What Comes With the Territory: Predators and Their Place in Northeastern North Carolina

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Abbreviations

APP - Albemarle-Pamlico Peninsula

ARNWR - Alligator River National Wildlife Refuge

CAB - Community Advisory Board

CVS - Carolina Vegetation Survey

ESA - Endangered Species Act

GIS - Geographical Information Systems

HSI - Habitat Suitability Index

LRV - Life Requisite Value

NEP - Non-essential Experimental Population

RSF - Resource Selection Function

USFWS or FWS - United States Fish and Wildlife Service

Study area - Beaufort, Dare, Hyde, Tyrrell, Washington counties on APP

Abstract

The landscape for top-level predators in the Albemarle-Pamlico Peninsula (APP) of North Carolina has undergone dramatic changes in recent years. Our research examined how three large predators, red wolves (*Canis rufus*), coyotes, *Canis latrans*), and black bears (*Ursus americanus*), fit into the landscape of the APP by taking into account both ecological and anthropogenic considerations. To accomplish this, we conducted spatial analyses of land cover and resources and conducted qualitative interviews with members of the community. Using existing data sets, we investigated the suitability of and change in habitat for black bears and assessed the availability and distribution of resources for red wolves in the APP. These analyses found that there was extensive, stable habitat that was suitable for black bears within the region, and optimal land resources for red wolves was found largely on privately owned lands in the APP.

Semi-structured interviews revealed that interviewees' perceptions of predators were shaped by their sense of place, attitudes about the government, and experiences with the animals. These factors had variable influences on how people viewed the predators: bears were positively viewed amongst the interviewees, while wolves and coyotes were generally viewed negatively. Our comparative approach allowed us to better understand how the factors influencing people's attitudes and views of predators can vary across different predators.

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Introduction

Large predators have long been a part of the heritage and landscape of the Albemarle-Pamlico Peninsula (APP) — specifically Hyde, Tyrrell, Dare, Beaufort and Washington counties. Major changes in the composition, population, and management of large predators, together with significant land use changes, have raised questions about how red wolves (*Canis rufus*), coyotes (*Canis latrans*), and black bears (*Ursus americanus*) fit into the ecological and cultural landscapes of the APP. The goal of this report is to use analysis of ecological suitability and community perceptions to provide information about how bears, red wolves, and coyotes interact with the environment and the people of this region.

In order to provide such information, this report will use ecological studies and geospatial analysis tools to evaluate habitat suitability throughout the APP study area for red wolves and black bears. By looking at which areas within the region offer the best overall living conditions for each of these species, conclusions can be drawn about where they are most likely to thrive and how certain land use and management actions might impact their populations. In addition, we will attempt to characterize aspects of these predators' interactions with humans in the context of the local culture and how people in the area are affected by their presence. We hope that the results of these analyses will provide new and useful information about public perceptions of these large predators and the ecological conditions that support them.

In order to address this larger goal, we outlined the following specific research objectives and questions:

1. How suitable is the Albemarle Pamlico Peninsula for black bears?
2. Has the land changed in terms of suitability for black bears? If so, how?
3. How suitable is the Albemarle-Pamlico Peninsula for red wolves?
4. Does the federal land allocated for the red wolves contain suitable habitat?
5. How do black bears, red wolves, and coyotes fit in to the local culture?
6. What are the local perceptions, attitudes, and values regarding red wolves, black bears, and coyotes?
7. What are the local perceptions, attitudes, and values regarding the environment and wildlife in general?
8. What are the local perceptions, attitudes, and values regarding government management practices?

We begin with an overview of the region's large predators and landscape. We then turn to the spatial habitat and quantitative methods used for our study. Following that, we will talk about our interviewing process and the qualitative aspects of the study.

Background

Predators

Red Wolf

The historic range of the red wolf covered the majority of the eastern region of the United States. Red wolves range in color from cinnamon buff, tawny, or cinnamon red with gray or black on the tail. Male red wolves are typically between 50 and 85 pounds and females are 45 to 68 pounds (North Carolina Wildlife Profiles: Red Wolf). Comparatively, they are between the size of a coyote and a gray wolf.

Red wolves inhabit areas of upland and bottomland forests, coastal prairies, swamps and marshes. For denning, they require dense vegetation. Not much is known about behaviors and patterns of red wolves in the wild, because their population declined rapidly before they could be studied (North Carolina Wildlife Profiles: Red Wolf). They are most active at dawn and dusk and live with a pack from two to eight wolves. This pack typically consists of a mating pair and their pups from that year (North Carolina Wildlife Profiles: Red Wolf).

After European settlers came to the area, the red wolf was extensively killed out of fear of the animal and to protect livestock. By the late 1960s, only a small population of about 14 pure-blooded wolves, based on morphology, remained in southeastern Texas and southwestern Louisiana (North Carolina Wildlife Profiles: Red Wolf). For fear that the entire species would become extinct in the wild, the United States Fish and Wildlife Service (USFWS) captured these individuals in 1970. As a result, in 1980, the red wolf was officially declared extinct in the wild. However there were, and still currently are, individuals in captive breeding programs across the country (North Carolina Wildlife Profiles: Red Wolf).

In September 1987, USFWS released four adult pairs into the Alligator River National Wildlife Refuge (ARNWR) in Dare County, North Carolina. There have been additional reintroductions, for example in the Great Smoky Mountains National Park in 1991, but this program failed due to low pup survivorship, disease, and lack of prey (North Carolina Wildlife Profiles: Red Wolf). The Alligator River population is considered a nonessential-experimental population (NEP) under Section 10(j) of the Endangered Species Act (ESA), meaning that "on the basis of the best available information, the experimental population is not essential for the continued existence of the species" (USFWS Endangered Species Act: Experimental Populations). This designation was given because there were stable numbers of red wolves breeding in captivity. NEP designation is important because it gives landowners and biologists more freedom with population management, such as allowing individuals to "take" (i.e. hunt, shoot, kill, trap) red wolves that are considered a demonstrable threat to human safety or livestock under the ESA (ESA; North Carolina Wildlife Profile: Red Wolf). In the early 2000s, the number of known wolves in the ARNWR reached a peak high of approximately 130 and then started to slowly decline (Murray et al. 2015). Changes made by the USFWS to the program, along with anthropogenic interaction and coyote hybridization, have affected the recovery of the red wolf. Current population estimates from the USFWS are between 45 and 60 red wolves left in the wild in the APP (US Fish and Wildlife Service).

Coyote

The coyote is native to the prairies and grasslands of North America and has the widest range of all of the wild canines in the United States. When Europeans settled, coyotes were limited to the Great Plains (North Carolina Wildlife Profiles: Coyote). Since then, they have expanded across the continent. Up until the 1980s, coyotes were illegally released in North Carolina for hunting (North Carolina Wildlife Profiles: Coyote). Into the early 1980s, some coyotes naturally began to expand from Tennessee, Georgia and South Carolina into western North Carolina, and as of 2005, are found in all 100 counties of North Carolina (Hill et al. 1987).

In comparison to red wolves, coyotes are smaller, with adults ranging in size between 20 and 45 pounds; they are dark gray, blonde, red or black with a bushy black-tipped tail and have sharply pointed ears (North Carolina Wildlife Profiles: Coyote). Coyote habitat includes agricultural fields, forested regions, and even suburban neighborhoods. This is because coyotes are carnivores and opportunistic feeders, eating foods that are the most readily available and easy to obtain. Coyotes typically dig their own dens, which are hidden from view and used to birth pups and sleep (North Carolina Wildlife Profiles: Coyote).

The coyote and red wolf are in the same genus and are capable of interbreeding and producing fertile offspring (FWS Red Wolves and Coyotes). Red wolves mate for life, but when an individual is lost due to death, a coyote may replace that individual in the breeding pair (National Wildlife Federation Red Wolf). A combination of the red wolf reintroduction program and the expanding coyote populations has led to multiple instances of hybrid offspring, which diminishes the pure red wolf gene pool (FWS Red Wolves and Coyotes).

Interbreeding has been the greatest threat to red wolf recovery and to the success of the Red Wolf Reintroduction Program (Bohling and Waits 2015). An Adaptive Management Plan was implemented by USFWS and the Red Wolf Recovery Implementation Team to prevent hybridization, which include sterilizing male coyotes that had paired with a red wolf to create placeholders, and in some cases, removing the coyote from the area altogether (Bohling and Waits 2015).

Coyotes often receive more public attention than red wolves because they tend to prey on livestock and domestic animals (Turner 2016). Managing these predators has been difficult because of their adaptability. The most prevalent management techniques are trapping and hunting (North Carolina Wildlife Profiles: Coyote). There is limited data on the size of the coyote population in the coastal region of North Carolina, but a survey done between 2002 and 2011 regarding coyote harvests estimated that 1,100 coyotes were trapped and 10,261 were killed in total over that time period by hunters (NCWRC Fox and Coyote Populations Report). This data shows that coyotes are prolific in coastal North Carolina, as well as throughout the state. When coyote populations decline, they respond by breeding at younger ages and producing larger litter sizes, often with high pup survivorship (North Carolina Wildlife Profiles: Coyote). This means that hunting pressure on coyotes may actually cause a population increase. Moving into urbanized spaces with readily available food sources has caused many coyotes to become acclimated to humans and consumption of unnatural food sources, indicating that coyote range has expanded to include anthropogenic resources as well.

Black bear

Originally found all across North Carolina, the black bear has experienced population fluctuations in recent years (North Carolina Wildlife Profiles: Black Bear). At the turn of the twentieth century, efforts to quell black bear numbers in conjunction with other large predators, including the gray wolf (*Canis lupus*), reduced the black bear population to historically low levels (North Carolina Wildlife Profiles: Black Bear). Progressive hunting policies and active black bear management in the past several decades have allowed the bear population to recover within North Carolina to nearly 15,000 bears (North Carolina Wildlife Profiles: Black Bear).

Adult black bears typically range from 100 to 700 hundred pounds, depending on gender and food availability (North Carolina Wildlife Profiles: Black Bear). Non-anthropogenic food preferences vary seasonally, but are generally a mix of fruits and nuts (soft and hard mast, respectively) from local vegetation (Landers 1979). Anthropogenic food, specifically corn, is a large portion of the bear diet throughout the year (Landers 1979). Bear activity tends to decrease during fall months, as some individuals near the seasonal hibernation threshold (Hamilton 1980).

The black bear has become an important and easily recognized cultural icon within the study area. Active management practices, including hunting, have been enacted for black bears and enforced by the North Carolina Wildlife Resources Commission (North Carolina Wildlife Profiles: Black Bear). Ecotourism centered on black bear encounters, as well as bear hunting expeditions into the coastal lowlands, bring vital economic activity to the region (Coastal Review Online 2015). Anthropogenic encounters also take place through automobile collisions and road crossings (Kindall 2007). Bear movement is typically limited to an established home range but can be extensive throughout that range, depending on seasonality and food sources (Jones 2002).

Landscape

The forests, wetlands, dunes, rivers, and estuary surrounding the APP make up a productive natural system that hosts a diverse array of species (The Nature Conservancy 2005). In addition to historical landscape resources, the five-county region also contains developed areas that contribute to an even more diverse landscape. Because natural resource availability as well as anthropogenic land use are key determinants of habitat suitability for species in this region, a landscape analysis is necessary for a holistic understanding of how the APP serves large predators. Table 1 describes the landscapes of Beaufort, Hyde, Dare, and Tyrrell counties. The data used in the table includes all of the land from the county areas; however, our study area was limited to mainland county areas on the APP. Washington County was excluded because there was no data available.

Table 1: Land use in Beaufort, Hyde, Dare, and Tyrrell counties. Developed land includes municipalities, rural development, rural cluster development, and industrial uses. Undeveloped land includes land used for "extractive" purposes as well as privately owned, vacant, or forest land.

	Beaufort		***Hyde***		***Dare***		***Tyrrell***	
Land Use Category	**Acreage**	**% of Total**	**Acreage**	**% of Total**	**Acreage**	**% of Total**	**Acreage**	**% of Total**
Agricultural Land	123,500	23	84,038	33	0	0	68,650	30
Developed Land	48,700	9	6,393	2	10,018	5	30,215	13
Undeveloped Land	349,400	66	15,604	6	16,681	8	47,961	21
State and Federal Lands	9,700	2	150,372	59	186,176	87	79,223	35
Total Land	531,300	--	256,407	--	212,876	--	226,049	--

Approach

The following sections will provide an explanation of the methods employed, including geospatial analysis of habitat suitability and qualitative research into residents' values and attitudes.

Spatial Habitat

In order to understand how red wolves, coyotes, and bears fit into the APP, an analysis of the resources available to these predators is helpful. The food, habitat, denning, and escape cover needs of large predators can be indicators of where they are likely to thrive in this environment. This information is best represented spatially using geographical data for vegetation and land features. The following sections detail how spatial data can be manipulated to provide information about habitat suitability.

Habitat Suitability Index

The purpose of creating a Habitat Suitability Index (HSI) is to quantify the habitat needs of an organism in a spatial context. An HSI relies on mathematical functions to indicate the relative importance of different habitat components. The HSI then uses spatial data to determine the total suitability of a given region or data point by providing an HSI value ranging from 0 to 1 – not suitable to highly suitable, respectively.

The reliability of an HSI model depends on the accuracy of the model and the input data. For the purpose of this report, a Western North Carolina HSI function for black bears (Zimmerman 1992) was used as a template and adjusted to fit observed differences in landscape to better understand how bears fit into the ecological landscape of the APP.

Resource Selection Function

A Resource Selection Function (RSF) creates a visual representation of where one is likely to find a specific organism in a geographic region given the habitat preferences of that animal. An RSF model works similarly to an HSI in that it assigns values to different habitat components and compiles those components in a mathematical model in order to show the highest concentration of suitable habitat components on a map. RSF models can be used to show where an animal is likely to be found. In the case of this report, an RSF analysis was used to determine where in the APP red wolves are most likely to survive and reproduce, according to an analysis conducted by Dellinger et al (2013).

Resource selection functions can differ in accuracy depending on the structure of the mathematics used to create the model. General Linear Models (GLMs) are most often used for analyses, but a variety of complex statistical models can be used in some cases to achieve various kinds of data structures and quality. For the purpose of this project, a linear model was used (Dellinger et al. 2013).

