	10 (7.9)
The Service is responding to requests to have wolves removed from private property based on what is mandated in the 10j rules.	39 (29.8)	20 (15.3)	2 (1.5)	9 (6.9)	20 (15.3)	19 (14.5)	22 (16.8)

Table G3. Synopsis of biological comments from participants of the public meetings.

Biological Comments	Response
1. Loss of wildlife/game species due to predation	Educational
2. Concern over increasing "mega-coyotes" thru hybridization	Informational
3. Loss of ability to manage coyotes on private property	Actionable
4. FWS said red wolves would keep out the coyotes	Educational
5. Sterile (placeholder) coyotes still eat deer	Informational
6. Red wolf population and genetics objectives have failed	Educational
7. Project will fail because of coyote hybridization	Educational
8. Coyotes are an invasive species	Informational
9. Stopping coyote hunting will greatly increase coyote numbers	Actionable
10. Fawn recruitment has suffered greatly due to red wolves/coyotes	Informational
11. Red wolf population (breeding pairs) is declining on its own	Actionable
12. Some believe red wolf doesn't exist or is genetically impure	Informational
13. Stabile population of red wolves would decrease hybridization	Actionable
14. Nature creates its own biodiversity	Informational
15. Killing coyotes means loss of "placeholders"	Actionable
16. Red wolf is part of the ecosystem	Informational

Table G3 (cont'd). Synopsis of biological comments from participants of the public meetings.

Biological Comments	Response
17. Need more research/answers on genetics	Actionable
18. Zoos and captive programs are strong partners	Informational
19. Red wolf is not a hybrid, but may hybridize with coyotes	Educational
20. Restoring keystone species is critical	Educational
21. Perform wildlife surveys to determine actual prey densities, would help with hunting argument and setting red wolf population goals	Actionable
22. Removing wolves will not make the coyote problem go away	Educational
23. Healthy predator population supports a balanced ecosystem	Educational
24. Red wolves have to be treated by veterinarians/vaccinations regularly to survive, how is this sustainable	Informational

Table G4. Synopsis of management comments from participants of the public meetings.

Management Comments	Response
1. FWS didn't remove red wolves from private property like they promised even after written requests	Actionable
2. Injunction has impacted legal coyote hunting in five counties	Actionable
3. Make ban on coyote hunting in five counties a permanent rule	Actionable
4. Red wolf program was working and people were not upset about it until the arrival of coyotes	Educational
5. Red wolves are the reason that coyotes are here	Educational
6. Issue take permits under 10j to allow landowners to deal with red wolves on their property	Actionable
7. Red wolves help farmers by keeping deer population in check	Informational
8. FWS cant keep red wolves on refuge like they said they would	Educational
9. People are mistaking coyotes for red wolves and the wolves are getting blamed for coyote issues	Educational
10. Need to establish two more recovery sites and complete the recovery plan	Actionable
11. Need a program designed to let landowners deal with coyotes while letting the red wolf project continue	Actionable
12. Recovery of Endangered Species is a nationwide responsibility and issue, not confined to the five county area	Educational
13. All wildlife has the right to exist	Informational
14. Must control coyotes for success	Actionable
15. Removal efforts need to be executed efficiently and timely	Actionable
16. Mark placeholder coyotes and red wolves visibly so that some coyote hunting can be allowed	Actionable

Table G4 (cont'd). Synopsis of management comments from participants of the public meetings.

Management Comments	Response
17. Program is successful and brought species back from extinction	Educational
18. Need to manage refuges for red wolf habitat	Actionable
19. Red wolves were released on private lands illegally	Informational
20. Need updated recovery plan. Current one is 30 years old	Actionable
21. Need to implement existing plan correctly	Actionable
22. Red wolf can't ever exist without human intervention	Educational
23. Red wolf program has been susceptible to "mission creep"	Actionable
24. Need to complete mandatory five year status review	Actionable
25. Red wolves have reached FWS population goal for this area	Actionable
26. Hunters are good wildlife stewards, but red wolves are hurting hunters	Educational
27. Wildlife, including red wolves, is held in the Public Trust	Educational
28. Habitat management on private land benefits all wildlife, but red wolves are having a negative impact	Educational
29. Should use hunter/trapper as a management tool to help control coyotes	Actionable
30. Land management practices have changed and are not good for red wolves	Informational
31. Fence in large areas to contain red wolves	Actionable
32. Protect the red wolves by leaving them in captivity	Actionable

Table G5. Synopsis of sociological comments from participants of the public meetings.

Sociological Comments	Response
1. Impinges on private property rights	Educational
2. Need to demonstrate importance of program and show that it is not impacting them financially in order to regain support	Educational
3. Overall there is community support, but a few people that don't like the program are stirring the pot	Informational
4. Only people that like red wolves are the people that don't have to live with them	Informational
5. Never been a reported case of a red wolf attacking a human	Educational
6. Need third party mediation services to resolve conflicts	Actionable
7. Local public is upset with Government in general and are taking it out on the red wolf project	Informational
8. Need continuous outreach on the project for the community, perhaps a dedicated communication specialist	Actionable
9. Use social media more effectively to explain the program	Actionable
10. Need major outreach effort with farmers and landowners	Actionable
11. Fear of program and red wolves is driven by misinformation and ignorance	Educational
12. People need to learn how to live with wolves	Educational
13. No history of public safety issues with red wolves	Educational
14. Continuing program may result in lawsuit against FWS from landowners	Informational
15. Must develop better working relationship with landowners	Actionable
16. Some locals depend on deer for subsistence	Informational

Table G5 (cont'd). Synopsis of sociological comments from participants of the public meetings.

Sociological Comments	Response
17. Must have local support for program to be a success	Actionable
18. Other carnivores on landscape that people don't mind (black bears)	Educational
19. FWS didn't keep their promise for many aspects of project	Actionable
20. Need to create a co-existence council like was done for Mexican wolf	Actionable
21. Don't want endangered species on private property	Informational
22. Red wolves are too close to homes	Educational
23. Red wolves are killing pets/livestock	Educational
24. Fear of red wolves attacking children	Educational
25. Red wolves are not fearful of humans	Educational
26. Need extensive public opinion survey of five counties	Actionable
27. Humans removed red wolves from landscape – should put them back	Informational
28. Doesn't want predators on their land or in backyard	Informational

Table G6. Synopsis of other comments from participants of the public meetings.

Other Comments	Response
1. Too expensive. Costs the taxpayers too much	Educational
2. Pay private landowners for red wolf use of their land	Actionable
3. Loss of economic value of property due to low interest in hunt leases	Educational
4. Cost of effective sterilization may be prohibitive	Informational
5. Not a wise use of public dollars	Informational
6. Fund program with private, non-profit organizations	Informational
7. Red wolves improve local economies from tourism	Educational
8. Loss of private property rights (perceived or real)	Educational
9. Current reviewed process is flawed. Need to use the required process for rulemaking/review	Actionable
10. Need to have 60-day comment period.	Actionable
11. FWS is trying to circumvent the review process	Educational
12. FWS failed to keep its commitment to local community	Informational
13. FWS broke the law by not removing red wolves from private property upon request	Informational
14. FWS broke the law by releasing red wolves on private property	Informational
15. FWS broke the law by not keeping red wolves on refuges	Informational

Table G7. Summary of online survey questions 5, 6, and 9.

Survey Item	All Respondents (n=6388)	North Carolina Residents (n=1438)	Recovery Zone Residents (n=265)	North Carolina Residents not in Recovery Zone (n=1173)	Respondents Outside of North Carolina (n=4950)
Q5. How would you rate the success of the red wolf recovery program?					
Highly Successful	28.4%	25.5%	29.4%	24.6%	29.3%
Somewhat Successful	42.2%	36.1%	24.5%	38.7%	43.9%
Somewhat Unsuccessful	6.9%	8.2%	8.3%	8.2%	6.5%
Highly Unsuccessful	6.2%	17.8%	30.9%	14.8%	2.8%
I Don't Know	16.3%	12.4%	6.8%	13.6%	17.5%
Q6. How would you rate public acceptance of the red wolf recovery program?					
Highly Supportive	29.9%	18.7%	13.6%	19.9%	33.1%
Somewhat Supportive	30.4%	29.3%	30.2%	29.2%	30.8%
Somewhat Unsupportive	11.7%	17.8%	14.3%	18.6%	10.0%
Highly Unsupportive	6.6%	20.7%	36.6%	17.1%	2.5%
I Don't Know	21.3%	13.4%	5.3%	15.3%	23.6%
Q9. If the habitat was available, would you support a red wolf restoration project that was located near you?					
Yes	91.4%	71.0%	55.1%	74.5%	97.3%
No	8.6%	29.0%	44.9%	25.5%	2.7%

Table G8. Summary of online survey questions 7 and 8.