Bear Habitat Change Model

A bear habitat change analysis was performed to examine three different variables - forest cohesion, forest diversity, and forest-agriculture edge density - and how they changed from 1996 to 2010 according to a past study conducted by Kindall and Van Manen (2007). The results show where habitat is changing and to which degree on a scale from -3 to 3, with 3 being greatly improving and -3 being severely worsening.

This change in habitat was then assigned estimated monetary values based on a variety of other studies. The values correspond to either the cost of restoring worsened land to its 1996 quality or the benefit of the improved habitat for black bears.

Human Dimensions

People have varying values associated with wildlife. Characterizing this variability can improve our understanding of people's perceptions of specific predators and the management of these predators. These perceptions are vital because they can often predict how an individual, or even a community, will react towards predator management, the predator species, and the ultimate future of the species or population (Browne-Nunez 2015). In this study we hope to understand local perceptions of black bears, red wolves, and coyotes to better understand the obstacles or support that these species may face.

To research the community perceptions of biodiversity and predator management, we adopted a qualitative approach. This is because qualitative analysis can support investigations that hope to understand the details of a specific experience or process (Bazeley 2013). It allowed us to develop deeper descriptions of interviewees' perspectives and permitted interviewees to expand on ideas and topics they found most important (Weiss 1994). Interviewing is a useful qualitative research method because it allows for unstructured collection of information that provides clues to identify any patterns or comparisons between thoughts and opinions gathered (Bazeley 2013). Through use of an interview guide, questions can be asked in a way to facilitate responses to complex topics (Browne-Nunez 2015). Recorded interviews are also useful because they allow for the interviewer to retrieve information at a later date without the error of handwritten notes (Bazeley 2013). Interviewing has been beneficial in the past regarding the reintroduction of gray wolves to Yellowstone National Park. Researchers used interviews to gather attitudes about wolf management and local feelings towards the wolves (Browne-Nunez 2015). This method will support our exploration and evaluation of attitudes regarding the three large predators in the Albemarle-Pamlico Peninsula.

Spatial Habitat

Methods

Using a combination of a RSF for red wolves, an HSI for black bears, and a model depicting changes in black bear habitat, this study characterized the ecological suitability of the landscape of northeastern North Carolina for black bears and red wolves.

Resource Selection Function

A RSF characterizes habitat quality by estimating the relationship between landscape covariates, anthropogenic disturbances, and an animal's observed presence. Dellinger et al. (2013) constructed a RSF for the red wolf in eastern North Carolina, which was employed as a guide to map suitable red wolf habitat in this study. In ArcGIS (version 10.4.1), we focused our RSF analysis on a study area on the APP. Within Geographical Information System (GIS) and using satellite imagery-based cover data from National Oceanic and Atmospheric Administration (NOAA) Coastal Change Analysis Program (C-CAP), road data from the North Carolina Department of Transportation (NCDOT), and population data from the United States Census, binary rasterized indicators were created for the study area, which captured the presence or absence of key habitat variables (Table 2). Based on each variable's weighted contribution to observing a red wolf's presence, as estimated by Dellinger et al. (2013), we employed the raster calculator tool to generate a red wolf prediction surface.

The prediction surface, or red wolf RSF map, generated values ranging from 0 to 1 where lower values indicated a low predicted probability of red wolf presence corresponding to less desirable habitat for red wolves. Higher predicted values represented more desirable red wolf habitat. Negative estimated values, outside of the Dellinger et al. (2013) sample range, were rare and are likely to represent areas void of suitable red wolf habitat. To address negative values and control for potential computed errors in our mapping, values below zero were reclassified as no data and values greater than zero were reclassified as one.

Here, we are considering the most general and least restrictive case wherein any location with a positive probability of predicting red wolf habitat is considered suitable habitat. A more nuanced analysis focusing only on high quality red wolf habitat, rather than the mere presence of all potential red wolf habitat, could be conducted by restricting the predicted surface. We leave this extension for future work.

Table 2. Habitat attributes and associated coefficients, from Dellinger et al. (2013) used in our study of red wolf habitat on the APP.

Coefficient	**Estimated Weight**
Intercept	0.62
Successional Fields	-0.21
Pocosins	-0.67
Wetlands	-0.81
Lowland Forests	-0.82
Pine Plantations	-0.95
Distance to roads	-1.29 x 10
Distance to water	2.85 x 10
Human Density	-0.08
Distance to roads and Lowland Forests	-2.70 x 10
Distance to roads and Pocosins	-2.79 x 10
Distance to roads and Wetlands	-2.48 x 10
Human Density and Distance to roads	4.146 x 10
Human Density and Pine Plantations	0.09
Human Density and Lowlands Forests	0.03
Human Density and Wetlands	0.08
Human Density and Pocosins	-6.29 x 10

Habitat Suitability Index

The HSI for black bears from Zimmerman (1992) that was adapted to fit the northeastern region of North Carolina in our study follows:

$$HSI = ((LRV_{FOOD}+LRV_{ESCAPE}+LRV_{DEN})/3)*(I_2)$$

Due to the fact that Zimmerman crafted this equation to fit black bear populations native to the Southern Appalachian Mountains, certain elements either needed to be excluded or changed so as to represent the habitat in northeastern North Carolina. The various changes that were made as well as descriptions of variables and the elements that comprise them are summarized in the following sections.

Data on the distribution and abundance of relevant species and vegetation cover used in the adapted HSI model were from 99 Carolina Vegetation Survey (CVS) plots within our study area to identify the distribution and abundance of relevant species and vegetative cover. The CVS is a research program that was “designed to document the composition and status of the natural impacts, and assessment of conservation status.” The CVS program has documented the vegetation and other environmental attributes of thousands of 10x10 m^2 plots throughout North Carolina (Peet 1998). This data is available to the public and updated annually (http://cvs.bio.unc.edu/).

Life Requisite Value – Food (LRV_{FOOD})

For the black bear food analysis component of our HSI, we described the seasonal vegetation and anthropogenic food components of the eastern NC black bear diet, and the spatial extent most likely to be traversed by bears in search of food. Species producing soft mast as well as anthropogenic and other natural food sources were identified via literature review of Beeman and Pelton (1980), Jones and Pelton (2003), and Landers et al. (1979), which allowed for a specific examination of the diet of bears in northeastern North Carolina. These species identified to be of food value were cross-analyzed with Carolina Vegetation Survey (CVS) data.

A model black bear HSI, featuring variables for a number of seasonal plant food species as well as home range size, was taken from Zimmerman's (1992) equation:

$$LRV_{food} = 1/7\ Fo_{TOT} + (1/7\ FSp_{TOT} + 2/7\ FSu_{TOT} + 4/7\ FFa_{TOT}) * I_1$$

LRV_{FOOD} stands for Life Requisite Value for food for black bears. In Zimmerman (1992), LRV_{FOOD} described the different food sources black bears relied on and incorporated coefficients corresponding to the relative amount of use they got from each. The first part of the equation, $1/7\ Fo_{TOT}$, is the component of good anthropogenic food. $1/7\ FSp_{TOT}$ refers to total amount of natural food eaten in spring; $2/7\ FSu_{TOT}$ refers to total amount of natural food eaten in the summer and $4/7\ FFa_{TOT}$ refers to the amount of natural food eaten in the fall. I_1 refers to the average home range size of a black bear in square kilometers. The variables were assigned values according to the corresponding data found in the literature review and used to determine the most suitable type of habitat for black bear food gathering.

The coefficients represented relative importance among the seasonal food sources. Compared to Zimmerman (1992), we had greater sources of anthropogenic foods. A striking proportion of the total land in the study area is agricultural (Kindall and Van Manen 2007). Therefore, we accounted for this by increasing the weight of the anthropogenic food coefficient and adjusting the others' weights accordingly. Another adjustment made was removing the I_1 variable which represented interspersion distance bears traveled to food on a continuous surface. This distance value was not useful because we completed the HSI using CVS plots at discrete locations, which resulted in discontinuity. The adapted equation used in our study was:

$$LRV_{food} = 7/14\ Fo_{TOT} + (1/14\ FSp_{TOT} + 2/14\ FSu_{TOT} + 4/14\ FFa_{TOT})$$

Less Seasonal Food Sources:

In order to measure the contribution to LRV_{food} from less seasonal sources (Fo_{TOT}), the equations from Zimmerman were adapted for the APP. Zimmerman's equation is as follows:

$$Fo_{TOT} = Fo_1 + Fo_2\ ,\ \text{for } Fo_1 + Fo_2 < 1.0;$$

$$Fo_{TOT} = 1.0,\ \text{for } Fo_1 + Fo_2 > 1.0.$$

The first adaptation we made to Zimmerman's equation for less seasonal food was to the variable for colonial insects (Fo_1). Fo_1 was assumed to be zero because colonial insects are not a major food source for black bears in the APP (Zimmerman 1992).

We also made some slight changes to Fo_2, which is the contribution from anthropogenic sources of food. Fo_2 has three factors: the source (Fo_{2a}), the distance to the source (Fo_{2b}), and the distance from the source to escape cover (Fo_{2c}), defined by Zimmerman (1992) according to the following equation:

$$Fo_2 = (Fo_{2a} * Fo_{2b} * Fo_{2c})^{1/3}$$

The source factor (Fo_{2a}) depends on the amount of food at the source (A), the risk associated with getting the food (R), and the seasonality of this source (S), according to the following equation:

$$Fo_{2a} = ((A+R)/2) * S$$

It appears from first-hand observations in the area and conversations with local residents that the primary source of anthropogenic food in this region is agriculture. Accordingly, a number of assumptions were made about the A, R, and S variables. The amount of food (A) was assumed to always be very high, because compared to Zimmerman (1992), where anthropogenic food included things like trash and bird feeders, the anthropogenic food in the APP comes from large, commercial agricultural fields. The risk associated with getting the food (R) was assumed to be zero. In this area, there is a plethora of anthropogenic food available and although there are short bear hunting seasons, and bear hunting usually takes place around agricultural land, the proportion of bears killed during foraging is so small that it is unlikely that the bears perceive any risk (USDA 1997). The seasonality of the anthropogenic food (S) was determined using USDA growing seasons data (1997) for the three crops that bears eat: wheat, corn, and soy. Since these crops are available during three seasons, a value of 3 was assigned to S. The final source (Fo_{2a}) equation resulted in a Fo_{2a} of 1 for all plots, corresponding to the "high quantity low-risk source available from emergence to denning" reported by Zimmerman (1992).

The second factor, distance to anthropogenic food (Fo_{2b}), can be represented by the following equation from Zimmerman (1992):

$$Fo_{2b} = -0.667x + 2 \text{ for } 1.5 \leq x \leq 3.0;$$

$$Fo_{2b} = 1.0 \text{ for } x \leq 1.5;$$

$$Fo_{2b} = 0 \text{ for } x \geq 3.0;$$

where x = distance (km) from the plot to the closest source of anthropogenic food.

The third factor, distance from plots within home range (7.8 km; NCWRC) of escape cover (Fo_{2c}) to anthropogenic food, can be modeled by the equation:

$$Fo_{2c} = 1.0 \text{ for } x < 25;$$

$$Fo_{2c} = -0.0017x + 1.0425 \text{ for } 25 \leq x \leq 200;$$

$$Fo_{2c} = -0.0015x + 0.6 \text{ for } 200 \leq x \leq 400;$$

$$Fo_{2c} = 0 \text{ for } x > 400;$$

where x = distance (km) from plot to anthropogenic food source.

If a point was not within home range of a conterminous forest area of at least 400 ha, $Fo_{2c} = 0$, which is different from Zimmerman (1992) because our measurements correspond to specific locations (CVS plots).

With these adaptations to Zimmerman's Fo_1 and Fo_2 variables for Fo_{TOT} our final equation for Fo_{TOT} was as follows:

$$Fo_{TOT} = Fo_2 \text{ for } Fo_2 < 1.0 \text{ and}$$

$$Fo_{TOT} = 1.0 \text{ for } Fo_2 \geq 1.0$$

Spring Value (FSp_{TOT}):

FSp_{TOT} represents the amount of spring food that is available to black bears in the study area. Zimmerman (1992) defined the spring foraging season as March to late May. *Smilax spp.*, or green briar, is the primary food source for black bears during this season, so *Smilax* species were taken into account to calculate spring food totals. The rest of the bears' spring diet consists of vegetation that is dependent on access to water. Therefore, Zimmerman's equation also takes distance to water into account. Distance to water is weighted more heavily to represent the importance of distance to perennial water for plant growth and need for water after denning. Zimmerman's summary equation for total spring food value is as follows:

$$FSp_{TOT} = (2\ FSp_1 + FSp_2) / 3$$

In our study, FSp_1 was calculated in a GIS as distance from each plot to perennial water, to account for the amount of spring diets made up of vegetation from perennially moist environments. FSp_1 values were calculated using the following from Zimmerman (1992):

$$FSp_1 = 1.0, \text{ for } x \leq 0.64;$$

$$FSp_1 = -1.167x + 1.75, \text{ for } 0.64 < x < 1.5;$$

$$FSp_1 = 0, \text{ for } x \geq 1.5;$$

FSp_2 was derived from the percent cover of *Smilax* within each plot. *Smilax* species in each plot were identified, and then percent cover was calculated as the sum of the percent cover values for each type of *Smilax* in each plot. Zimmerman (1992) proposed the following for calculating FSp_2 based solely on *Smilax* cover, which was used for our study:

where x = distance (km) to perennial water.

$$FSp_2 = 0.08x, \text{ for } x < 12.5;$$

$$FSp_2 = 1.0, \text{ for } x \geq 12.5;$$

where x = percent cover by *Smilax spp.*

Summer Value (FSu_{TOT}):

Summer food availability for black bears in the APP was calculated following the example cited in Zimmerman (1992). This calculation accounted for soft-mast and hard-mast sources of food, and treated them as independent variables in the overall equation, which was formulated as follows:

$$FSu_{TOT} = FSu_1 + FSu_2, \text{ for } FSu_1 + FSu_2 \leq 1.0;$$

$$FSu_{TOT} = 1.0, \text{ for } FSu_1 + FSu_2 > 1.0.$$

FSu_1 reflected the availability of soft-mast fruit available to black bears during summer months, notably various berries. This calculation deviated from the one performed in Zimmerman (1992) as the primary species considered in that paper, blueberries (*Vaccinium spp.*), huckleberries (*Gaylussacia spp.*), and blackberries (*Rubus spp.*), differed from coastal species. Coastal berry species, such as American persimmon (*Diospyros virginiana*), muscadine (*Vitis rotundifolia*), large gallberry (*Ilex coriacea*), and other species, were included in addition to berry species that occurred in both coastal and mountainous locations. The formula for FSu_1 was as follows:

For n=1*:	For n=2:	For n=3:	For all n:
$FSu_1 = 0.033x$	$FSu_1 = 0.037x$	$FSu_1 = 0.042x$	$FSu_1 = 1.0$, for $FSu_1 > 1.0$

*Where n = number of berry genera present;
and x = percent understory cover of soft mast species.

Following Zimmerman's (1992) example, the percent of understory cover of soft mast species (x) was calculated as follows:

$$x = (FSu_1 - 0.1(n-1))/0.033;$$

Where n = number of berry genera present; and $FSu_1 = 1.0$.

FSu_1 genera totals were calculated by identifying and summing the number of all soft-mast bearing genera among the species listed per CVS plot.

Again, following Zimmerman's (1992) approach, hard-mast species, particularly oak (*Quercus spp*.) were selected for calculation of the FSu_2 value. Oaks tend to harbor a parasite known as squawroot (*Conopholis americana*), which serves as an additional source of food for black bears in summer months. Accounting for this species selection for this value, plots with co-dominant or dominant oaks were assigned an FSu_2 value of 1, and plots that did not have these species as dominant or co-dominant were assigned 0. Dominance and co-dominance was determined through the plot classification tab of the CVS data findings, where the dominating species within a plot was listed under "translated scientific name of community concept" of the CVS dataset. Total summer food availability (FSu_{TOT}) was calculated using the following equation:

$$FSu_{TOT} = FSu_1 + FSu_2, \text{ for } FSu_1 + FSu_2 \leq 1.0;$$

$$FSu_{TOT} = 1.0, \text{ for } FSu_1 + FSu_2 > 1.0.$$

Fall Value (FFa_{TOT}):

To calculate the contribution of fall food from natural sources to the overall black bear HSI, the following equation was used:

$$FFa_{TOT} = ((2FFa_1 + FFa_2)/3) * FFa_3$$

The three separate factors (FFa_1, FFa_2, and FFa_3) affecting food availability were assessed from the CVS plots in the study area. FFa_1 represents hard mast species in a black bear's diet. FFa_2 represents soft mast species. FFa_3 represents distance between plots and roads. In calculating the LRV of fall food for each plot, hard and soft mast values were weighted and added and distance to roads was considered as a multiplicative factor.

The first factor, FFa_1, described the contribution of hard mast such as oak and maple seeds to bear diet. Data specifying observation site, hard mast producing plant species present, stem diameter (cm), and site observation area (m^2) were extracted from the CVS dataset for the study area. Stem area was calculated assuming a circular stem shape for all species. The sum of stem area by site was then divided by that site's observation area and multiplied by 100 to produce a percent basal cover of hard mast (Van Manen and Pelton

1997, Kaminski 2013). FFa_1 values were determined for each site using different formulas depending on the range of percent basal cover of all hard mast species within each plot (as in Zimmerman 1992). If percent basal cover = 0-15%, then $FFa_1 = 0$; if percent basal cover = 15-40%, then $FFa_1 = 0.6$; if percent basal cover = 40-100%. then $FFa_1 = 1$.

The second factor, FFa_2, described the contribution of soft mast species, specifically grapevines, to black bear diet in the fall. As for the first variable, all genus *Muscadinia* species, the observation areas (in square meters), and *Muscadinia* stem counts were extracted for each CVS plot. The number of grape stems was summed for each plot and divided by the plot observation area (in hectares) to get a measure of grape stems per hectare. FFa_2 was then determined for each plot depending on which of two ranges the grape stems per hectare values fell into (the ranges being 0-200 stems and >200 stems):

$$FFa_2 = 0.005x, \text{ for } x \leq 200;$$

$$FFa_2 = 1.0, \text{ for } x > 200;$$

where x = number of grape vines/ha.

The third variable, FFa_3, accounted for the distance between each plot and the nearest road, which was necessary because of the impact distance to roads has on bear food availability. Department of Transportation road data for the APP and a Euclidian distance tool within a GIS was used to obtain a distance (km) between each plot and the nearest road, as in Zimmerman (1992). FFa_3 was assigned a different value depending on which of three ranges the distance value fell into:

$$FFa_3 = 0.33, \text{ for } x \leq 0.2;$$

$$FFa_3 = 0.454x + 0.273, \text{ for } 0.2 < x \leq 1.6;$$

$$FFa_3 = 1.0, \text{ for } x > 1.6;$$

where x = distance (km) to closest road

These model values were based on the assumption that all relevant roads in the study area were paved, hence the reason FFa_3 was assigned values corresponding to Zimmerman's (1992) function for paved roads.

Life Requisite Value – Escape:

The LRV for escape cover as modeled by Zimmerman (1992) consists of four variables: area (ha) of conterminous forest (E_1), understory cover (E_2), slope (E_3), and distance to roads (E_4). To represent this, Zimmerman came up with the model:

$$LRV_{ESCAPE} = (E_1 + 0.5E_2 + 0.25E_3) * E_4 ;$$

$$\text{If } LRV_{ESCAPE} > 1.0 \text{ then } LRV_{ESCAPE} = 1.0.$$

We adapted this model from Zimmerman to fit our study area in northeastern North Carolina. Undercover story (E_2) was adjusted to reflect plants that are found in the study area from Landers (1979) and Hellgren et al. (1989). Slope (E_3) was found to always be zero because topography within the study area is flat.

Conterminous Forest (E_1):

The first value (E_1) in the LRV for escape cover function, as described by Zimmerman (1992), is the availability of conterminous forest - that is, a continuous area of forest uninterrupted by roads. The C-CAP land cover dataset (NOAA 2010) was used to identify different sized parcels of conterminous forest. Areas under 400 hectares were considered insufficient to allow for bears to escape; the average range for a bear is 3,200 hectares

(Zimmerman 1992). According to Zimmerman, the value of conterminous forest rises quickly and then levels out so a logarithmic function is needed to determine its value.

$$E_1 = 0, \text{ for } x \leq 400;$$

$$E_1 = 1.11(\text{Log } x) - 2.89, \text{ for } 400 < x < 3200;$$

$$E_1 = 1.0, \text{ for } x \geq 3200;$$

Where x = area (hectares) of conterminous forest

Understory Cover (E_2):

The second value needed, E_2, for Zimmerman's LRV for escape cover gives the availability of understory cover for bears to hide, travel, and rest. The process of defining understory species located in black bear habitat in the study area evolved from information found in Zimmerman (1992). Zimmerman listed rhododendron and mountain laurel as components of the dense understory that bears used (1992). Literature review revealed understory species specific to northeastern North Carolina and included: mountain doghobble (*Leucothoe fontanesiana*), wild grape (*Vitis spp*.), greenbriar (*Smilax spp.*), blueberry (*Vaccinium spp.*), and fetterbush (*Lyonia spp*.) (Landers et al. 1979; Hellgren et al. 1989). The CVS was used to locate plot areas of these species. We limited the data to our study area and were able to manually find percent cover of the understory species. Plot coverage of species was based on two factors located in the CVS: area of plots and percentage cover of each species. Area (ha) of the plot was multiplied by percentage coverage of the understory species to give area cover of plant species in the plot. Area cover is defined as *x*. The minimum cover was judged to have a value of 20% and the importance rises exponentially to a maximum at 80%, (Zimmerman 1992). None of our literature review has indicated that these values should be changed and we, therefore, used the same formulas. The resulting summed percentage values were the variables plugged into Zimmerman's formula.

$$E_2 = 0, \text{ for } x \leq 20$$
$$E_2 = -0.007x + (2.38*10\text{-}4)x^2 + 0.06, \text{ for } 20 < x < 80$$
$$E_2 = 1.0, \text{ for } x \geq 80;$$
where x = percent canopy cover of understory.

Slope (E_3):

The third value needed, E_3, for Zimmerman's LRV for escape cover is the slope of the terrain. However, because we were looking at northeastern NC and not the Appalachian Mountains, slope was not a factor. All of northeastern NC has an insignificant slope when looking at Zimmerman's formula. Therefore, $E_3 = 0$ throughout the entire study area (Zimmerman 1992).

Distance to roads (E_4):

In order to determine E_4, the distance to roads variable, we had to determine the impact of roads on bear. This was based on the distance a road is from where the bears are harvested by hunters (Zimmerman 1992). There is no available literature that contradicts Zimmerman's use of harvest rates by hunters of black bears are 50% and 73% when the distance from roads is 0.8 km or 1.6kms. Moreover, there is no available literature that suggests the values for E_4 would change in a coastal area. Distance from roads was calculated as Euclidean distance between the CVS plots and a transportation data layer (United 2002).

$$E_4 = 0, \text{ for } x = 0;$$

$$E_4 = 0.156x + 0.195x^2 = 0.25, \text{ for } 0 < x < 1.6;$$

$$E_4 = 1.0 \text{ for } x \geq 1.6;$$

Where x = distance (km) to nearest road.

Life Requisite Value – Denning:

The LRV for the denning of black bears, as outlined by Zimmerman (1992) in the southern Appalachian Mountains consists of four major components: area of conterminous forest (ha), terrain slope, presence of large diameter trees, and canopy cover of dense understory. While this model was designed to suit the southern Appalachian area, elements of the model can be adapted to fit the topography and habitat typical of the study area. Specifically, the requisite value for conterminous forest remained the same while the requisites for percent cover of dense understory and presence of large diameter trees were expanded to include vegetation indigenous to northeastern North Carolina. The aspect of slope was reduced to zero given the extremely minimal elevation change throughout the study area. The overall formula, as stated in Zimmerman's paper, for the LRV for black bear denning is:

$$LRV_{DEN}=[((D_1+D_2)/2)(D_3+D_4)]^{0.5}$$

$$\text{If } LRV_{DEN} > 1.0 \text{ then } LRV_{DEN} = 1.0$$

Where D_1 is the area of conterminous forest, D_2 is the percent area covered by dense understory, D_3 is the slope, and D_4 is the presence of large diameter trees. The different aspects of the D subsections are expounded upon and given values in the following sections. Due to differences in these values between the Appalachian Mountain study area where Zimmerman conducted their experiment and this study area, the formula was adapted to:

$$LRV_{DEN}=((D_1+D_2)/2)+1/23(D_3+D_4)$$

$$\text{If } LRV_{DEN} > 1.0 \text{ then } LRV_{DEN} = 1.0$$

The reduced weight of D3 and D4 was based on Martorello and Pelton (2003), which showed that only 1 in 23 black bears in coastal North Carolina utilized tree denning. The equation was made additive instead of multiplicative because of the minimal importance of trees for black bear denning in the study area. Raising LRV_{DEN} to the power of 0.5 was done by Zimmerman due to the fact that two denning values were multiplied in that equation. Seeing as the adapted equation is additive, the exponent was removed as it was not relevant to our study.

Conterminous Forest (D_1):

According to Zimmerman (1992), the area of conterminous forest is important in determining chance of disturbance. He suggested a minimum area of conterminous forest for denning to be 200 ha (to reflect half of the area needed for escape); below which the suitability index (SI) for denning, D1, would be zero. He used the average female home range of 1,225 ha to be the area where D1 levels out at 1.0. Using this, he created a linear relationship between the minimum and maximum area for D1 and derived the function:

$D1 = 0$ for $x \leq 200$;

$D1 = (9.8x10^{-4})x - 0.20$, for $200 < x < 1225$;

$D1 = 1.0$, for $x \geq 1{,}225$;

where x = area (ha) of conterminous forest.

We used spatial land cover data from C-CAP (NOAA 2010) within a GIS to find areas of conterminous forest.

Area Covered by Understory (D_2):

The process of defining understory species for D_2 was the same as for escape (E_2), differing only in how the understory related to denning as opposed to escape. Relating to denning, Zimmerman (1992) defined understory as suitable when a contiguous area of understory cover is greater than 30 hectares. A regression of a line from the origin to this maximum gave the function:

If $x < 30$, then D_2 is multiplied by 0.0333.

If $x \geq 30$, then $D_2 = 1$.

If D_2 was multiplied by 0.0333, then there is an uncertainty of black bears being located there or not. If the number were greater than 30, the plot was certainly suitable for bears and these areas were given a value of 1.

Slope (D_3):

As previously stated, the parameter of slope was reduced to zero for all sites within the study area given the rather uniform elevation. Seeing as the slope and presence of large diameter trees was cumulative, $D_3 + D_4$ reduced to D_4.

Presence of Large Trees (D_4):

Bears use trees for denning, but in order to be suitable for denning, the trees have to be of certain size. Therefore, as the number of large diameter trees increase, with large diameter referring to bald cypresses that are greater than 145 cm (Crook and Chamberlain 2010) and other trees whose diameters are greater than 90 cm, the number of bear dens in trees should also increase. The data collected by the CVS listed both tree type as well as diameter at breast height for vegetation within the study area. Only trees meeting the aforementioned parameters were included in the calculation and then individual vegetation survey locations were given weight under a certain set of conditions. These conditions were that if a site had more than 250 trees greater than or equal to 90 cm in diameter, then D_4 would equal 1.0 (Zimmerman 1992). If there are less than 250 trees that fit that qualification, the number of trees are plugged into the equation $D_4=0.564(\ln(x))-0.352$ with the number of trees substituting for x (Zimmerman 1992). Due to the overwhelming lack of trees above 90 cm in diameter and bald cypresses with a diameter greater than 145 cm, this variable was altered so that if any number of trees were found greater than 145 cm for bald cypresses and 90 cm for all other trees, then D_4 would equal 1.0. Any plot that did not have trees of this size was given a D_4 of zero.

Table 3. The adaptations that were made to the equations found in Zimmerman (1992) to better suit our study area. The variables that were changed, the original Zimmerman (1992) equations, the new manipulated values, and the justifications for each change are shown.