Item Ranked as Most Important for Questions 7 and 8	All Respondents (n=6388)	North Carolina Residents (n=1438)	Recovery Zone Residents (n=265)	North Carolina Residents not in Recovery Zone (n=1173)	Respondents Outside of North Carolina (n=4950)
Q7. From the human perspective, how would you rate the benefits of Red Wolf Restoration?					
Restores a critically endangered species to the wild	53.6%	47.2%	41.5%	48.5%	55.5%
Part of the ecological balance	31.6%	26.3%	22.6%	27.1%	33.1%
Helps control rodent and small mammal populations	5.7%	9.4%	11.7%	8.9%	4.6%
Provide opportunity for research	4.6%	10.9%	15.8%	9.8%	2.8%
Attract money and tourists to the region	4.4%	6.2%	8.3%	5.7%	3.9%
Q8. From the human perspective, how would you rate the threats of Red Wolf Restoration?					
May lead to further federal restrictions because they are endangered	35.9%	34.1%	30.2%	35.0%	36.5%
Damage to livestock or crops	17.3%	19.8%	18.5%	20.1%	16.6%
Safety of your pets	16.0%	15.9%	17.7%	15.5%	16.0%
Decrease in deer population	15.9%	18.2%	18.9%	18.1%	15.2%
People fear for their safety	14.9%	12.0%	14.7%	11.3%	15.7%

Table G9. Staff responses to survey (reported in percentages only).

Survey Item	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	I Don't Know
The Red Wolf Recovery Program is a priority of the Service.	0.0%	0.0%	11.1%	11.1%	44.4%	22.2%	11.1%
The Red Wolf Recovery Program has become more of a priority for the Service during the last 20-30 years.	0.0%	0.0%	44.4%	11.1%	27.8%	0.0%	16.7%
Funding for the Red Wolf Recovery Program has increased since the Program's implementation.	0.0%	0.0%	0.0%	5.6%	61.1%	16.7%	16.7%
The budgetary needs of the Red Wolf Recovery Program have increased since the Program's implementation.	0.0%	0.0%	0.0%	0.0%	22.2%	50.0%	27.8%
The Red Wolf Recovery Program has received adequate funding to meet its goals.	0.0%	5.6%	11.1%	16.7%	44.4%	11.1%	11.1%
The Red Wolf Recovery Program has received adequate institutional support to meet its goals.	16.7%	22.2%	22.2%	5.6%	22.2%	11.1%	0.0%
The Red Wolf Recovery Program has been successful at meeting its biological goals.	5.6%	0.0%	0.0%	11.1%	33.3%	44.4%	5.6%
I feel that I can voice my Suggestions to increase the chances of success of the Red Wolf Recovery Program.	0.0%	5.9%	17.6%	11.8%	35.3%	29.4%	0.0%
The public is supportive of the Red Wolf Recovery Program.	0.0%	26.7%	13.3%	13.3%	46.7%	0.0%	0.0%
The USFWS has been a good partner during the planning of the Red Wolf Recovery Program.	0.0%	11.1%	16.7%	11.1%	33.3%	16.7%	11.1%
The USFWS has been a good Partner during the implementation of the Red Wolf Recovery Program.	0.0%	5.6%	16.7%	5.6%	50.0%	16.7%	5.6%
The lands within Alligator River NWR and Pocosin Lakes NWR are adequately managed for red wolves.	11.1%	0.0%	44.4%	0.0%	22.2%	22.2%	0.0%

Table G9 (cont'd). Staff responses to survey (reported in percentages only).

Survey Item	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree	I Don't Know
If a red wolf is identified as a "repeat offender," it should also be identified as a "nuisance wolf."	0.0%	0.0%	22.2%	0.0%	22.2%	0.0%	55.6%
The current management structure is equipped to handle an increasing number of requests for red wolf removal from private property.	11.1%	44.4%	22.2%	11.1%	0.0%	0.0%	11.1%
The Service has adequate facilities to handle captured wolves.	11.1%	66.7%	0.0%	0.0%	11.1%	0.0%	11.1%

Appendix H. Reviewer Comments

Kim Titus, Ph.D., Chief Wildlife Scientist, Alaska Fish and Game Department

Peer Review of
A Comprehensive Review and Evaluation of the Red Wolf (Canis rufus) Recovery Program.
By Kim Titus, Ph.D.
Chief Wildlife Scientist
Alaska Department of Fish and Game

Thank you for the opportunity to provide commentary on *A Comprehensive Review and Evaluation of the Red Wolf (Canis rufus) Recovery Program.* I have reviewed some, but far from all of the supplementary documents provided by the Wildlife Management Institute. The context of my review is based on my 25 years of experience as a wildlife professional with the Alaska Department of Fish and Game. This includes significant experience in wildlife regulatory and planning forums (regional supervisor, deputy director) where regulations are established based on the applied wildlife science presented to a board. Those forums have significant and ongoing input from local wildlife advisory committees, hunting organizations, and conservation groups and federal land management agencies. along with input from sportsmen's groups. More recently I have been very involved in ESA related issues with wolves, goshawks and polar bears. Those ESA planning/recovery activities rely heavily on the best available science, conservation groups, hunting organizations and land owners, all of whom are critical to program success.

General Comments
The review is thorough and excellent. The explanation of the state of the science regarding life history and especially genetics is very good.
***Other Partners?* - The most fundamental I have comment is the relationship between the Fish and Wildlife Service (FWS or Service) and NGO's to aid in the conservation and recovery of the red wolf. The review seems conspicuously silent on a key conservation partnership model that is so widely used. As a wildlife professional, I am perplexed and troubled that a discussion of the relationship among existing potential key partners is lacking. The Service does has extensive experience with such partnerships for recovery and in many instances Service staff note that "we can't do it alone". Notable examples include the grizzly bear and California Condor. In the case of wolves in the western US, the Service relies heavily on various partners for day to day management, particularly state fish and game agencies, NGO's and land managers. Who is helping the Service in recovery and day to day management? Is anyone helping?**
Placeholder strategy - The placeholder strategy is a bit unclear to those not familiar with the program. Readers would benefit from a few sentences explaining the actual practice.
Funding - The review of the low funding seems appropriate. It is noted that the red wolf recovery funding is among the highest priorities for the Southeast Region of the FWS. To me, the budget review is a bit incomplete and it seems low to assist with the recovery of a canid. It is unclear to me how other (non FWS entities) are assisting with efforts, particularly the North Carolina state agency and others, especially certain NGO's. The review seems to be silent on other funding and in-kind support to the project. My current involvement with the polar bear recovery team had the Service lead an effort to have

themselves and all other collaborators (USGS, state of Alaska, North Slope Borough, industry, conservation groups) provide a summary of their potential funding to assist with various efforts. These included scientific data gathering, outreach, harvest management, etc. I can only assume that in the instance of the red wolf recovery a multi-faceted approach to recovery has not been updated with partners.
Is the FWS actually doing the local trapping/moving? Or is Wildlife Services/USDA doing this under contract as is the case in most of the US.
Other states -It is unclear what support, if any exists from other states for releases in their states.
Climate change/sea level rise – This section is thorough to the point of being overly thorough. This part of the review is useful but it seems to place the issue in the same context as the near term issues. I suggest that the near term threats, lack of additional release areas, and lack of a clear strategy about hybridization are far more important.
Red wolf and coyote predation on deer, and human harvest - The review seems to lack an analysis of the predator, prey, habitat/human system from a wildlife and human ecology standpoint. An analysis of this system is often conducted, even if qualitatively, in other areas where wolves occur. Examples include Alaska, western and northern Canada, Minnesota, Yellowstone, and more recently in states such as Idaho, Montana and Wyoming. It is unclear why the Service did not request this robust assessment or ask related questions. Perhaps this is because the red wolf population is so low that such an analysis is unnecessary and recovery is the sole focus. However, one might conclude that such an analysis is still useful, even at this small scale – because the human element is so important to program success.
Budgets, funding and staffing - This section is a very perplexing because it focuses solely on Service funding. Nothing else. Many ESA recovery programs use/rely on a suite of funding, including state agencies, conservation groups, and industry (where possible and necessary) for their operations. A species like the California Condor comes to mind noting the significant differences, especially the vast areas of federal land where the bird is presently found. However, from my perspective there are similarities. The condor occurs in very low numbers, like the red wolf. It is also very much a hands-on management program with birds being trapped and handled on a regular basis. The Peregrine Fund manages much of the day to day operation as I understand it.
If those other entities are not engaged or won't engage in the recovery of this canid, then this is a really important part of the discussion.
The review would benefit earlier on from an analysis about why others could, would or won't participate in the recovery. Certain conservation and hunting/sportsmen's groups have tremendous local credibility that the Service may not be able to bring to the table for a variety of reasons. The review is silent on this aspect of recovery for a species like the red wolf. A similar comment is necessary for the state fish and game agency. Further reading indicates that the relationship between the Service and the NCWRC is "tenuous." There are however, examples where state fish and game agency assistance and local hunter acceptance is key to helping an ESA issue. For the condor, the Arizona Game and Fish Department has an extensive program that relates hunters, lead ammunition, education and condor survival in the northern part of the state. It is unclear until late in the document how the recovery of the red wolf, at a local level, relates to these non-FWS efforts and broader collaboration.