Manipulated Variable	Zimmerman (1992) value	Manipulated value	Justification
LRV_{food}, Life Requisite Value of Food	$= 1/7\ Fo_{TOT} + (1/7\ FSp_{TOT} + 2/7\ FSu_{TOT} + 4/7\ FFa_{TOT}) * I_1$	$= 7/14\ Fo_{TOT} + (1/14\ FSp_{TOT} + 2/14\ FSu_{TOT} + 4/14\ FFa_{TOT}) * I_1$	Anthropogenic food weighted more heavily
Fo_1, variable for colonial insects	$= 0.00082x + 0.1$, for $x \leq 1100$; $= 1.0$, for $x > 1100$; where x = downed logs/ha.	= 0.0	Beeman and Pelton (1980); Jones and Pelton (2003); Landers et al. (1979)
Fo_{2a}, Source of anthropogenic food	$= ((A+R)/2) * S$	= 1	First-hand Observations
Fo_{2c}, Distance from anthropogenic food source to escape cover	$Fo_{2c} = 1.0$ for $x < 25$ $Fo_{2c} = -0.0017x + 1.0425$ for $25 \leq x \leq 200$ $Fo_{2c} = -0.0015x + 0.6$ for $200 \leq x \leq 400$ $Fo_{2c} = 0$ for $x > 400$ where x = distance (km) from plot to anthropogenic food source	$Fo_{2c} = 1.0$ for $x < 25$ $Fo_{2c} = -0.0017x + 1.0425$ for $25 \leq x \leq 200$ $Fo_{2c} = -0.0015x + 0.6$ for $200 \leq x \leq 400$ $Fo_{2c} = 0$ for $x > 400$ where x = distance (km) from plot to anthropogenic food source within conterminous forest of ample size	North Carolina Wildlife Black Bear Profile
I_1, Interspersion	$=1.0$, for $x \leq 5$; $=-0.07x+1.35$, for $5<x\leq 19$; $=0$, for $x>19$; where x = travel distance (km).	Not included	Interspersion is only relevant when examining a continuous surface instead of individual plots
E_3, Slope and Escape	$=0$, for $x<15$; $=0.0333x-0.5$, for $15\leq x\leq 45$; $=1.0$, for $x>45$; where x = slope (degrees) of terrain.	= 0.0	First-hand Observations
D_3, Slope and Denning	$= Tan(x)$, for $x \leq 45$; $=1.0$, for $x>45$; where x = slope (degrees) of terrain	= 0.0	First-hand Observations
D_4, Presence of Large Trees	$= 0.564(Log_{10}\ x) - 0.352$, for $x \leq 250$; $=1.0$, for $x>250$; where x = number of trees ≥90 cm DBH/ha.	$= 0.564(Log_{10}\ x) - 0.352$, for $x \leq 250$; $=1.0$, for $x>250$; where x = number of trees ≥90 cm DBH/ha. where x = number of bald cypress ≥145 cm DBH/ha.	Crook and Chamberlain (2010)
LRV_{DEN}, Life Requisite Value of Denning	$=[((D_1+D_2)/2)(D_3+D_4)]^{0.5}$; If $LRV_{DEN} > 1.0$ then $LRV_{DEN} = 1.0$	$=((D_1+D_2)/2)+1/23(D_3+D_4)$; If $LRV_{DEN} > 1.0$ then $LRV_{DEN} = 1.0$	Martorello and Pelton (2003)

Land Use Change and Black Bear Habitat Replacement Cost in Northeastern North Carolina

Historical land cover data from 1996 and 2010 were used to examine changes in black bear habitat over time and to estimate the corresponding cost to restore worsened lands to their 1996 conditions. We used habitat quality conditions to identify aspects of the landscape, including forest cohesion, forest diversity, and forest-agriculture edge density, which are suitable habitat for black bears in northeastern North Carolina (Kindall and Van Manen 2007).

To examine changes in land use from 1996 to 2010, NOAA's Coastal Change Analysis Program's dataset was used within ArcGIS (version 10.4.1). The 1996 and 2010 datasets were first reclassified to identify only cohesive forests in the region based on the presence of deciduous forests, evergreen forests, mixed forests, palustrine forested wetlands, and estuarine forested wetlands (Kindall and Van Manen 2007). All of these areas were reclassified to the same value because, regardless of the forest type, cohesion was the desired variable. For each of the years, we then uniquely identified each forest type, which was then used to calculate our measure of forest diversity. Forest-agriculture edge density variable was determined by reclassifying forested land and cultivated crops as unique indicators.

Each variable in each year was processed in FRAGSTATS. The forest cohesion variable for each 1996 and 2010 dataset was processed using the Patch Cohesion Index within the software with square 300 meter x 300 meter patches. This produced a .tif file for both years, which was then uploaded into ArcGIS. Within ArcGIS, any forest with patch cohesion ≥91 was considered favorable black bear habitat (Kindall and Van Manen 2007).

The forest diversity raster datasets were then analyzed in FRAGSTATS by using the Simpson's Diversity Index calculation with the same patch definition used for forest cohesion. Consistent with Kindall and Van Manen (2007), we reclassified values ranging from 0 to 0.5 as a range suitable for black bears. These cells were attributed a value of 1 and any area that did not fall within the range was given a value of zero.

Forest-agriculture edge diversity was computed using the Edge Density tool within FRAGSTATS and applied to the two reclassified datasets concerning the variable. Based on visual inspection, this indicator was reclassified as favorable edge density for black bears for those values ranging from 0.25 to 0.5.

Within ArcGIS, the change in black bear habitat from 1996 to 2010 was determined using the raster calculator for each raster cell (300 meter by 300 meter). Within the calculator, the cumulative values of all variables from 1996 were subtracted from the cumulative total of variable present in 2010. This calculation resulted in a scale ranging from -3 to 3. Each of these values was given a description (Table 4).

Table 4. Degree of Change of Black Bear Habitat and Description

Description	Degree of Change
Greatly Improved	-3
Moderately Improved	-2
Slightly Improved	-1
No Net Change	0
Slightly Worsened	1
Moderately Worsened	2
Severely Worsened	3

The weighting (Table 4) assumes that each variable's contribution to black bear habitat is independent of one another and that the reduction or improvement in one variable has an equivalent impact on black bear habitat as analogous change to another variable. Although the above scaling is likely to capture broad trends in black bear habitat quality, a more nuanced approach might consider these habitat characteristics individually. For example, the cost of restoring agricultural-edges may be more expensive than replanting to increase forest cohesion.

We used the tabulate area tool to summarize the raster cells within each private parcel of land that were "severely worsened," "moderately worsened, or "slightly worsened." The total cost of restoration was then determined for the study area and related, on a parcel-by-parcel basis, to the value of land in these counties.

The costs of habitat restoration are highly uncertain and are likely to vary across space and time. For example, under the United States Department of Agriculture's Wetlands Reserve Program, similar replanting efforts have been conducted in Arkansas and Louisiana with the aim of supporting the Louisiana Black Bear (*Ursus americanus luteolus).* Nationally, in 2001, "the average cost of purchasing and restoring a permanent easement was approximately $1,200 per acre. The average cost of purchasing and restoring a 30-year easement was around $770 per acre. Restoration cost-share agreements, which do not include easement acquisition costs, averages around $450 per acre" (USDA 2016). In Delaware, the per-acre cost of forest restoration is $400 when growing forests; wetland restoration projects were approximately $1,500 per acre; replanting of riparian forest buffers were approximately $500 per acre and restoring forested Bog turtle habitat costs approximately $1,000 per acre (FWS 2016). Using these cost estimates as a guide, and recognizing that habitat worsening in terms of the multiple indicators, forest diversity and forest cohesion, is more costly to restore, we assume restoration costs of $300 per acre if one of our three indicators is worsening, $600 per acre if two indicators are worsening and $1000 per acre if all three indicators are worsening. We then employed land parcel valuations from county assessor offices to gain perspective on the restoration cost as it compares to the property's market valuation for thirty years. These costs accounted for only the direct costs of restoration, such as replanting efforts, and not for indirect costs, such as land acquisition or rental and disruption of existing human use. Therefore, our estimations of the final cost are on the lower bounds of the true cost of black bear habitat restoration.

Results and Discussion

Red Wolf Habitat Suitability on the APP

Figure 1 shows the discrepancy between suitable habitat and federal lands. The red wolf reintroduction program released wolves on federal lands, namely the ARNWR. Whereas, our analysis revealed that suitable red wolf habitat is located disproportionately in the more inland portion of the of the study area. This finding supports the claim made by Dellinger et al. (2013) that red wolves prefer to remain distant from human development, but close to large agricultural fields and intact agricultural edges. These habitat characteristics provide a stable food source (i.e. small game) and preserve low interactions with humans (Dellinger et al. 2013). Northeastern Beaufort and southern Washington counties are predominately agricultural land (Figure 2). Agricultural expansion in these regions, as well as throughout the entire study area, may improve the suitability of the region's habitat for the red wolves.

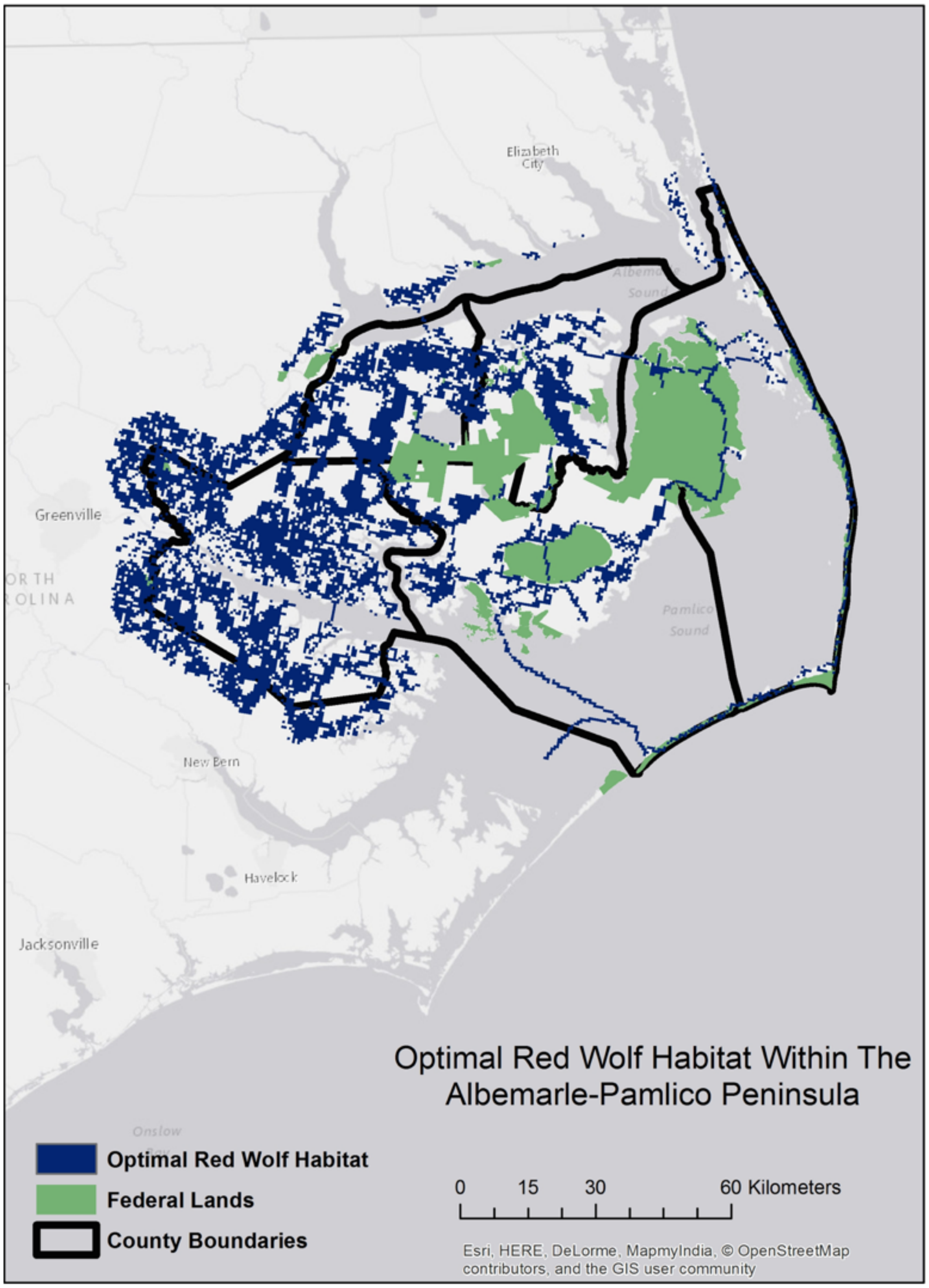

Figure 1. The culmination of multiple RSF (resource selection function) layers, derived from Dellinger et al (2013), that represent the most suitable red wolf habitat in Northeastern North Carolina in 2013 in comparison to the federal lands also located in the region. Constructed in ArcGIS by reclassifying favorable habitat types and then subtracting away land that is not traditionally indicative of red wolves. Blue areas represent suitable red wolf habitats. Green areas represent federal lands. The black border represents the counties we are studying.

Habitat near federal lands, where the USFWS placed the red wolves for the reintroduction program, is largely fragmented. Taking into consideration the large expanses of land needed to support a red wolf pack, federal lands have comparatively little potential to help sustain populations. Also, much of the federal land is Pocosin forest (Figure 2), which, according to the North Carolina Wildlife Red Wolf Profile, is considered suitable red wolf habitat. This RSF indicated that Pocosins and wetlands are unsuitable for red wolves (Table 2; Dellinger et al. 2013). Therefore, the refuges and lands that the USFWS deemed suitable for the red wolf reintroduction program are likely less suitable than previously believed. However, because little was known about red wolf behavior and preferences prior to the Red Wolf Reintroduction Program (because red wolf populations had been decimated), information gleaned from the APP wild population's behavior is valuable and noteworthy. Information about red wolf biology and ecology gathered through the NEP program on the APP will be useful in examining the suitability of future landscapes to support red wolves.

Habitat presence does not necessarily determine the absolute presence of red wolves in the area; due to the fragile nature of the red wolf population, the population may be more concentrated in areas where they are significantly managed. If management efforts do strongly influence the location of red wolf populations, then management in areas that the RSF deemed as more suitable may be more beneficial to the fragile population. Intensive management efforts, like the placeholder management method to reduce coyote hybridization, along with removals of red wolves from private land by the USFWS shows that unfettered access to these lands, which is available on federal lands, was vital (Bohling and Waits 2015; Murray et al. 2015). Intensive management practices and natural limitations to migration, such as habitat fragmentation and anthropogenic harvesting, may concentrate the location of red wolves to federal lands despite their less than suitable habitat.

Although federal land does not contain a majority of habitat most suitable for red wolves in northeastern North Carolina, there still is justification for the USFWS's decision to locate the reintroduction program on federal land: there was no cost to acquire these lands and access to manage on these lands was unfettered. In comparison, since the most suitable habitat was located on private land, access would require landowner support, which might require compensation or another form of incentive. An effective incentive program would focus on connecting fragmented habitat and encouraging landowners to allow wildlife managers on their land. These results are consistent with the Williams et al. (2014) conclusion that construction of such an incentive program is necessary for the successful management of red wolves in such a diverse landscape.