Specific Comments
Is there an approved FWS – Institutional Animal Care and Use Committee process for the trapping/tagging? How does the review and approval occur for the ESA permits?
Page 25 – Variation in projected habitat use and population size. This section seems especially relevant to understanding the potential habitat suitability and prey availability. These analyses are key to future decision-making.
Page 36 – What is unclear in this section is why certain areas of the 1.7 million acre area in the 5 counties is only partially inhabited by red wolves. Also, it seems reasonable that the 144,000 acres of NWR lands are insufficient, yet no particular science analysis is provided. It seems really obvious that this is too small for wolves over the long-term, but some mapping or other visual products would be helpful to the reader. Otherwise the reader has to dive into any number of FWS documents.
Page 36 – If the review had some context of the average size of the pack territory here, the reader would be better able to evaluate the size if various NWR land and private tracts as part of a territory.
Page 37 – identifying additional sites – WMI indicated that they are "unaware of substantive progress on the selection of suitable future sites." It is unclear why this is the case.
Page 38 – The explanation of the captive program seems a bit short.
Page 43 – The sea level rise information is useful and informative if not too long. Then on page 44 there is a notion that red wolves will disperse to the west. This is not surprising but there is no explanation and perhaps no analysis of the habitat, prey and public issues associated with what will surely happen with seal level rise.
Page 45 – Who is capturing/trapping and moving these wolves and are there protocols in place?
Page 52 – is there a written protocol for wolf removal? Same as page 45.
Page 55 - Assessing public awareness and support - I have no reason to dispute the findings from WMI regarding the apparent lack of human dimension research, outreach, etc. My experience in Alaska as a wildlife professional and my current involvement in ESA issues suggests that local support or at least modest acceptance for ESA type of regulations is key to a successful management of species like bears and wolves. Our department invests heavily in public outreach with educators and when possible we join forces with federal agencies when it is in the best interest of the public and their wildlife resource. Because we often have long-time, experienced biologists who live in rural communities, we can sometimes accomplish outreach in ways that federal agencies cannot. I might sense from the review that the same might be true for red wolves and local use of the public's wildlife.
Page 68 – This section is silent on the cooperation, or not, with sportsmen's groups. See general comment.

Michael Phillips, Executive Director, Turner Endangered Species Fund

Dr. Jonathan Gassett
Wildlife Management Institute
226 Victoria Way
Georgetown, Kentucky 40324

October 31, 2014

Dr. Gassett,

I appreciate the opportunity to offer the following comments as an external review of the Wildlife Management Institute's (WMI) draft report *A Comprehensive Review and Evaluation of the Red Wolf (Canis rufus) Recovery Program*. Having been part of the northeastern North Carolina (NENC) red wolf restoration project from its inception in 1986 until 1994, it is an honor for me to offer thoughts on your review and evaluation.

The nature and amount of material considered by the WMI team in preparation of the report was appropriate and impressive. In the body of my comments and at the end of this review I offer a few citations that might improve the final report. I can provide copies of each if that would be helpful.

I apologize if my comments appear scattershot and less than finely developed. I simply ran out of time to improve them. Nonetheless, I hope they are helpful.

Comments

Page 9, 2nd para, 1st sentence: "*On August 11, 2014, WMI signed a contract with the United States Fish and Wildlife Service (FWS) to conduct a review and evaluation of the red wolf recovery program.*"

Page 11, 1st para, 1st sentence: "*The programmatic review of the red wolf recovery and restoration project in eastern North Carolina focused on three distinct aspects: Supporting Science, Program Management, and Human Dimensions.*"

I was a bit unclear about the focus and scope the WMI report. Understandably, it mostly considers the NENC red wolf restoration project. The red wolf recovery program, of course, entails more than one project as WMI alludes to throughout the report. I think, however, that it would be appropriate to make patently clear that while the WMI report considered many aspects of the red wolf recovery program, it principally focused on the NENC red wolf restoration project and does not represent a comprehensive assessment of the red wolf recovery program.

Page 14, 3rd para, 3rd sentence: "*His original job was the Project Leader for the Yellowstone Wolf Project which involved the reintroduction and restoration of wolves to Yellowstone National Park."*

Doug Smith's original job with the Yellowstone wolf project was "Project Biologist" not "Project Leader".

Page 17, 3rd para, 1st sentence: *"The project demonstrated that captive red wolves could be successfully reintroduced into the wild and rear offspring of their own in an area not occupied by coyotes."*

I suggest adding the word "born" after "captive" and before "red". It should be noted that we also determined that captive born red wolves could be acclimated in a manner that seemed to significantly decrease the tendency for individuals to exhibit wide-ranging, post release movements. Given the state of knowledge about wolf restoration in the mid-1980s, these were both important findings that came out of the NENC restoration project.

Page 17, 4th para, 3rd sentence: *If further investigation of red wolf taxonomy ultimately leads the FWS to determine that red wolves are derived from a hybrid origin of coyotes and gray wolves as suggested by Wayne et al (1991), red wolves may no longer qualify for protection under the Endangered Species Act"*

It should be noted that Mech (1970:25) probably was the first to posit that the red wolf was a hybrid owing to wolf x coyote crosses.

Page 18, 1st para, 1st sentence: *"... continued existence of the "pure" red wolf genome (an objective of the current recovery program)."*

It should be clearly noted in the report that the red wolf genome that exists is the product of selective breeding by U.S. Fish and Wildlife (USFWS) biologists in the 1970s. (This issue is also considered on page 84 of the WMI report.). The text on page 18 could be expanded to note that over 400 canids were captured in Louisiana and Texas in the early 1970s and examined for red wolf traits. Of these I recall that about 43 were allowed to breed to determine the nature of pups produced. Of those that were allowed to breed, 14 were chosen as the founding stock for the captive breeding program.

While I recognize that the USFWS biologists did the best they could with the information that was available at the time, it is still true that selectively moving animals through a review process that was based on somewhat arbitrary minimum taxonomic standards (USFWS 1984:10) represents selective breeding that resulted in a certain phenotypic (and probably genotypic) type of red wolf. There is no denying that the existing red wolf genome is something of a human construct. Given Congress' clear intent for the 1973 ESA to serve to conserve genetics (US House Report 1973:143), a clear understanding of the origins of the red wolf genome is of cardinal importance.

Page 26, para 2, last sentence: "*Further, future restoration areas should provide the opportunity for genetic exchange between the 3 populations which will require maintaining connectivity between the areas."*

Decisions by the Service concerning wolf recovery in the Northern Rocky Mountains diminish the claim that recovery would require the maintenance of connectivity between areas to ensure natural genetic exchange. The second supplementary information in Carroll et al. (2014) provides a comprehensive summary of federal efforts to explain why genetic connectivity did not need to be a requisite for delisting the gray wolf in the Northern Rocky Mountains.

Page 27, 5th para, 3rd sentence: *"One approach would be to reintroduce red wolves into a new area of suitable habitat somewhere within the historic range of the species."*

Given circumstances in NENC and the ubiquitous distribution of coyotes, this approach seems misguided.

Page 27, 5th para, last sentence: *"The other approach would be to designate a portion of the current recovery area (e.g. federal lands on the Albemarle Peninsula) for continued application of the placeholder strategy to maintain genetic integrity in that area, while suspending efforts to preclude interbreeding in the remainder of the recovery area."*

This approach makes more sense, although given the contiguous and porous nature of the restoration area to canids, I question whether the apportioning called for by this approach could be adequately assured.

It seems to me that the USFWS may have reached an appropriate time to carefully consider terminating efforts to manage wolf-coyote interactions to minimize hybridization to determine of the red wolf genome can be perpetuated by natural processes. By continuing for 5 to 10 years the intensive and extensive monitoring of both red wolves and coyotes and seeking the support of landowners to tolerate the presence of red wolves throughout the period, the USFWS would be in a position to determine the viability of natural maintenance of the red wolf genome in an area that is highly suitable for the species.

I think that much potential litigation over such an approach could be forestalled if the approach was advanced as an essential experiment to determine the recoverability of the red wolf in the traditional sense of the ESA.

If natural processes are unable to minimize hybridization between red wolves and coyotes to an acceptable level, then one would have to conclude that the red wolf simply lacks the ability to persist in the wild absent persistent management efforts to prevent hybridization with coyotes.

Anticipating this outcome that WMI report could explore, at least briefly, the notion of the red wolf as a conservation-reliant where delisting in the traditional sense (establishment of a sufficient number of self-sustaining populations across all but an insignificant portion of the species' historical range) is highly unlikely. This is a useful concept even though some argue (Carroll et al. 2014) that it has been too casually applied by some proponents (Scott et al. 2005, Scott et al. 2010, Goble et al. 2012).

As a guard against a casual application of conservation-reliant concept, the WMI report could consider (briefly) the recoverability of the red wolf against the relatively narrow and explicit definition of Carroll et al. (2014): those species that lack the ability to persist in the wild in the absence of direct, persistent, and ongoing human manipulation of individuals or their environment due to the presence of insurmountable technical challenges posed by novel ecological stressors.

Unfortunately, the red wolf's ultimate contribution to imperiled species conservation work may be as a well understood example of one of many species for which recovery in the typical sense of the 1973 ESA (i.e., self-sustaining populations) is simply not possible because of insurmountable technical challenges posed by a novel ecological stressor. In the case of the red wolf the novel stressor is the propensity to hybridize with coyotes, a very resilient congener for which eradication from any reasonably sized area is not a practical management aim. Indeed as pointed out by Hinton et al. (2013:729): "*As history has proven, coyote populations are too resilient to state and federal eradication programs and clearing the Albemarle Peninsula of coyotes poses an overwhelming challenge*." And as pointed about by Carroll et al. (2014:5):
"*... a species that requires repeated population augmentation or intensive control of invasive competitor or predator species (*or congener with which it readily breeds and produces vigorous, fertile offspring) *or disease does conflict with the paradigm of listing as a temporary stage followed by recovery of self-sustaining populations."*

Such a conclusion that the red wolf in a conservation-reliant species for which delisting is not possible should not be viewed as an opportunity for the USFWS to 'wash their hands" of the species, but rather to redouble efforts to find strategic and cost-effective ways to ensure the continued existence of the species in some form or fashion. It might be possible, for example, for a small number of free-ranging red wolves to occupy mainland Dare County which given its peninsular nature could possibly be maintained free of coyotes through active management by staff from the Alligator River National Wildlife Refuge and the Dare County Bombing Range.

Page 30, 4th para, 2nd sentence: *"As discussed under the preceding questions, this suggests the FWS may need to revisit and revise the red wolf recovery plan."*

This statement should be strengthened by removing all qualifiers and then repeated where appropriate throughout the WMI report. It is patently unacceptable that the recovery planfor a data rich, controversial, noteworthy, and handsomely funded effort has not been updated for 24 years. This is especially true for a plan that does not present downlisting or delisting criteria and clearly states the need for an update as early as 1995 (USFWS 1990:Executive Summary). The 2007 5-year review (USFWS 2007) and the 2009 red wolf action plan (USFWS 2009) both called for revising the recovery plan it remains noteworthy that seemingly no progress on this important front has been made.

Page 35: The entire sentence that is footnote #3 to Table 2 needs to be presented -- *"Additionally, the Service does not believe that private land should be summarily excluded from consideration."*

The importance of private land is a point that the WMI report should emphasize. Not only does private land offer much suitable habitat for red wolves and typically no demonstrable problems arise from wolves occupying such settings (and when problems do arise typically they are easily resolved), but in the U.S. with wildlife managed as a public trust, it is problematic to provide private landowners the authority to demand that publicly owned wildlife be removed absent a problem. Such authority was not provided to private landowners in response to gray wolf reintroductions in Yellowstone National Park and central Idaho. Curiously, such authority was provided to landowners in the southwest in response to Mexican wolf reintroductions. Predictably, the authority has been exercised to hinder that restoration effort.

The red wolf is not unique among the roster of imperiled species in its reliance on private land for a secure future. If, as a matter of course, the Service acquiesces to the demands of private landowners to remove imperiled species in the absence of problems, then recovery for many listed species, especially those reliant on reintroduction projects, will remain a pipe dream.

Page 37, section d.:
The recovery plan is in desperate need of updating. The WMI report should make this point very
clear. Even an interim recovery plan that fell short of deciding on the fate of the recovery effort
(e.g., did not present downlisting and delisting criteria) but only updated knowledge about the
species and laid the scientific and administrative foundation for reaching a reliable decision about the potential for the red wolf genome to be perpetuated naturally (i.e., in the absence of intense management of wolf-coyote interactions) would be a decided improvement.

Page 38, 1st para, 1st sentence: *"WMI concluded that the recovery plan should be reviewed, updated and/or revised to incorporate the 27 years of knowledge and experience associated with the 5 county recovery area program."*

This is perhaps the most important finding in the WMI report.

Pages 38-45:
The section on climate change, especially sea level rise is very useful. It did remind me, however, of the need to be consistent with measurement units throughout the document.

Page 45, 3rd para: "*FWS staff reported to WMI that some red wolves were released on private property with the permission of the landowner. These actions conflict with the 10(j) Rule that stated red wolves would be released on the Alligator River NWR property. WMI was provided with a list of releases that indicated that of 132 releases of red wolves between 1987*

and 2013, 64 were released on private property. WMI is unaware if agreements existed between the FWS and private landowners with respect to these releases; however, they appear to be in contradiction to the 1986, 1991, and 1995 10(j) final rules."

Further investigation by WMI should reveal that agreements were in place to allow lawful releases on private land and wolves to occupy private land.

While it is appropriate to draw critical light to inconsistencies between field practices and final rules that governed the NENC restoration project, it is also appropriate to highlight the cutting edge work by project staff to memorialize useful, functional relationships with landowners (that mightily benefitted red wolves) in executed agreements and faithfully maintained hand shake agreements. I have spent decades focusing on the role of private land to recovery of listed species. I know as well as anyone that in many important respects the NENC red wolf restoration project is an outstanding example of how to realize the potential of private land to advance recovery of a controversial imperiled species.

The WMI report does not sufficiently highlight this important characteristic of the NENC red wolf restoration project.

Page 47, 2nd para: "*During the course of the recovery program, the programmatic oversight has changed from the Refuge program to the Ecological Services program. The change should better position the program from an oversight and supervisory perspective. Obviously, the close working cooperation between Refuges and Ecological Services must be maintained.*"

When the NENC restoration project began, programmatic oversight was assigned to and provided by Ecological Services. Both Warren Parker and Gary Henry, who served as red wolf recovery coordinators for the USFWS, worked for Ecological Services. As the field coordinator for restoration project I was directly supervised by the Alligator River NWR manager (John Taylor and then Jim Johnson), but I worked closely with Parker and Henry. Gary Henry was still serving as the red wolf recovery coordinator (as Ecological Services staff) when I left the red wolf project to lead the effort to restore the gray wolf to the Greater Yellowstone Ecosystem by reintroducing wolves to Yellowstone National Park.

Page 47, last para: "*WMI expected greater oversight and support for a landmark recovery program involving one of the most imperiled canids in the world. Declining population growth without a scientific explanation, lack of public outreach, lack of captive facility capacity, lack of the identification of suitable alternative reintroduction sites, and the lack of a rigorous adaptive management that includes evaluation and analysis, are signs of a program that is in need of additional review and course correction*."

I think this is a very useful conclusion. A critically important part of any useful course correction would be updating the red wolf recovery plan. It also makes imminent sense to me that as part of any course correction the USFWS should assemble a red wolf recovery team to assume responsibility for updating the recovery plan and providing technical and other support as practicable to the NENC restoration project.

Page 48, 2nd para, 1st sentence: "*From a budgetary perspective, the red wolf recovery program is the highest priority within the Southeast Region.*"

I find it shocking that the NENC restoration project was handsomely funded without any functional response by the USFWS to update the recovery plan. Not long after 1995, updating the recovery plan should have been a primary task of the recovery coordinator, appropriate regional office staff, and a properly assembled recovery team. The WMI report could suggest that such a team should be led by someone other than the USFWS's red wolf recovery coordinator. This would increase the capacity of the recovery program, at virtually no cost to the federal government, and would provide potentially useful independence for the recovery team. This arrangement has served other endangered species recovery programs well.

A case can be made that the 1999 population and habitat viability analysis (Kelly et al. 1999) was designed to be a de facto recovery planning exercise. That design was, however, set aside at the outset of the workshop when participants realized the gravity of the hybridization problem.

Not surprisingly the workshop led to the determined application of field-based efforts to manage red wolf – coyote interactions to minimize hybridization. Then the understandable decision was made to set recovery planning aside for several years to determine if such management efforts could be successful. But surely between 2005 and 2007 it would have been appropriate to restart the updating process for the 1990 recovery plan. And the 2007 5-year status review (USFWS 2007), which the WMI report (page 83) referred to as a recovery plan update, actually fell well short of that mark.

Page 52, Table 2:
I believe that the budget estimates provided are inflated. For example, I am certain that research on two potential restoration sites could be accomplished for far less that $500,000. To support this claim I note that less than $100,000 was spent to assess habitat suitability for the Mexican wolf throughout the southwestern U.S. and northern Mexico. That work has had a marked influence on the assembly of an updated Mexican wolf recovery plan and was of such quality that three peer-reviewed publications resulted (Carroll et al, 2003, Carroll et al. 2006, Carroll et al. in press).

Estimating funding needs for the NENC red wolf restoration project and other components of the red wolf recovery program would be an important part of any effort to update the 1990 recovery plan.