Black Bear Habitat Suitability Index

The average calculated HSI for the 99 CVS plots was 0.56 with a standard deviation of 0.23 (all HSI calculations and their corresponding locations and CVS plots are provided in Table 7 in the Appendix). The values ranged from 0.14 for a parcel in mainland Dare County to 0.91 for a parcel in Beaufort County (Figure 2). This HSI value is similar to, and slightly greater than, Zimmerman's estimation of 0.48 in the Appalachian Mountains, which is an area with a thriving black bear population similar to our study area.

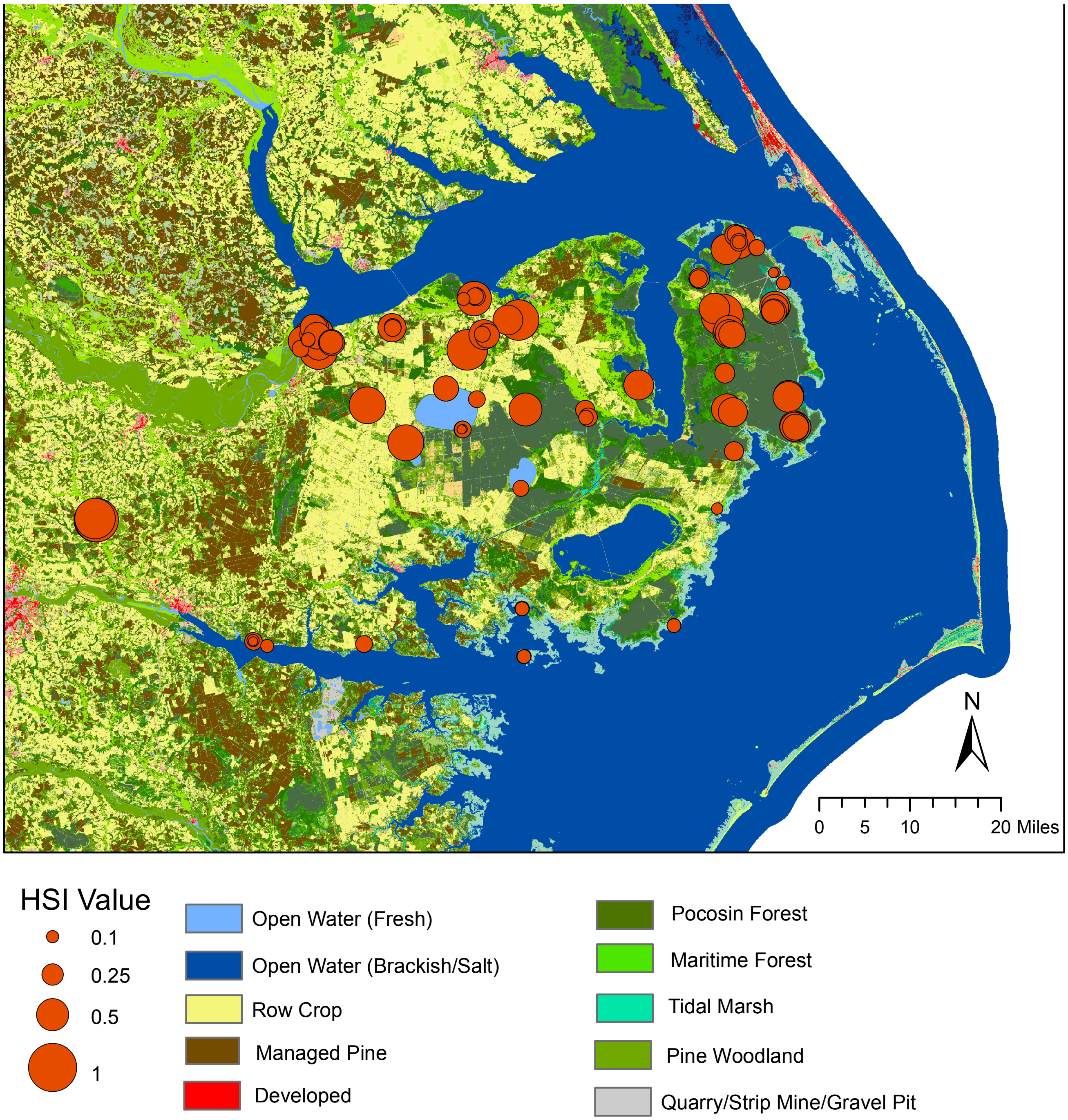

Figure 2. Land use and calculated HSI values at CVS plots within the study area of the APP. Land use is classified by color and HSI value is indicated by the size of the point. Land use was derived from CCAP (2010) and HSI values were calculated from CVS data using a model adapted from Zimmerman (1992).

If we dissect the HSI, again, we have three contributing factors, denning, food, and escape cover. The denning LRV average was 0.79, which means that it had the strongest influence on our final HSI calculation. The other average values were 0.40 for the food LRV and 0.49 for the escape cover LRV.

Our HSI results may not accurately represent the habitat value of all locations on the APP, which is different from the continuous surface resulting from Zimmerman's (1992) analysis of land in the Appalachian Mountains. CVS plots, which were used as HSI calculation locations, are largely located in natural communities, and thus, underrepresent agricultural areas that serve as important black bear habitat, especially contributing the LRV food, within our study area. These agricultural areas, row crop, pasture/hay, and managed pine, comprise approximately 27 % of the land area of the APP. This leads us to believe that if anything, our modeled average HSI for the APP is low relative to real-world habitat suitability of the APP for black bears. Another factor that limits the applicability of our results to the entire landscape is the point-based approach we took to the black bear HSI. Here, we considered and measured only the habitat quality for precise point locations, which does not account for spatial effects, i.e, nearby landscape conditions that affect habitat quality. For instance, a wetland location adjacent to forest or agricultural fields would be measured as poorer quality habitat despite the presence of nearby high quality habitat.

One of the major differences in the HSI equation between our study and Zimmerman's is the denning LRV. While our average denning LRV is relatively high (0.79), that high value is largely driven by one value, understory cover (D_2) contributing to the denning LRV. Whereas Zimmerman (1992) had several factors contributing to denning suitability, two of those values, local conterminous forest value (D_1) and the tree diameter value (D_4), had some points with values of zero in our study and slope (D_3) was removed from our calculation. The D_1 value is zero for 35 out of the 99 plots, which would indicate that there is a higher percent of habitat fragmentation in the area, preventing bears from making dens. Again, the first hand observation of bears in the field seems to undermine the fact that denning space is unavailable and therefore the area is unsuitable for black bears. This may mean that denning, or at least conterminous forest denning, is not critical for black bears in northeastern North Carolina. The D_4 value similarly brings down the denning LRV due to the fact that there are not many large diameter trees in the study area that qualify as what Zimmerman (1992) found was necessary for black bear denning. This lack of large diameter trees in northeastern North Carolina could be due to a combination of factors such as a lack of sustainable land use practices in favor of black bears, deforestation and development, and the general differences of habitat and what it can support between Zimmerman's study area and our own. The weight we gave D_4 reflects this reduced reliance on trees of large diameter in our study for bear denning (Martorello and Pelton 2014). These factors indicate that some adjustment to the HSI equations and values should be made to better reflect the situation of the bears in the area in further studies and the importance of site-specific HSI models.

Bear Habitat Change Model

We also examined bear habitat change from 1996 to 2010 within our study area. The extent of habitat improved or worsened from 1996-2010 in the study area is shown in Table 5 and Figure 3.

Table 5. Area (acres) within each county that fell into one of the seven categories that ranked the amount of positive or negative change in regards to black bear habitat. Positive numbers represent positive change, with 3 having the largest magnitude, and negative numbers represent negative change, with -3 having the largest magnitude. The composition of overall improved or worsened areas in the counties are also shown in this table.

	Beaufort	*Hyde*	*Dare*	*Tyrrell*	*Washington*
3	63	8	0	4	31
2	1153	355	4	96	224
1	17954	25577	15335	11102	5371
0	246676	201381	183110	164745	92223
-1	64022	22564	5955	15303	22185
-2	18093	4516	212	3331	5873
-3	2794	614	0	454	944
Improved Area (acres)	19170	25941	15340	11202	5626
Worsened Area (acres)	84910	27694	6166	19087	29003
Total Area (acres)	350756	255016	204616	195034	126852
Improved Percentage	5.47	10.17	7.50	5.74	4.43
Worsened percentage	24.21	10.86	3.01	9.79	22.86
Unchanged Percentage	70.33	78.97	89.49	84.47	72.70

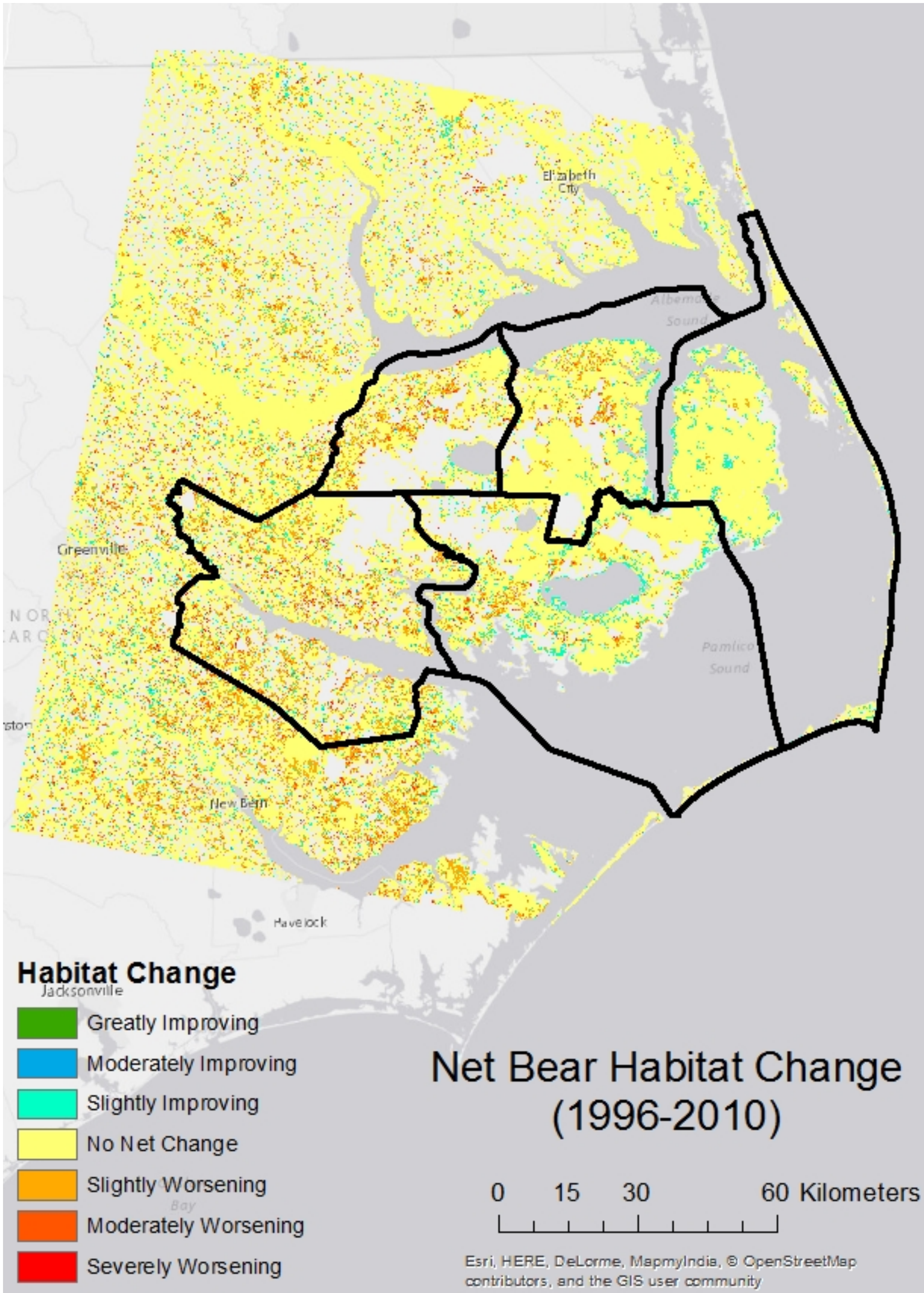

Fig. 3. The change in land use from 1996-2010 on the APP as a representative of worsening or improving black bear habitat. Three variables, forest cohesion, forest diversity, and forest-agriculture edge density, were compared from their 1996 value to their 2010 value. The improvement or worsening was calculated based off Kindall and Van Manen (2007), measured using FRAGSTATS, and finally mapped using ArcGIS.

A majority of habitat neither worsened nor improved across the counties, as indicated by the large amount of yellow-colored land in the Figure 3. This trend of no change is especially evident closer to the coast. Much of Dare (89.49%), Hyde (78.97%), and Tyrrell (84.47%) counties exhibited no change in black bear habitat suitability from 1996 to 2010 (Table 5). This could be because there has not been much change in land use over the time span due to federal protection in lands like ARNWR, Dare County Bombing Range, and numerous game lands throughout the counties, compared to other regions. Additionally, in these three counties, there were some patches of land that slightly improved, especially in the heart of the Dare County game lands and in Hyde County near Lake Mattamuskeet and Swan Quarter. The game lands are protected from habitat destruction and because of this likely increased in forest cohesion and forest tree diversity, which would improve the area for black bear habitat. On the other hand, Swan Quarter and Lake Mattamuskeet areas are rich in farmland, which likely increased forest-agriculture edge density, which would also improve the land in terms of bear habitat. Outside of these three counties, however, bear habitat worsened more noticeably. In general, there was more change to the habitat in Washington (27.3%) and Beaufort (29.67%) counties compared to the other three and a majority of this change was a worsening, which can be seen by the high amount of slightly worsening land in Figure 3 and Table 5. This could be tied to greater change in land use in Washington and Beaufort counties, but further related information would be needed to make such a conclusion.