Page 53, 1st para, 3rd sentence: "*We also concluded that GPS telemetry collars, although expensive, could provide real time locations of collared individuals that would assist FWS to respond to landowner requests and determine the legitimacy of those requests. Further, they would improve data collection and provide better information for managers and landowners within the recovery area.*"

I am ambivalent about the need for a large number of GPS collars.

Page 53, 3rd para: "*WMI believes that the designation and management of "repeat offenders" and "nuisance wolves" is a policy decision of the FWS that requires recommendations outside the scope of this report. However, we would note that the establishment of additional recovery areas would allow the transfer of red wolves from one site to another possibly diminishing the concern about the disposition of "nuisance" wolves.* "

I think that on average nuisance wolves would be poor candidates for re-release at "additional recovery areas." At a minimum the final sentence of 3rd paragraph need to be qualified by replacing "would" with "may under certain circumstances".

Page 54, 3rd para, final two sentences: *"The "Collaborative Conservation of Red Wolves and Other Canids on North Carolina's Albemarle Peninsula" memorandum of understanding (FWS/NCWRC MOU) signed by the FWS and NCWRC in 2013 detailed a substantial commitment for cooperation between the agencies to benefit canid management. We do note that the relationship between the FWS and NCWRC law enforcement staff was cooperative."*

Given the executed Collaborative Conservation MOU and the cooperative relationship between federal and state LE staff, I am at odds to understand how the furor over coyote hunting ever came to pass. The MOU would seem to be the ideal platform for establishing a lasting and durable solution to the current controversy.

Such a solution could provide the USFWS the necessary latitude to address at least some of the persistent shortcomings of the NENC restoration project (e.g., potential of the red wolf genome to be perpetuated naturally) and the recovery program generally (e.g., lack of a current, scientifically reliable recovery plan).

The WMI report should consider emphasizing the potential capacity of the executed Collaborative Conservation MOU to play a central role in resolving the current controversy.

Pages 55 – 62:
I appreciate that WMI notably flagged the shortcomings of the surveys. Given the biased nature of the surveys, I think the data that resulted have marginal value.

Page 62, 3rd para: "*Finally, WMI has concluded that the red wolf recovery program has a strong biological focus but lacks an interdisciplinary approach to public outreach and engagement that would garner public support and acceptance of the red wolf recovery efforts in the 5 county area. WMI believes that the (as described in the FWS/NCWRC MOU). Nature abhors a vacuum, in the absence of public information and transparency; the public will be left to speculate and to, at times, conjure up misconceptions and controversies that may or may not be valid*."
As I think you were trying to say with the 2nd sentence (which is incomplete), the Collaborative Conservation MOU would seem to be a great compass for navigating out of the storm created by the recent court ruling about shooting coyotes. If that's not where you were headed with the 2nd sentence, then please consider that direction.

Page 62, 5th para: *"WMI concluded that additional funding for GPS telemetry collars would assist monitoring and research. In addition, these collars would provide additional information for staff and the public with respect to the management of wolves that travel across private property. We also believe that additional funding may be required for a rigorous analysis of the effectiveness of the placeholder strategy and for human dimensions research and conflict resolution efforts within the recovery area."*

As stated previously, I'm ambivalent about the need for extensive use of GPS collars.

I do agree that there is a need for a rigorous assessment of the placeholder strategy. I also believe that the WMI report could find that after over a decade of active management of red wolf-coyote interactions to minimize hybridization, a case can be made to determine empirically if the red wolf genome can be maintained naturally (i.e., without the placeholder strategy being
employed). After an appropriate period of time (e.g., 5 to 10 years) monitoring data would reveal what is possible after establishing a core red wolf population that includes ~ 100 animals.

During this period of assessing the "natural maintenance of the red wolf genome" (by monitoring the consequences of terminating the placeholder strategy and other efforts to minimize hybridization) it would be important to continue to recruit landowners to allow red wolves to occupy private holdings. Recruitment would advance the likelihood of natural maintenance succeeding and is consistent with the type of post-delisting activities (assuming the restoration of at least two other red wolf populations that counted toward recovery) that could be reasonably included in an adequate North Carolina red wolf management plan (or any state management plan for that matter).

If the data indicated that the red wolf genome was being lost, then the Service would have to wrestle with the challenge of advancing the persistence of a true conservation-reliant species (i.e., a species that is impossible to recover in the traditional sense) (Carroll et al. 2014).

And if the data showed that the red wolf genome persisted in the absence of the placeholder strategy, then the Service would have a much clearer sense of what was required to restore the other red wolf populations that are requisite to delisting the species.

When considering the wisdom of using the WMI report to advance the notion of assessing the natural maintenance of the red wolf genome, it is important to recall that early on principals with the red wolf recovery program hypothesized that for a large enough wolf population (i.e,, a core population) hybridization would not be a primary concern. Perhaps a case should be made that ~ 100 wolves (all at least a couple generations removed from captivity) should stand as the "core population" against which to test the "natural maintenance hypothesis".

If current circumstances that define the NENC red wolf population are not appropriate for initiating an assessment of the natural maintenance hypothesis, then it is incumbent on the USFWS to define the requisite circumstances (e.g., the size and social and spatial characteristics of the red wolf population and their stability, sources of mortality, etc.) and then take those steps necessary to achieve them to move post haste to initiation of the assessment of the hypothesis. I recall that as recently as 2004 and 2005 the NENC red wolf population included over 20 stable packs configured as a core population that seemed to prevent coyotes from establishing sufficiently to pair and breed with red wolves. If data can be retrieved that support this recall, then maybe the 2004/2005 population is the target core population to establish before initiating efforts to determine the capacity of natural processes to maintain the red wolf genome.

By completing whatever actions are needed to create a core red wolf population that would justify a move to assess the natural maintenance hypothesis, the USFWS would have eliminated all threats (excepting hybridization) to that wolf population that would otherwise prevent it from contributing to recovery of the species in the traditional sense of the ESA (i.e., self-sustaining populations).

This would represent a substantial achievement and would focus the recovery program on the one issue that has clouded its future since inception -- the likelihood of the red wolf being successfully restored as self-sustaining populations in a landscape occupied by an unknown but persistent (and possibly increasing) number of coyotes.

One could argue that post-delisting activities should include active management of red wolf – coyote interactions to minimize hybridization, assuming of course that at least two other red wolf populations had been restored that were large enough to contribute to recovery and were only threatened by hybridization. However, given the potential intensity and chronic nature of activities necessary to minimize hybridization, it would be easy to conclude that they actually fall well outside the type of management actions that should be included in any state management plan that the USFWS would need to approve before delisting could be achieved. If that conclusion was reached (which seems likely) then the red wolf could not be delisted until the threat of hybridization had been eliminated naturally.

When considering the likelihood of the natural maintenance hypothesis being affirmed, it is important to note the final two sentences from the preface of the 1990 recovery plan (USFWS 1990): "*If this study demonstrates that red wolves successfully compete with resident coyotes, then objectives set forth in this plan can likely be achieved. If, however, it becomes evident that the two wild canids exhibit social interactions and interbreeding, then the fate of the red wolf will likely rest with island sanctuaries where the genetic integrity if <u>Canis</u> <u>rufus</u> can be maintained only through long-term management.*"
The study referred to in the passage above was the reintroduction effort in the Great Smoky Mountains National Park. At the time the 1990 recovery plan was approved, the NENC
restoration effort was deemed apparently successful; wolf-coyote interactions would not become an issue there until ~ 1994.

A realistic assessment of past and present circumstances surrounding red wolf – coyote hybridization indicates that recovery in the traditional sense may not be possible. The USFWS should move posthaste to resolve lingering uncertainty around this important issue. The NENC restoration project should be managed to provide maximal assistance in this regard. The WMI report would be justified in identifying this as its most important finding.

Page 63, 2nd para: *"WMI is familiar with community engagement efforts of the FWS (e.g., Blackfoot Challenge) that could improve community relations in the recovery area.*"

The Blackfoot Challenge is noteworthy in many respects, and it probably offers lessons to the NENC red wolf restoration project. It is worth noting, however, that the Blackfoot Challenge is based on an approach that focuses on the majority of issues the unite folks while avoiding those issues that divide. For myriad reasons, wolf restoration may be a problem that divides more than it unites thus defying the capacity of many traditional collaborative approaches like the Blackfoot Challenge.

To some extent this can be counter-balanced by a determined federal approach that makes clear the USFWS's intent to exercise its authorities under the ESA to restore a population of red wolves in NENC that will count toward recovery of the species. Local folks may be far more inclined to participate in a Blackfoot Challenge type arrangement if they believe that free-ranging red wolves are simply a fact of life in northeastern North Carolina.

Given the importance of shooting as a source of mortality for red wolves, the recent court ruling created an ideal opportunity for the USFWS to manifest such intent by redoubling efforts to establish a core red wolf population that allows for a test of the natural maintenance hypothesis considered above. The WMI report could offer this opportunity as an important finding.

Page 65, 11th bullet: "At least two approaches that would allow the FWS to experimentally assess the ability of red wolf genes to persist in the absence of active efforts to preclude hybridizations."

Please see above for a third approach to determine the capacity of the red wolf genome to persist naturally (i.e., without active field efforts to manage wolf-coyote interactions to minimize hybridization).

Page 65, 8th bullet: "*Reintroduction of red wolves to other areas would increase the program's redundancy and resiliency.*"

Additional reintroduction projects would also increase the recovery program (Shaffer and Stein 2000). And all three – representation, resiliency, redundancy – constitute relevant aspects of conservation science that the USFWS now routinely uses in delisting decisions (e.g., USFWS 2009).

Page 65, 12th bullet: *"Future restoration areas should provide the opportunity for genetic exchange between the 3 populations."*

As already mentioned, natural genetic exchange may not be required for delisting the red wolf. The second supplementary information in Carroll et al. (2014) serves as a comprehensive summary of federal efforts to justify a lack of genetic connections as a requisite for delisting the gray wolf in the Northern Rocky Mountains. Given the relative lack of connecting habitat in the southeastern United States, and the infrequent need for genetic rescue of any restored population of red wolves that was large enough to count to recovery (e.g., > 100 animals), human-assisted genetic management could be a part of any assemblage of satisfactory red wolf management plans that would be implemented post-delisting by the affected states.

It is much harder to imagine how active management of wolf-coyote interactions to prevent hybridization could reasonably be expected to be a component of adequate state plans for managing red wolves as a recovered species (see above for more thoughts on this).

Page 68, 8th bullet: *"The 10(j) Rule was deemed necessary to gain public acceptance for the reintroduction in the Alligator River and Pocosin Lakes NWRs."*

The 10(j) approach also advanced the support of federal agencies affected by the reintroduction project (e.g., the Department of Defense) and favorably affected the prospects of other reintroduction projects for the red wolf and other imperiled species (Parker and Phillips 1991). The 10(j) approach should not be construed as eliminating protections for red wolves on public or private land or the "right" of red wolves to occupy private land, just like other species of wildlife, in the absence of a real problem. The WMI report would be justified in making sure that the intent and limitations of the 10(j) designation were well presented. This would serve as important ballast against the likely widespread misunderstanding of section 10(j) among state and federal biologists and administrators and the general public. It is, for example, not widely acknowledged that any 4(d) rule promulgated for a reintroduction project is only lawful if is advances recovery of the species in question. A case can be made that removing red wolves from suitable tracts of private land absent a bona fide problem does not advance recovery and is therefore unlawful.

Page 72, 3rd para, last sentence: *"In addition to captive breeding sites across the U.S., island propagation sites were set up in South Carolina, Florida, and Mississippi to provide "wild-reared" wolves for reintroduction in North Carolina (van Manen et al. 2000)."*

The island propagation projects were also justified on the grounds that they could facilitate reintroduction projects on other public lands on the mainland. This was especially the case for the Bulls Island project, which is proximate to the Francis Marion National Forest which was viewed an appropriate site for considering a mainland reintroduction project. (This still might be the case).

Page 77, 1st full sentence: *"Karlin and Chadwick (2011) examined non-breeding wolves in packs and determined that a non-breeding wolf typically is related to the female (offspring), which likely explains why he was allowed to stay in the pack the pack.*"

Delete the second occurrence of "the pack".

Page 78, 1st para, 1st sentence: *"Red wolf observed and documented habitat use within the Red Wolf Recovery Area as well as provides managers with valuable information about both the suitability and availability of habitat within the current area.*"

Calling NENC "the Red Wolf Recovery Area" seems to diminish the need to restore additional populations to recover the species. It seems more appropriate to call the NENC area "The Red Wolf Restoration Area".

I think the WMI report should offer standard language throughout that draws a clear distinction between efforts to use **reintroductions** and subsequent management of released animals and their offspring to **restore** a population that contributes to **recovery**. All too often confusion is created when related words (e.g., reintroduction, restoration, recovery) are used too casually and inconsistently.

Page 80, 1st para, 5th sentence: *"The authors conclude that if conservation of the red wolf is possible, it will not take place on protected natural landscapes along but on a patchwork of natural, managed, and human altered areas (Dellinger et al. 2011).*"

I think the word "along" needs to be replaced with "alone".

Page 81 Taxonomy:
Nowak et al. (1995) and Phillips and Henry (1992) provide useful background about red wolf taxonomy and should be considered by the WMI report.

Page 83, 1st para, 4th sentence: "*The 2007 Recovery Plan Update included research that calculated an intrinsic rate of increase as 0.346 (0.037, 0.655; 95% CI), which is comparable to other wolf species (USFWS 2007)."*

While a useful document resulting from a useful exercise, it is incorrect to consider USFWS (2007) to be a recovery plan update. It was a listing review to determine if the status of red wolf under the ESA should be changed. It is noteworthy that the 6th recommendation for "Future Actions" (USFWS 2007:34) indentifies the need to "*Draft a new recovery plan and species survival plan for the red wolf*."
Page 84, 1st para, last sentence: "*The USFWS is attempting to address this issue by implementing an Adaptive Management Program, whereby sterilized coyotes are introduced into the red wolf population to mate with a red wolf that lost a mate to help hold a place for another red wolf to come into the pack, while not being able to reproduce (Hinton et al. 2013)."*

I think that "to mate with" needs to be replaced with "to pair with".

Page 86, 1st para, 4th sentence: "*Dellinger et al. (2011) indicates that red wolves already paired with a coyote will leave their mate if the opportunity arises to pair with a red wolf.*"

I was unable to find any support for this remarkable statement in Dellinger et al. (2011), which is not surprising since the paper presents data about food habits based on scat analysis. Further I was not able to find support for this remarkable statement in Dellinger et al (2012).

Given the importance of the claim that red wolves paired with coyotes will leave their mates if the opportunity arises to pair with a red wolf, the proper citation should be identified. I reviewed several other papers but was unable to find clear evidence supporting the claim in question.

Page 87:
Phillips and Scheck (1991) provide useful data on parasitism in captive and reintroduced red wolves.

Page 88, 3rd para, 1st sentence: *"Historically, the general public attitude towards wolves has been strongly negative (Mech 2012)*."

The best social work about wolves has probably been done by Stephen Kellert. I can provide several citations if there is interest.

Before finalizing the WMI report that authors should take note of Quintal (1995) and Rosen (1997). Both present public survey data of relevance to the NENC restoration project and red wolf recovery more generally.

Page 88, 4th para: *"Historically, the general public attitude towards wolves has been strongly negative (Mech 2012). The sanctioned persecution through bounties and other targeted extermination programs is well-documented and lead to drastic population declines by the early 20th century. Since the passage of the Endangered Species Act in 1967, the general perception of wolves has seemed to improve driven largely by the popular media; however, negative media coverage has been shown to affect public opinion as well (Mech 2012, Williams et al. 2002, Enck and Brown 2002).*

Heberlein (2012) is an important work that might contribute usefully to WMI's consideration of the public's perception of the NENC red wolf restoration project.

Phillips (1990) provides an early look at some measures of public attitudes about the NENC project, and might be a useful addition to the WMI report.

Page 88, 4th para, 3rd sentence: *"The USFWS engaged landowners through a "Safe-Harbor" program to facilitate cooperation while addressing landowner concerns (USFWS 2013).*

Safe Harbor programs create opportunities to engage private landowners and are best employed to advance the prospects of reintroduction programs that involve individuals released as "endangered" under the ESA. Similar opportunities can be created by reintroducing individuals as members of an experimental/non-essential population per section 10(j) of the ESA. This approach is probably favorable for red wolf reintroductions compared to safe harbor since it does not require landowners to generate any conservation benefits for red wolves to take advantage of the accommodating provisions of the 4(d) rule that is required by 10(j).

Page 89, 4th para, 2nd sentence: *"Understanding the underlying perspectives of stakeholders is important before attempting to modify attitudes (Mazur and Asah 2013, Lute and Gore 2014)."*

Heberlein (2012) is an important work that might contribute usefully to WMI's consideration of the public's perception of and attitudes toward the NENC red wolf restoration project.

Page 91, 2nd para, 4th sentence: *"The North Carolina Coastal Resources Commission Science Panel on Coastal Hazards used these estimates to determine that North Carolina will likely see an increase of 0.4 meters to 1.4 meters of sea-level rise by the end of the century, and the Panel recommends adopting a one meter rise scenario by 2100 for policy and decision-making purposes in the state (2010)."*

"NCCRC" needs to precede 2010 in the parentheses.

Page 95, 3rd para, 2nd sentence: *"Previous research documented pocosins being used by red wolves, which make up a significant portion of Zone 1 and Alligator River National Wildlife Refuge."*

A citation is needed to support this statement. During my tenure and I think ever since telemetry data have indicated that pocosins are not used to any notable extent by red wolves (Dellinger et al. 2012.

Thanks again for the chance to contribute thoughts. It was a pleasure to review WMI's draft report *A Comprehensive Review and Evaluation of the Red Wolf (Canis rufus) Recovery Program.* I stand ready to continue to help advance red wolf recovery as practicable.