In only one county, Dare, did more area improve than worsen. In Hyde, there was nearly equal improvement and worsening, although there was more land area that moderately or severely worsened than there was land that moderately or greatly improved. By accounting for three separate variables, our analysis was able to determine the intensity of worsening relating to those three variables, which is important in understanding the extent of which the habitat worsened. In Tyrrell, almost twice as much land worsened as improved while Washington and Beaufort both had almost five times more land worsen than improve, with Beaufort showing the highest percentage of worsened land. Across these counties, the three factors are generally worsening for bear. This is important to realize when examining future land use changes if black bear habitat is to be considered. If the past landscape changes from 1996-2010 are repeated over the coming years, bear habitat will continue to decrease in suitability pertaining to the variables we considered.

It is important to note the sizes of the counties when examining the data. The county with most worsening land in terms of percentage, Beaufort, also is the largest county in terms of total land area. In fact, more land area worsened in Beaufort County than all other counties combined. Behind Beaufort, the counties that worsened most in terms of land area, in descending order, are; Washington (despite being the smallest county in terms of total land area), Hyde, Tyrrell, and then Dare County. Contrastingly, the county that improved most in terms of percentage, Dare, is only the third largest county in the study area. Because of this, it was also only third in terms of total area of improvement while Hyde actually ranked first in terms of total land area improved followed by Beaufort, Dare, Tyrrell, and Washington County. While as a county, Dare is improving, the statistic, when applied across the study area, does not carry much weight because more than double the amount of land worsened (166,857 acres) than improved (77,277).

It is very important to realize that since the change in habitat was quantified on a binary basis before being summed, it does not take the extent of worsening or improving of habitat into account in a significant matter. And finally, the change in habitat was not examined in a way that took the effects of one variable on another into account. Although we do focus on three clear contributors to habitat change, the potential for synergies amongst our indicators to impact habitat quality is not examined. For example, agricultural expansion may create edge habitats while also reducing forest diversity. In our examination, these factors would offset in their contribution to habitat quality. In reality, edge habitats may be disproportionately attractive to black bears in the presence of high forest diversity. Accounting for such interactive effects would require a clearer understanding of black bear habitat suitability in highly diverse landscapes.

Table 6 shows an estimation of the costs associated with restoring negatively impacted lands to a better suited habitat for black bears and as well as the monetary benefit of improving bear habitat from 1996-2010 based on costs from a Delaware restoration project (Kindall and Van Manen 2007). Unsurprisingly, the cost of restoring negatively impacted land to improve habitat suitability for black bears is directly related to land area that worsened from 1996 to 2010. Beaufort would require the most financial commitment to restore their land at about $32.9 million followed by, Washington ($11.1 million), Hyde ($10.1 million), Tyrrell ($7.0 million), and lastly Dare ($1.9 million). Normalizing this by land area (acres) that worsened, Beaufort had the highest cost of restoration per acre ($387) followed by Washington ($384), Tyrrell ($369), Hyde ($364) and finally Dare ($310). Similarly, the benefit of improved habitat quality in Table 6 correlated with the amount of land area improved in Table 5. Hyde had the highest benefit at about 7.9 million dollars followed by Beaufort (6.1 million), Dare (4.6 million), Tyrrell (3.4 million), and Washington (1.8 million). Normalizing this by land area (acres) improved, Beaufort had the highest benefit of improved habitat per acre ($320) followed by Washington ($316), Hyde ($304), Tyrrell ($303), and finally Dare ($300). These normalized values for both restoration cost and improving habitat reflect the degree to which habitat was worsened or bettered across the counties in a way that displays necessary financial commitment to restore land or compensation for improving the value of land. The highest restoration costs per acre are associated with the two counties that had the most land area worsen, showing that not only did a lot of habitat worsen but it did so in a more significant manner than in other counties. The only county that had more improvement of habitat than worsening, had the lowest benefit for improved habitat quality, which shows that most of the land that improved in Dare County only improved slightly. In fact, 15,335 acres out of the total 15,339 that improved did so only slightly. When considering the three variables accounted for, it was much more likely for the worsening to be severe than the improvement to be great.

Table 6. The monetary costs, which were derived from a Delaware restoration project, associated with restoring the land that has worsened from 1996 to 2010 can be seen (Kindall and Van Manen 2007). The value from pro-social behavior is the amount of money that was saved when lands improved to better suit the black bear from 1996 to 2010.

Total Private Parcel	*Hyde ($million)*	*Beaufort ($million)*	*Tyrrell ($million)*	*Dare ($million)*	*Washington ($million)*
Restoration Cost (1996 to 2010)	10.09	32.86	7.04	1.91	11.12
Benefit from pro-social behavior (1996 to 2010)	7.89	6.14	3.39	4.60	1.78

In all counties except Dare, the cost for restoring worsened lands to their previous conditions outweighs the economic benefits that resulted from improved lands for bear habitat. Overall, more land area worsened than improved and the costs from that worsening greatly outweighed the benefit of habitat that improved. However, it is important to understand that despite the results found in our study, black bears are thriving in the area and so the extent of "worsening" bear habitat in the study area does not seem to determine the bear population's general status. This study of changing bear habitat only accounted for three variables on a binary basis and weighted them evenly, both separately and aggregately. There are likely more complexities involved in the bettering or worsening of bear habitat in the study area that were not accounted for in our analysis.

To compare our HSI to a different habitat suitability model, we contrasted the index to positively indicative land values for black bear habitat in 2010 (Kindall and Van Manen 2007). Many of the locations that the HSI indicated as suitable for black bears are not suitable for black bears in the context of the variables outlined by Kindall and Van Manen (2007; Figure 4). One reason may be that Kindall and Van Manen's variables, forest-agriculture edge density, forest diversity, and forest cohesion, were predominately forest based. While the forest is relevant for black bears in both models, the HSI also stressed natural food sources, which Kindall and Van Manen (2007) does not directly consider. This may be one shortcoming of relying solely on large-scale geospatial analysis to guide management actions. Whereas, a shortcoming of the HSI for specific locations is that they may not necessarily be scalable to the broader landscape.

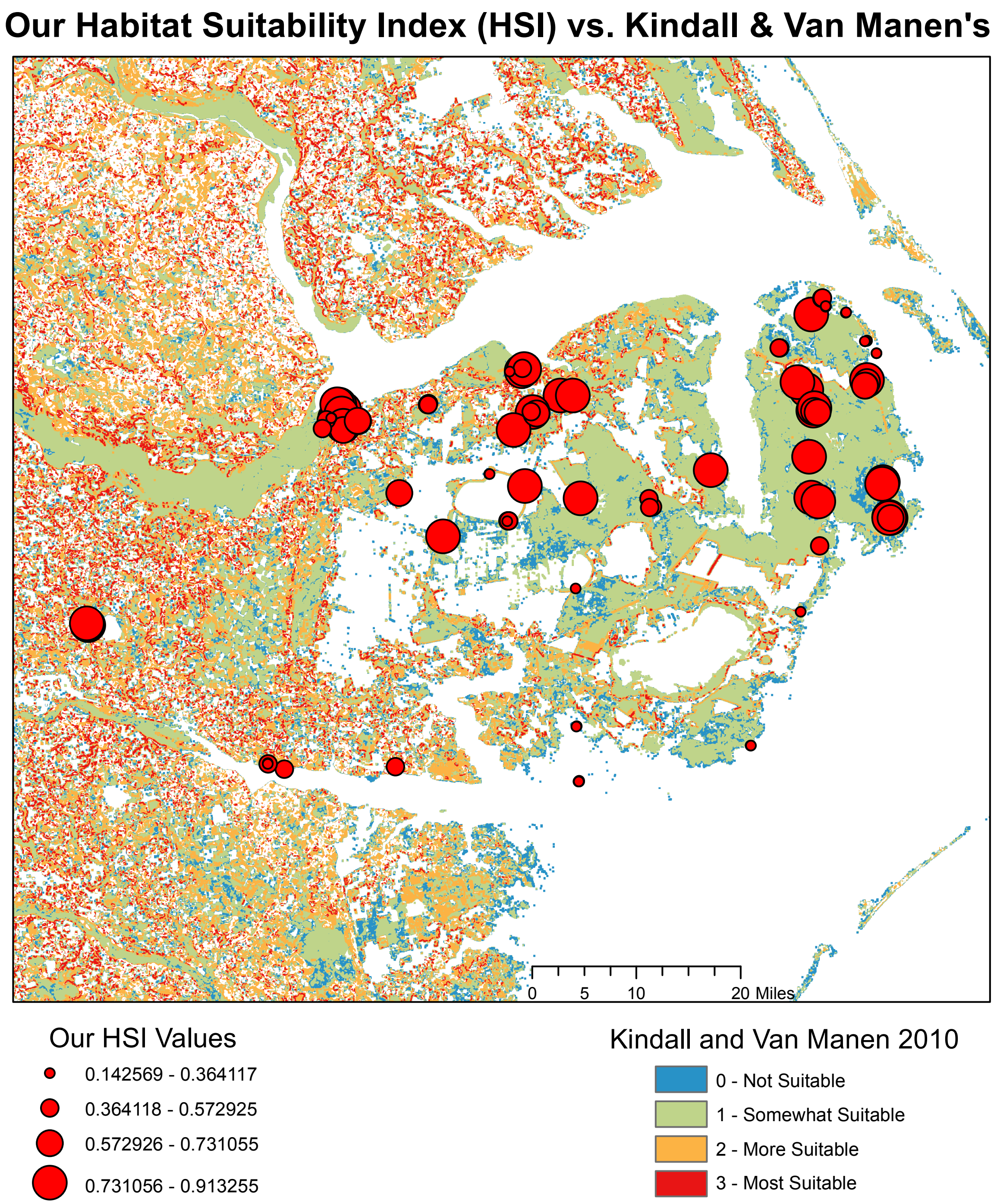

Figure 4. Comparison of HSI's calculated from CVS plot data and black bear habitat model calculated from satellite imagery. HSI values are represented as red dots with size correlating to the magnitude of the HSI values (model adapted from Zimmerman (1992)). Habitat quality as determined by Kindall and Van Manen (2010) was based off of forest cohesion, forest-agriculture edge density, and forest diversity.

Our recommendation for the habitat suitability-based management of black bears would be a combination of usages of on-the ground detailed measurements and site-specific models, such as the CVS data and our application to our HSI and landscape-scale models, similar to Kindall and Van Manen (2007). In this way, the larger models can be used and the resulting findings can be confirmed or adjusted based on more detailed, site-specific methods. Despite the differences seen between the two models, deeming one universally right and the other wrong would be erroneous. Each model consisted of different variables with differing weights. Groundtruthing and comparisons of the habitat suitability to habitat use by organisms are highly recommended tools to confirm the suitability of indices before they are used to guide management decisions.

Human Dimensions

Methods

We conducted semi-structured interviews using an interview guide. Interview questions focused on the interviewee's background and environment, as well as bears, red wolves, coyotes, and management (see Appendix for the full interview guide). There were similar questions about all three predators that would eventually allow us to compare and contrast perceptions of these animals. The guide format allowed for tailoring questions depending on the individual's profession and level of interaction with the predators. For example, we might have asked a farmer slightly different questions than a hunter. We asked open-ended questions allowing interviewees to express their ideas and focus on what was meaningful to them within the question posed. When the interviewee moved off topic, we had the ability to redirect, and when the interviewee found something more meaningful, we had the ability to focus in on that aspect of the conversation. At the end of the interview, we asked for any additional information that the interviewee might find important but had not been addressed with the questions in our guide. All interviews were conducted in accordance with the standards of the UNC Institutional Review Board (IRB), and we maintain the confidentiality of the identities and responses of interview participants.

Sampling

We purposively sampled residents of Tyrrell and Hyde Counties, NC that were farmers, hunters, and local officials who have knowledge and experience with one or more of the study predators. We used referrals to identify interviewees, with initial contacts from field site faculty and contacts in the study area. We received subsequent referrals using snowball sampling in which each interviewee was asked to recommend other potential participants. We contacted potential interviewees by email and phone.

Due to the controversial nature of the Red Wolf Program, we anticipated that we might run into barriers when asking individuals to participate in our study. However, we also ran into other difficulties when trying to sample to saturation, or when we no longer heard new information in the interviews. It is likely that individuals were already receiving numerous phone calls due to the presidential race coming to an end, and it is possible that our calls were screened out. There was also a limited time frame for conducting these interviews. We were able to achieve a broad interviewee base; however, we did not sample to saturation because we were still learning new information from each interview. Ideally, we would have liked to talk to residents of the other three counties in our study area, Beaufort, Washington, and mainland Dare Counties, as well as hunt guides and state and Federal managers.

Analysis

Interviews were transcribed word-for-word using Otranscribe, a free open-source web app. Transcripts were analyzed by coding using NVivo v.10, qualitative analysis software. Coding involves categorizing statements made by the interviewees. Using a set of emergent codes or labels, we categorized segments of interviews based on their contents. The coding process allowed for clearer and more regimented identification of themes, as well as easier comparison of statements made across interviews. Breaking down key concepts in this manner provided more meaningful and more easily referenced results for each topic of interest. Using the codes, we pulled broader themes out of the data to make coherent characterizations of the attitudes of interviewees. An important aspect of the process was that each interview was analyzed shortly after its completion rather than after all interviews had been conducted. Analyzing on a rolling basis allowed for a faster overall process, an opportunity to identify topic saturation, and the ability to explore emerging themes in subsequent interviews.

Sample size and limitations

We interviewed 12 individuals who live in the study area — seven residents of Hyde County and five residents of Tyrrell County, including two women and ten men. The sample is comprised of individuals from a wide variety of backgrounds. While our sample included farmers, hunters, and government officials, the relevant stakeholders in this project, the small size of the sample somewhat hindered our ability to draw a complete picture of the attitudes of the people on the APP. Ideally, we would have conducted so many interviews that we would start to hear much of the same information from interviewees within the same stakeholder group. Unfortunately, we were not able to do that, and so the perspectives we got, while sometimes aligned, often differed quite significantly within the various stakeholder groups. Nevertheless, we were able to characterize some of the shared attitudes among interviewees about large predators.

Results and Discussion

Several key themes emerged from the interviews in Hyde, Tyrrell, and mainland Dare Counties that we organized around perceptions of landscape, predators, and wildlife management in eastern NC. Respondents expressed an appreciation of nature and its role in their professional and personal lives, as well as a strong sense of pride in their wild and challenging landscape. In characterizing large predators, respondents tended to identify black bears as non-threatening, longtime residents of the area that exemplify the beauty and uniqueness of the landscape, while they characterized red wolves as elusive recent additions that lack a true place in the area. Coyotes were identified as unwanted pests, threatening because of both their behavior and their rapidly growing population. With regard to how these predators are being managed, respondents' attitudes were generally shaped by their perceptions of state and federal government and influenced by their livelihoods and their feelings about the landscape overall.

Landscape Perceptions and Values

The land is extremely important to people who were interviewed, and their local culture and community were inevitably intertwined with it. As one Tyrrell County resident said, "It's an island of non-development" (2). With a lack of conveniences, like large grocery and department stores, and an abundance of farm and game land, there is a consensus of appreciation for the natural landscape. Many people's jobs and hobbies are tied into the land. Farmers, hunting and eco-tourism guides, wildlife managers, and loggers comprise a large part of the workforce in the APP; hunting, fishing, and outdoor sports take up much of people's free time. According to the most recent CAMA Land Use plans for Tyrrell and Hyde Counties, fishing, hunting, logging and farming jobs comprise 16.8% and 15.9% of the workforce, respectively, two of the highest rates in the states (Holland Consulting Planners Inc. 2010, 2008). One of the interviewees described this, "… people work in the fishing industry or the farming industry or the forestry. That's the three big ones of course, the school system and the prisons employ a lot of people but mainly farming, fishing and forestry" (1). The ways in which the subjects value the land differ greatly depending on how they use the land, as well. For instance, a farmer might value the land for the fertile soil to grow crops while a hunter might value it for the habitat it provides for game. One of the interviewees said, "… Hyde County is real fertile soil for what I'm growing, for farming. It's really great, and the terrain, I like the flat ground" (2). This interviewee had a clear appreciation of the land that involved his occupation. Another interviewee had a similar experience, "Just seeing the wildlife and also hunting, it's fun. Or while I'm deer hunting one [a bear] will cross in the woods, you're hoping he'll just go on his way" (3).

Connections to the landscape run deep — many subjects emphasized enjoyment of wildlife. One interviewee mentioned, "It's so open and the sky is so big" (2), another stated "this place is still wild" and called the area a "paradise" (3). While others might struggle living in this environment, these people are drawn to or perhaps shaped by the area in such a significant way that they do not want to imagine living anywhere else.

To live on the APP is to live among a unique environmental framework, where wildlife and Pocosin wetlands define your daily life and struggles. The people of the peninsula have adapted to a landscape that is not for the weak-hearted. The people strive to make a living in a small community with few support systems and handouts. One person stated:

> The level of wildlife here is ubiquitous in that you live with wildlife, you live with nature, and you live with the force of nature here every day … you will not be here unless you choose to be ... You are a self-starter. You want to be here. You appreciate the quality of life out here and you are willing to do whatever it takes to be successful. So you have a tremendous amount of fiercely independent, fiercely prideful, fiercely individualistic people who are crafting a life in an environment that is beautiful and challenging (5).

According to this interviewee, there is a strong sense of independence and individualism in the people who reside in this landscape. The people are not put off by the challenges of the environment. They are people of pride, and they also take pride in their wildlife.

Many respondents expressed pride in the fact that the bears outnumber the people. In regard to Tyrrell County, one respondent said, "From a demographic standpoint, it's the smallest town in North Carolina. It's 800 square miles, 3,645 people, and 12,000 black bears living here" (5).

Another thing respondents boasted about is the lack of corporations influencing urbanized growth in these communities. Pride in the prevention of urbanization was a recurring theme among respondents: "Walmart is an hour away, which is a good thing" (6). There are not McDonalds or Walmarts around every corner. This rural preservation is important to the small towns where unity and tradition largely keep these populations connected in such a harsh environment. Though this may seem like an inconvenience to many people, it is not so for the majority of interviewees.

Characterizations of Large Predators

Black Bear

Respondents see the black bear as an irreplaceable feature of their natural world. Interviews showed people's positive perceptions of the animal, as well as the lack of threat they feel from such an enormous creature. The majority of the respondents described the black bear as a beautiful yet wild animal that they take pride in having in the area. One interviewee said:

> If you spend enough time in Tyrrell County, you're gonna run into bears, and they are … they're beautiful, and it's exciting when you see cubs scampering across the field or marching across your front yard or you see them in a field (5).

Others had similar experiences with black bears, as another interviewee put it:

> I love them just for the wildlife factor … I think they are beautiful. They are charismatic megafauna, I don't even know how to compare it. It would be like, if we had elk down here like they have up in the mountains now, it's like, there's something about the megafauna that just like, it's awesome but you know there is a cool factor about all mammals really. Especially the bigger, the cooler, I guess (10).

These two quotes show that the respondents are proud to have the black bear where they live. The bears are wild, much like the wild land that characterizes the study area. This connection is such that interviewees are excited when they see a bear, as if seeing them is a treat.

Moreover, interviewees talked about a lack of threat associated with the black bear. The animals have plenty to eat due to the enormous amount of cropland, and people have been encountering them for generations. One interviewee stated, "If one crosses in front of me while I'm walking the dogs, the bear's running away, you know? It's not us running away" (10).

Interviewees described black bears as not only a symbol of the wildness of their landscape, which they very much valued, but as a source of economic prosperity, as well. "Hunting is a big part of the economy" and other similar statements were made in many interviews (3). Another respondent emphasized that "bear hunters will especially pay a premium to come after a bear … and I mean a lot of money" (2). The specific dollar amounts associated directly with bear hunting were never explicitly mentioned. One respondent referred to bear hunting as being able to "make a little money off the land" and called it a "legitimate use of a resource" (3). It appears that most people who invest significant time and energy into bear hunting expect a considerable benefit. For example, "One farmer last year spent 15,000 dollars on bait…just bait" (2). We can assume from this that this specific farmer expects to make back at least that value, which is just one part of the bear hunting process.

Bear hunting also attracts money to the area in the form of non-local hunters. Not only will outside hunters "pay a premium," but they also "come from all over to come to Hyde County" to shoot bears (2; 3). Another person said there are normally "more people in those six days [in November], then all the rest of the year combined" (2). Bear hunting is not only attracting a significant amount of money, but also a significant number of people.

There is also a significant cost associated with having bears in an area, including the effects black bears have on agriculture. One subject said bears can "do a lot of crop damage. They graze in the beans and …you can count 12 to 20 bears in a single field. So the farmers, when you're in farmer mode, it's not what you like" (3). This depredation by black bears is definitely not seen as a positive outcome. One respondent summarized concisely, "I don't really particularly like feeding a whole bunch of them [black bears] in my crops," (6). In this way, people seem to be rather annoyed with the animal's presence; so much so that "there are times when you have to pull your hair out when you're trying to work and live where these animals are trying to make their living" (3).

Despite this annoyance, black bears seem to be widely tolerated. One respondent said that black bears are essentially part of the community, saying, "Most people out here get along with them — just part of being out here" (3). Because the bears are a commonly accepted part of the landscape, people have "learned to live with the bear" (1). Despite harm to crops, one respondent said, "We never, as farmers, run the bears off" (9). Another aspect to toleration of bears could be that farmers realize the revenue made from hunting balances out the amount of revenue lost from crop depredation. One respondent said, "They pay us for all the crops that they eat" (11). Although bears are to blame for crop damage, their status as a part of the local culture makes this damage somewhat excusable. One interviewee said:

> There's always bears here … and I think that it's really ingrained in people. It's not like the most important thing, but it's part of their landscape and their mind to a point that some of them take it for granted (2).

Bears have resided in the area for generations and have become part of the local culture because of it. It appears that time and familiarity make the annoyances that black bears cause easier to forgive, and our interviewees seem to tolerate or even enjoy having them around.

Red Wolf

While black bears are a familiar site in the APP, the red wolf, which is considered new by the local people, is generally much less tolerated. For example, one interviewee stated:

> Everybody has a story about a bear, but there's always been bears here, you know, the wolves— if they're beyond the memory of these families, and the early families wouldn't have had a sweet spot in their heart, because they would have been perceived as a threat back then, you know, automatically.... it's not a cultural — it's not a piece of the culture you know, they almost feel like someone took a piece of a culture somewhere else and just stuck it in and tried to jam it in, you know? (2).

Compared to the bear, respondents had a more neutral, and in some cases even negative, attitude toward the red wolf. Many of our interviewees have only had fleeting interactions with them and have never seen them for longer than a few seconds. One respondent said of his encounters, "They took off. I mean, and the only time I ever saw them was in the dark on the back roads in here — the gravel roads. And as soon as they see or hear the vehicle, they start running" (4). Because wolves are not present in interviewees' daily lives, there is a distance between them that leads some to characterize wolves in more detached terms, indicating that wolves are valued less than bears by respondents. Wolves tend to avoid people and human development, which may have reinforced this disconnect interviewees expressed and prevented them from imbuing the wolves with personality and charisma. One resident said, "I don't see wolves enough to be able to say their behavior is this way or that way" (2). The elusive nature of red wolves has been an impediment to residents of their introduction area forming a connection with them, because many people in the area have been here for an extended period of time, but haven't encountered the animal.

Compounding these issues are a perceived lack of historical connection between the red wolves and the area and the nature of the wolves' introduction. One interviewee commented on the red wolf's lack of historical tie, stating "there was never no red wolves around here in 60 some years that I've lived in Hyde County. So they're putting their scientific proof on something that the locals have never had to deal with" (1). While the USFWS identified the region as part of the red wolf's historical range, the animals had not lived here for nearly a century. Some interviewees therefore do not believe the red wolves have a place in the APP because members of the communities were not alive when the wolves were originally in the area. One respondent simply said, "I'm not going to say I'm a big fan of red wolves, 'cause I don't think they were ever here regardless of what everybody says" (9). Some respondents look at the red wolves as intruders. The government backing of the red wolf reintroduction program further complicates the issue, leading people to often reject the wolves based upon distrust of the government. Lack of interaction with the red wolves may cause a sort of distance between the community and the wolves that is heightened by an association of the wolves with the government and USFWS management practices.

Another factor that has affected the perception of red wolves in the area is the perceived effect the wolves have on the deer population. Respondents, both hunters and farmers, noted a decrease in the white-tailed deer population and often attributed that decrease to the presence of red wolves and coyotes. One respondent, a farmer, talked about the effect of the perceived decreasing deer population:

> One thing the red wolf is known for is eating white tailed deer. We've got some farms that I don't have as many deer — the deer aren't hurting my

> crops as bad as they were five years ago. I lay that to the coyotes and the red wolves because they eat them when they're yearlings, you know when them deer are born. There's not as many deer as there used to be, so they're not eating my crops as bad (2).

While it appears that a reduction in the deer population is not entirely a bad thing for farming, deer hunting is a large enough industry in the area that some may have seen business negatively impacted by wolf-deer interaction. Another respondent described this perception by saying, "probably the most impact that the coyotes and wolves have is on deer hunting, running the deer out of a certain area. The deer will come back after the wolves move out of that area, but if wolf is in a certain area the deer leave" (1). The deer leaving hurts hunting businesses, leading some to associate the red wolf with an economically harmful pattern.

However, other respondents did not consider wolves to be a great threat to the hunting economy because they believe there is still a healthy and even increasing deer population. One respondent noted:

> We were told, the general public was told that they would help take care of the deer population. Which we haven't really seen. There's more deer now than there ever was. So that didn't hold to be true (9).

Some interviewees were not opposed to seeing the deer population reduced, but cited the large and seemingly growing numbers of them as an unfulfilled promise of the red wolf program, tying back to their doubts about it. Thus, respondents on both sides of the deer issue see the red wolf as being at fault for something, complicating perceptions of the wolf's place in the ecosystem.

Nearly all interviewees responded negatively when asked about the red wolves' place in local culture, including those that were supportive of the program generally. One interviewee responded, "They never got to that point here, which is sad" (3). Given all of the above factors, the wolves may not have been able to become part of the local culture and gain acceptance in the same manner of black bears. This is not to say that there are overwhelmingly negative attitudes toward wolves across the study area — rather, our interviews revealed that wolves are not considered an integral part of the area.

Coyote

In general, interviewees had a negative attitude toward coyotes. This is mainly because coyotes are invasive, threatening, and perceived as a nuisance. However, a secondary reason coyotes are disliked is their association with the Red Wolf Program. Coyotes moved into the area around the same time as the red wolves, and the two have been known to interbreed.

The fact that coyotes are invasive is one of the primary reasons they are so disliked. While the people in the area generally have positive opinions of nature and wild animals, coyotes are seen as more of an invasive pest than an admirable part of the natural landscape. The following quote expresses this sentiment:

> And when they see a coyote, they shoot the coyote because he's a nuisance. Not because he's a sporting animal. When you kill a nice sized black bear, you're proud of that. It makes you happy to kill one of them. Or a nice deer or a nice buck. But when you kill a coyote, you just killing him because he's a nuisance. And I don't think it's the same (6).

As opposed to the black bear, which is hunted for bragging rights and has historically inhabited the area, coyotes are seen as foreign animals that have disrupted the natural order and are killed because they are nuisances. Differing reactions to the recent population growth of the two animals are particularly telling. Coyotes and black bears have both increased in numbers, and while interviewees did not seem to be bothered by the increase in black bear population, they have been frustrated by the coyote population increase. Bears, which are viewed as part of the local culture and bring revenue to the area, are free to reproduce as much as they want, without the locals minding too much, but coyotes are seen as pests and nuisances, so the increase in their numbers is seen in a negative light. Because the coyote is an animal that has not been seen in the area until recently, the recent growth in its population is seen as a disruption of the natural order. Numerous interviewees emphasized the recent drastic increase in coyote numbers. Respondents said they "used to not ever see a coyote" (2) and that they "see a lot more coyotes, more than … ever" (1). Another interviewee straightforwardly said, "The population is growing dramatically here" (1). Their howls are considered loud, disruptive, and can wake people up in the middle of the night. One respondent said the coyotes sounded like a bunch of "college kids drunk" (11) when they howled late at night.

Residents also are concerned about a drop in the white-tailed deer population, comparable to a sentiment expressed about red wolves. One interviewee said, "Every time the coyote population goes up, the deer population gonna go down" (6). However, within our respondent base, there seems to be conflicting ideas about whether a decline in the deer population exists. Another subject said, "They're here, and I'm sure they're eating fawns, but there are enough deer to make up for that, to make up for that depredation"

(10). Respondents blame coyotes for killing young deer, which some interviewees say is leading to a drop in the deer population.