Sincerely,

Mike Phillips
Executive Director
Turner Endangered Species Fund

1123 Research Drive
Bozeman, Montana 59781
P 406.556.8500
C 406.599.5857
E mike.phillips@retranches.com

Literature Cited
(only those citations in the comments above that were not included in the WMI report)

Carroll, C., M. k. Phillips, N. H. Schumaker, and D. W. Smith. 2003. Impacts of landscape change on wolf restoration success: planning a reintroduction program based on static and dynamic models. Conservation Biology 17:536-548.

Carroll, C., M. K. Phillips, C. A. Lopez-Gonzalez, and N. H. Schumaker. 2006. Definint recovery golas and strategies for endangered species: the wolf as a case study. BioScience 56:25-37.

Carroll, C, R. J. Frederickson, R. C. Lacy. In press. Developing metapopulation connectivity criteria from genetic and habitat data to recover the endangered Mexican wolf. Conservation Biology.

Carroll, C., D. J. Rohlf, B. Hartl, M. K. Phillips, R. F. Noss. In press. Connectivity conservation and endangered species recovery: a study in the challenges of defining conservation-reliant species. Conservation Letters.

Dellinger, J. A., C. Proctor, T. D. Steury, M. J. Kelly, and M. R. Vaughn. 2012. Habitat selection of a large carnivore, the red wolf, in a human-altered landscape. Biological Conservation 157:324-330.

Heberlein, T. A. 2012. Navigating environmental attitudes. Oxford University Press, Oxford. 228 pp.

Mech, L. D. 1970. The wolf: the ecology and behavior of an endangered species. Natural History Press, Garden City, New York. 384 pp.

Nowak, R. M., M. K. Phillips, V. G. Henry, W. C. Hunter, and R. Smith. 1995. The origin and fate of the red wolf. Pages 409 – 415 in L. N. Carbyn, S. H. Fritts, and D. R. Seip, eds. Ecology and conservation of wolves in a changing world. Canadian Circumpolar Institute, Occasional Publication No. 35. 642 pp.

Parker, W. T., and M. K. Phillips. 1991. Application of the experimental population designation to recovery of endangered red wolves. Wildlife Society Bulletin 19:73-79.

Phillips, M. K. 1990. Measures of the value and success of a reintroduction project: red wolf reintroduction in Alligator River National Wildlife Refuge. Endangered Species Update 8:24-26.

Phillips, M. K., and J. Scheck. 1991. Parasitism in captive and reintroduced red wolves. Journal of Wildlife Diseases 27:498-501.

Phillips, M. K., and V. G. Henry. 1992. Comments on red wolf taxonomy. Conservation Biology 6:1-4.

Quintal, P. K. M. 1995. Public attitudes and beliefs about the red wolf and its recovery in North Carolina. M.Sc. Thesis, North Carolina State University, Raleigh. 75 pp.

Rosen, W. 1997. Red wolf recovery in northeastern North Carolina and the Great Smoky Mountains National Park: public attitudes and economic impacts. Department of Policy Analysis and Management, Cornell University, Ithaca, New York.
Scott, J. M., D. D. Goble, A. M. Haines, J. A. Wiens, and M. C. Neel. 2010. Conservation-reliant species and the future of conservation. Conservation Letters 3:91-97.

Scott, J. M., D. D. Goble, J. a. Wiens, D. S. Wilcove, M. Bean, and T. Male. 2005. Recovery of imperiled species under the and Endangered Species Act: the need for a new approach. Frontiers Ecology and Environment 3:383-389.

Shaffer, M. L., and B. A. Stein. 2000. Safeguarding our precious heritage. Pages 301 – 322 in B. A. Stein, L. S. Kutner, and J. S. Adams, eds. Precious heritage: the status of biodiversity in the United States. Oxford University Press, Oxford, UK. 399 pp.

US House of Representatives. 1973. Endangered and threatened species conservation act of 1973. US House Report No. 93-412:140-179.

USFWS. 2009. Final rule to identify the northern Rocky Mountain population of gray wolf as a distinct population segment and to revise the list of endangered and threatened wildlife. Federal Register 74:15123-15188.

John Kilgo, Ph.D., Research Wildlife Biologist, U.S. Forest Service Southern Research Station

31 October 2014

Dr. Jonathan Gassett
Wildlife Management Institute
226 Victoria Way
Georgetown, KY 40324

Dear Dr. Gassett,

Thank you for the opportunity to serve as an external reviewer for WMI's programmatic review of the U.S. Fish and Wildlife Service red wolf recovery program. I have completed my review and I found the document to provide an insightful and thorough description of the successes, failures, challenges, and status of the red wolf recovery program. Following are a few comments.

1. Pages 21-24 (Population dynamics): You appropriately conclude that given the ongoing nature of the FWS analysis of population dynamics, you were "unable to ascertain the specific reasons for the decline in the red wolf population." However, it seems clear that gunshot mortality to breeding wolves could explain the decline. I agree that this should not be offered as the definitive cause of the decline, but I suggest that it could appropriately be more strongly emphasized as a likely potential cause, pending further analysis and confirmation. You do allude to the possibility and provide discussion that "lends credence to the FWS's concern" but the current language and presentation seems almost dismissive, reading as though gunshot mortality may be involved but we really have no idea. Gunshot mortality is not even mentioned in this portion of the Summary of Significant Conclusions (p. 65). I suggest clarifying in a concluding sentence or two that gunshot mortality is a cause for serious concern, it may well be the cause for the decline in breeding pairs, but is awaiting the outcome of ongoing analysis for confirmation.

2. Page 27, last paragraph: The suggested alternative strategy of allowing red wolves and coyotes to interact without human intervention is an interesting possibility but because it represents such a radical departure from the status quo, it warrants more

thorough discussion. Even if conducted in only a portion of the recovery area or a new area, it would certainly result in a "reduction in genetic integrity of red wolves in the wild" (p. 28). As such, the resulting hybrids likely would not warrant ESA protection, as you allude to in reference to potential litigation costs. Lack of protection may not be a problem, as this would be experimental only, but goals would need to be clearly articulated. For example, even if the stated purpose was to learn what would happen with gene flow in the absence of placeholder management, it may be difficult to guard against the perception that FWS is admitting that red wolves cannot persist unaided and that a coyote-wolf hybrid is closer to the ideal than a coyote and is therefore more desirable. Such an animal may be closer to the historical Southeastern canid and may be better able to "fulfill the ecological functions [red wolves] once did" (p.28) due to their larger size. However, because such animals would not be red wolves, the conservation and philosophical implications may end up far afield from the intent of the ESA. To consider such a strategy, even as a research endeavor, would seem to require extensive up front consideration, such as genetic modeling to predict potential outcomes, as well as plans to address and manage various outcomes.

3. Page 52, Question (g): The question asks about the adequacy of facilities to handle captured wolves. I did not note where this aspect was addressed.
4. Human Dimensions: Recent research regarding the effects of coyotes on some deer populations in the southeastern U.S. has unfortunately fueled negative public sentiment against coyotes. This sentiment seems at least partially responsible for the increasing incidence of gunshot mortality to both placeholder coyotes and breeding red wolves. As part of the extensive public relations and education work that is necessary to improve effectiveness of the recovery program, a

couple of points may be helpful. First, the limited data you present on deer population status in the recovery area indicates that the population is healthy and is not declining. Perhaps compiling and disseminating additional data to demonstrate the stability of the deer population, or even conducting deer recruitment surveys if necessary, would help to convince at least some of the public that shooting canids is unnecessary. Second, disseminating information demonstrating that removing canids can be counter-productive to the goal of protecting deer may help limit mortality. For example, information from the recovery area on what happens when a territorial canid is removed (i.e., many more come in) is compelling reason not to shoot the placeholder. This could be combined with information from recent research in South Carolina indicating the futility of killing even large numbers of coyotes to increase deer recruitment, much less the few that can be removed by opportunistic shooting.

5. Per your request, I did not focus on editorial details but I noted a few places where wording was confusing or clarification may be helpful.
    a. Page 22, 3rd sentence: I think I understand the meaning but am confused by the last phrase "by the absolute population estimate." Should that not be deleted?
    b. Page 23, 1st paragraph, last sentence: It may be helpful to clarify the importance of "when it occurs."
    c. Page 47, last line of 1st paragraph: Should this not read "red wolf removal from *private* lands"?
    d. Page 53, question (h), 2nd paragraph: Which island population?

I hope these comments are helpful in finalizing the WMI review. If I may be of further assistance or if anything requires clarification, please do not hesitate to contact me.

Best regards,

John Kilgo, Ph.D.
Research Wildlife Biologist
U.S. Forest Service Southern Research Station

Douglas Smith, Ph.D., National Park Service Rocky Mountain Wolf Recovery Lead Biologist

Memorandum

TO: Jon Gassett, Wildlife Management Institute

FROM: Douglas Smith, Yellowstone National Park

SUBJECT: Red Wolf Program Review

DATE: 7 November 2014

I have attempted to review all of the materials sent and involved with an assessment of the US Fish and Wildlife Service's (USFWS) Red Wolf Recovery program. In addition, I have visited Alligator River National Wildlife Refuge (ARNWR) in a professional capacity as part of my long-term involvement with wolf research and management. I have also been a peer reviewer in a number of instances for publications submitted on red wolves. This has given me some insight and intuition into the program, which I am relying on in addition to the large number of documents mailed to me to review.

In short, programmatically this has been an exemplary project. The administrative record is exhaustive and documentation of issues, research and problems has been excellent. It is probably not too much to say that such thoroughness is an envy in endangered species recovery. Therefore, the problem lies not with administration or execution of recovery, rather with biological and social issues, which are hard to resolve, potentially unresolvable in this case. Any decision about continuation of the program should be here and not with administration, or with objectives, which have been clear. Specifically, hybridization with coyotes and illegal take, and/or mistaken identity as a coyote leading to harvest, are the significant issues. Habitat erosion is also a significant concern (I have listed a few others in my detailed comments – but these deserve the most attention). All of these issues together suggest, and this was mentioned in some of the foundational documents, red wolves may not be recoverable, or become a self-sustaining population which leads to perpetual management (or at least long term) – which in itself is not necessarily bad given its unique taxonomic status, but moving forward this should be explicit. Some may take issue with the cost of such a federal program (1.2 m/year), as it is the custom to strive toward delisting not long- term management. And lastly, and no less significant, and perhaps the most important concern underlying any decision is the taxonomic status of the species, which is still murky, and despite near Herculean efforts to avoid coyote intermixing red wolves from the start may be part coyote, or not the uniquely evolved species once thought (but not all publications agree but clarification here is needed). Like the peer-reviewed publications on this matter, I do not have enough insight to clarify this matter – it unfortunately is an important distraction. If it is a uniquely evolved taxon (the Nowak view) this argues more strongly for a continuation of the program, if it is not, and given the expanding human population linked to habitat destruction, perhaps allowing a new taxon to 'naturally' evolve in the area is the most judicious course of action.

Program Management/Administration- I am choosing not to focus here due to the extensive past review this program has been subjected to and the published literature evidencing the scientific work completed. An overview suggests competent and thorough work. This has not

been the cause of a lack of progress toward recovery goals. As noted, the recovery plan is dated, but not irrelevant. The goals of the plan are still appropriate, hence I do not recommend a re-write/update as that would drain valuable time away from other more vital activities.

Recovery – Foundational documents and objectives for the program are to have three populations of approximately 220 wolves in the wild (plus captive stock which I deem adequate but did not study this as much). Neither of these non-captive objectives has been achieved and the population appears 'stuck' at about 100 wolves below the goal although some documents suggested this may be the carrying capacity of ARNWR – which supports establishment of another recovery area.

Hybridization- Despite intensive efforts to prohibit introgression of coyote's genes, continued questions arise over genetic purity and viability. The 'red wolf repulsion (often referred to as 'placeholder')" hypothesis does not have adequate evidence to support or reject but intact red wolf social groups do not appear prevent or hold-off coyote occupation. Continued intervention in terms of carefully managed coyote control/interbreeding continue to be necessary. The Hedrick predictions, if achieved, give some hope that intensive management can be successful.

Human-caused Mortality- Like most wolf populations, managing humans and their attitudes is often the key to success. Possibly the easiest to address, reducing human take is an important first step. I say 'easy' because it is a factor far easier to resolves than coyote hybridization and habitat destruction, but human attitudes arguably are as hard to change/adjust as any biological/ecological issue, so I mean potentially easiest to solve as if people just stop killing them the population may increase (but possibly not enough to reach population objectives). Therefore, it does become necessary to not allow coyote hunting in the area – just too many mistakes and too many legitimate identification issues (red wolf staff even struggle with this with an animal in hand). This may lead to an anti-wolf backlash and increase illegal take. But like Mexican wolves, stepped up law enforcement, monitoring, and public outreach will have to follow. Again, and not stressing this is easy, but this factor may be the one that is most controlled via management intervention. Although hard to control vehicle strikes seem to be an issue too. Are different traffic regulations necessary (slower speed limit)? This may be an unavoidable loss but the current lack of population growth means reducing human-caused mortality to a minimum.

Habitat Loss- As with all endangered species, the red wolf is getting squeezed out because humans don't want to share or limit/control their population (is this not the underlying reason for the review – conflicts with humans?). This too is most solvable but like human-caused mortality doesn't necessarily mean it can be solved. Quite simply the animals need space and likely more of it as relatively speaking the area they have is small compared to most carnivore recovery areas. Further, additional populations are needed to create redundancy and safeguards to just having one population. More room near ARNWR and at least another recovery area is necessary to restore the species/taxon – as stated in foundational documents.

Human Attitudes- Although potentially not a category by itself and related to *Human-caused mortality* this is an overarching objective for any recovery program and without doing an analysis probably half of this issue of restoring the red wolf to the southeast. Outreach,

communication, public relations – all of the above and already being done – in a stepped up fashion should precede all other actions in the program is to continue. If not, and as Ron Nowak suggested >10 years ago – ARNWR should be fenced to keep wolves in and coyotes and people (and thereby control human caused mortality) out. Fencing will limit human take and eliminate coyotes. Periodic releases of red wolves will be necessary to maintain genetic diversity. I suspect after the initial cost of the fence, maintaining such a population will be cheaper than the current efforts. A fenced population may be contrary to Endangered Species Act objectives for recovery (e.g., self-sustaining, natural population).

Captive Population- It seems that the number of facilities and animals in captivity is adequate. Many documents stress the importance of captive breeding and having enough wolves for release and augmentation in the wild. I am not delving into detailed comment on captive management other than to stress the vital need for zoo space for many other endangered species recovery efforts. Continuation of captive breeding may need to be a stand-alone objective – public enjoyment – or have the twin purpose of human enjoyment and augmentation for a wild population. Numbers in captivity will depend on which one or both of these goals are decided upon.

Taxonomic Issues- What is the red wolf? Due to my cursory review and number of documents to digest determining the taxonomic status of red wolves is necessary to justify any continuation of recovery. If the red wolf is a wolf/coyote hybrid this argues against 'propping up' such a taxon as it would be an event caused by human disturbance weakening any argument to preserve a 'unique' taxon. If however, it truly evolved into its present form then this adds greater weight to trying to keep such a taxon from perishing. The review committee needs to take a position in this debate as it is important justification for continuation of the program, including deciding if a new species classification is warranted (eastern wolf). But clarity is this area is necessary for goal justification.

Disease- Again a big issue and potentially solved via treatment of captured individuals – which should continue as part of intensive management. Continued monitoring necessary.

Symbolic Value- In short, some of the obstacles to further red wolf recovery may seem insurmountable biological issues (hybridization, taxonomic status). Regardless, most of the other issues are human caused (habitat loss, human caused mortality, private land issues, human population) and solving them may or may not succeed. Nevertheless, continuation of the program would serve as a reminder and example that coexistence with non-human species is a societal objective and worthy of investment of taxpayer dollars. Preserving the red wolf is a buttress against a human dominated world, such an example forces people to make accommodations. Further, there is great educational value (scores of school groups learning as well as the general public) and value for many (perhaps a majority) of gaining pleasure from just knowing they are there. Indeed contrary to the ESA (self-sustaining, natural population), we are well beyond 1973 and it may be necessary to preserve some of wild nature just because some people want it there – no ecological reason – and this then is worthy of investment and a re-focusing of objectives.

General Comments- The volume of materials prevented me from a detailed review, hence I augmented my comments via exposure to the program, including an onsite visit, and periodic review and reading of the literature through the years. The program has undergone frequent review and assessment, and the latest 5-year Status Review was most helpful. But the key issues are hybridization, human-caused mortality, and habitat loss (related to human attitudes). A deliberate reassessment of objectives is needed including a clear statement of what taxon we are dealing with and a push to establish at least another recovery area as virtually all the conservation biology literature would find one population woefully inadequate. Human attitudes is always the Achilles heel for wolves, hence re-double public outreach. The worth of symbolic values of nature should not be underestimated – this alone may be enough of a reason to continue the program. However, allowing the 'new canid' to evolve under current conditions needs to be considered for economic reasons – but so does fencing the entire refuge – which would best serve long-term survival and send a message that wild nature has value.

Appendix I. Biographies of Review Participants

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

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

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

JONATHAN GASSETT, Ph.D. – Jon is WMI's Southeast Field Representative. John works with all SEAFWA states and served as President of AFWA, MAFWA and SEAFWA. He is a graduate of the National Conservation Leadership Institute and serves on their Board of Directors. Jon also serves as WMI's State-Industry Liaison, helping to build and improve relations between state and industry partners. Jon has over 14 years' experience with Kentucky Department of Fish and Wildlife Resources including 8 years as Commissioner of the department.