Because coyotes are hardy survivalists and are not sensitized to human presence, coyote encounters often involve property damage or loss of animal life, causing people to fear their presence. Coyote will feed on chickens, rodents, and even small pets. One interviewee (6) said that when his dog was a puppy, he would keep it very close to the house at night because he was afraid that the coyotes would hear the puppy and come eat it. This fear runs deep, and another interviewee went so far as to say that “If there are coyotes around, I will be more careful with small children” (2). Although the people of the region admire the natural landscape, they have a negative attitude about coyotes because they perceive them as threats. One interviewee said, “People will let a coyote be a coyote until it tries to eat your chickens” (5). In other words, people will respect any creature in the natural landscape until it is perceived as a threat to their physical, emotional, or economic well-being.

A handful of interviewees expressed negative attitudes about coyotes because of their relationship to the Red Wolf Program. Because the coyote’s arrival has coincided with the Red Wolf Reintroduction Program, some interviewees associate the two, and because they do not like the Red Wolf Program, hold negative attitudes towards coyotes. One respondent claimed, “They may have been brought here to actually be put in this area” (6). Although this connection to the program contributes to the overall negative feelings towards coyotes, it is a relatively minor component. Primarily, respondents have strong negative attitudes about the coyotes because they are perceived as invasive pests that annoy people and pose a threat to the safety and economic well-being of the community.

Comparison

In general, people feel a connection with the bear that they do not feel with the coyotes and red wolves. This is likely due to the fact that the bears have been here for longer and are a part of a culture, while the red wolves and coyotes are seen as invasive pests that have disrupted the natural order of things. Interviewees document having multiple instances of interaction with the bear, but described interactions with red wolves as short and fleeting. In other words, our interviewees have gotten to know the black bear, because they see it regularly and it has been here a long time, but have not gotten to know the red wolf, because it is shyer and has only recently been introduced into the area. The coyote is an entirely different story. While our interviewees interacted with the coyotes on a regular basis, these interactions were overwhelmingly negative. Furthermore, because the coyote is a new addition to the landscape, our interviewees were very hostile towards it. In conclusion, time of inhabitance and connection with place are the factors that seem to influence how interviewees characterized the animals.

Attitudes about the Management of Large Predators

General Attitudes about Federal, State, and Local Governments

Interviewees' perceptions of the federal government seem to play a crucial role in how they view the management of large predators on the APP. Many interviewees advocate for small government and being largely left alone to their own devices. Both federal and state wildlife management agencies are active in the APP, and interviewees generally expressed skepticism about the federal government, but were more receptive to the more local state agencies.

Skepticism of the federal government among interviewees came from a variety of interactions, not just those related to the red wolf reintroduction. Talking about drainage, interviewees expressed many negative attitudes about federal regulations. One interviewee said that there are "so many regulations and regulatory agencies out there" that draining his farm was "always a battle" (1). Another described certain drainage regulations as "misplaced" (5). Discussing the coyote night hunting ban, one interviewee said that the ban was "the federal government stepping on people's toes" (10). One interviewee was so skeptical of the federal government that they said:

> A lot of people here say that some of the federal agencies released the coyotes here to be here for the red wolves and also help eat nutria and keep the deer population low (11).

All of these sentiments expressed by the interviewees point towards a generally negative attitude towards the federal government and perceived perceptions of overregulation. The interviewees seem to think the federal government is trying to do too much, and are skeptical of their involvement in the region.

In contrast, many interviewees took special notice of the active management actions taken by local and state agencies. These include door-to-door contact and conversation with locals, biological measurements of harvested animals for recordkeeping purposes, and nonintrusive animal tracking, which some felt were more effective at maintaining communication. One subject summarized this relationship, "They are a part of the community, and I think they do as good a job as they can about keeping relationships with the locals" (3).

A key element in this relationship is direct personal contact between the local agents and members of the community. Interviewees did not feel that federal agencies maintain this sense of closeness. One interviewee noted that USFWS seems like an outsider in the community:

> Right now I think locals favor the state agencies over the federal agencies, and you do have a lot of state agencies that make their homes in these places more. And a lot of federal agencies have folks from away from here. And I'm not saying you can't be that way, but you can't be that way and be a jerk about it (2).

In other words, the situation might be different if federal government representatives were from the area, and not trying to impose so many regulations on the people. However, because they are viewed as outsiders telling the locals what to do, interviewees generally viewed the federal government negatively. State agency management was preferred because of their perception that state officials have greater knowledge of and respect for local issues, as well as the greater amount of personal contact that comes from having state officials living in the area.

Respondents noted that the way USFWS works limits its local appeal. It seems that residents see the value of the agency, but they do not necessarily support how their tax dollars are being used. One respondent said, "We got all kinds of refuge, and that the people don't get any tax value back from it" (1). Another interviewee said they see both sides of the issue:

> Well you know I think there's two sides to it. I'm all for trying to maintain a species and keep it from going extinct and trying to reestablish their welfare. But, the flipside of that is that's all being done through taxpayer's dollars. (4)

The interviewees generally did not approve of the way that their tax dollars were being spent on certain programs, and how the federal government was both preventing local tax revenue from being raised by protecting large swathes of land, and wasting the money that the locals spend on federal taxes.

It's Not the Wolves, It's the Government

An issue raised by many interviewees was that residents are not necessarily against having red wolves in the area; rather, they object to the strict regulations that come with the reintroduction program. Some feel the federal government has overstepped its bounds and is regulating land use in the introduction area, and has spent too much money on the program. A number of interviewees have also questioned the success of the reintroduction program and the effectiveness of red wolf management. Interviewees also objected to the spatial component of the reintroduction strategy, arguing that wolves should be kept on federal land but that the government did not take any measures to keep them there, allowing them to roam.

Because the red wolf reintroduction program requires so much active government involvement, the program has become a source of contention among local residents. One respondent pointed out that hostility toward the red wolves and the reintroduction program may stem from issues with the government in general:

> I don't think it's so much the species; I think it's the federal government. People's opinion of the federal government. I think the main point is that I don't think it's the wolves themselves. I think it's just people being mad at the

> government and taking it out on them… So it's probably the people who have negative opinions towards [red wolves] are probably more so the individuals who have negative opinions towards the government (10).

This quote elegantly illustrates how general perceptions of the federal government have a direct impact on the attitudes about not only the management of these predators but of the predators themselves. In this case, the interviewee expressed the sentiment that the people of the region do not have a problem with the red wolf itself, but rather have a problem with the federal government and its activities.

A variety of perceptions including excessive regulation of land use, fiscal waste, and doubt about whether genetically pure red wolves still exist caused a number of the interviewees to disapprove of the federal government's management strategy. For instance, consider the following concerning the program's fiscal waste:

> After spending tens of millions of dollars on the program and not having any success, you can see how somebody like me who pays a lot in taxes and sees my money being thrown away like it's been thrown away, why we would be reluctant to support it (12).

A lack of return on investment has been a complaint among some landowners as they see their tax dollars put toward a program that hasn't been able to maintain the red wolf population effectively. Thus, the wolves have become a symbol of government intervention and waste, causing some to lean toward a negative opinion of them where they would have otherwise been indifferent. Complaints about the management tended to be at the program scale; issues relating to bad personal interactions with officials did not come up.

A number of interviewees were skeptical of the number of genetically pure red wolves in the area, compounding their negative opinions of the management. Residents realize that canines of different species are capable of interbreeding, and because there has been recorded hybridization between wolves and coyotes in the recovery area, many have doubts about the long-term efficacy of the program. The two species are also virtually physically indistinguishable to a majority of the public, which has caused problems since the start of the program; as one interviewee bluntly phrased the issue, "It's real hard to distinguish a red wolf from a coyote" (9). This confusion occasionally leads hunters to shoot red wolves that they assumed to be coyotes, resulting in harsh punishment because of the species' endangered status. These types of interactions test the public's patience, as some believe that the government is putting resources toward establishing a hybrid population. The following describes this sentiment well:

> I think there should be no red wolf program, because like I said it's not a genuine red wolf anymore. If it was, it might be different, but when you shoot a coyote or a red wolf or whatever and you lay them on the tailgate of your truck, the wildlife manager can't tell you which one it is. (6)

Some residents do not see the point of maintaining a population of red wolves that may not even be genetically pure.

Furthermore, some interviewees believe that roaming away from federal land allows wolves to pose a greater threat to deer and other animals, as well as breed and form packs with coyotes, which further undermines the program. The following sums up this sentiment:

> I really don't think it's so much the red wolves themselves but the federal government trying to introduce these wolves into the wild which of course when you introduce something under a refuge, it is not going to stay where you put it. (10)

This quote shows how the federal government is perceived by some interviewees to be incompetent. This interviewee in particular thought it was quite naïve of the government to expect a wild animal to remain on federal land, and especially unwise of them to not even attempt to keep the wolves on federal land. These negative attitudes about the amount of government resources put into the program and the situation that has resulted have led some to see the red wolf as a failed experiment, tying their perceptions of it more to the government than to the place itself.

Perceptions of Hunting

A number of interviewees also think about management in terms of hunting, which is important in the area for both economic and recreational reasons. Hunting is important as a source of revenue in the counties, as well as the state, and is a part of life that residents in the area enjoy. Bear hunting brings a substantial seasonal influx of revenue into these counties during the 20-day season in November and December. Eastern North Carolina has a thriving black bear population, as both individual bears and the overall population are reaching larger sizes than they have in the past few decades. A large bear population carries risks: bears can cause crop loss and are involved in vehicular accidents. One of the main ways the population is managed is through a short hunting season, and multiple respondents suggested elongating the season to improve bear population management. For example, one interviewee said, “I feel like a longer season would be beneficial to the farmers. The farmers are complaining about the bears eating the crops and you know, he’s trying to make a living" (7). Additionally, another respondent said:

> We could do another two weeks and I don’t think that it would hurt at all and it would identify some of the bear who probably need to be culled because the size of some of these bears that are coming out now show that the readily available food is not really all that good for the bear. They’re just huge and bears shouldn’t be 700 pounds. You’re getting just these monstrous bears and

> it's because they'll just sit down in the middle of a soybean field and just eat all day (5).

Although many respondents were generally skeptical about the government and its management practices, they viewed the regulations on bear hunting as legitimate and part of life on the APP. A minor hunting season adjustment was the only topic that came up with regard to better bear management.

In contrast, respondents were upset about certain restrictions on coyote hunting, citing them as federal overreach. Multiple interviewees brought up the need for fewer hunting restrictions on coyotes, citing looser regulation in central NC. To ensure wolves would not be confused for a coyote and mistakenly killed, the North Carolina Wildlife Resources Commission implemented a ban on hunting coyotes at night in the five counties on the APP. This night hunting ban that was intended to protect the red wolf was questioned by interviewees who thought residents should be able to kill coyotes at will to control the population. As one interviewee put it, "I think you should be able to shoot one at any time you see one … nobody I associate with approved of the ban" (6). Since the coyotes are primarily active at night, the night hunting ban essentially eliminated any ability for the locals to control the coyote population. As a result, the night hunting ban contributed to opposition to the reintroduction program.

The consensus from the interviewees was that management of bears and coyotes is best done through hunting and could be better if both seasons were longer, allowing for more takes. While management of black bear hunting is generally viewed favorably and as a necessary part of the hunting culture, the management of coyote hunting is seen as an intrusion and an impediment to the natural way of living on the APP. Hunting perceptions are also tied to each predator's perceived role in the area. Bear hunting was generally viewed positively because of the revenue it brings to local economies and the pride hunters take in hunting a historic and valuable animal. The need to hunt coyotes, however, was viewed negatively because of its lack of economic benefits and the associated restrictions, which are tied to the red wolf program. Thus, hunting was a point where respondents tended to voice disapproval of both coyotes and red wolves.

Synthesis

For respondents, life on the Albemarle-Pamlico Peninsula is largely tied to their perceptions of the land — a mainly undeveloped, wild setting in which people and other animals coexist. They hold generally positive views of black bears, more negative views of red wolves, and extremely negative views of coyotes. In terms of the government, respondents held generally negative views of the federal government, but more positive views of state government. While they felt that a lot of federal regulations were misplaced, they viewed state regulation of things like hunting to be for the most part satisfactory, with only minor suggestions for improvements.

Attitude toward government, place identity, and the nature of the animal itself were identified as the main factors around which interviewees based their perceptions of each species. All three factors played some role in the way each species was perceived, but their relative importance varied.

Attitude toward government was the main factor influencing how the respondents view red wolves. People's attitudes about government impact their perceptions of the management of predators, and their attitudes about the wolves themselves. This same relationship between government perception and attitude toward wolves has been demonstrated in a number of studies. Browne-Nunez et al. (2013) found that attitudes towards the government influenced attitudes about the gray wolf more than the people's perceptions of the wolves themselves. Kreye et al. (2016) found that perceived government mismanagement has an impact on how people view predators. The nature of the wolf also influenced how people viewed them, but it was not as much of a factor as their attitudes about government. Red wolves are shy and elusive, so respondents generally did not have as much contact with them as the other species.

Place identity was the main factor influencing respondents' views of black bears. Because of their history in the area, bears are in a sense synonymous with place and so respondents' opinions tended to blend in with their sense of place value. The farmers we interviewed viewed crop damage from black bears as a part of life in the area. This is similar to results from Bowman et al. (2001) who found that landowners who have experienced damage from black bears still have a generally positive view toward the species. The nature of the animal was a secondary influence on how people viewed the black bears. Black bears are charismatic, predictable, and passive, so people are able to identify with them, and enjoy seeing them.

The nature of coyotes, themselves, was the main factor influencing how respondents view the species. Coyotes are adaptive, invasive and are relatively unafraid of humans. Because of this, coyotes are viewed as a nuisance. Secondarily, some respondents associate coyotes with the red wolf program, and since some have a negative view of the red wolf program, that negatively influences their opinions about coyotes.

Our comparative approach offers the ability to see the differences in opinions of the various predators, and overall provides a more holistic way of assessing how the community viewed the predators, and why they felt that way. Previous literature has attempted to associate certain values with feelings about animals, and has in some cases tried to lump predators together when explaining how people feel about them. For example, Hunter and Brehm (2004) attempted to assess attitudes towards wildlife held by people in rural areas, but made little attempt in their analysis to differentiate between species.

Our work suggests that a comparative approach that asks interviewees about each predator individually may be better for characterizing how the people feel about the predators and why they have the attitudes that they do. In this study, we found that a comparative approach may allow for a better representation about how these general attitudes influence perceptions of predators, and how those perceptions about each predator differ.

Conclusions

As recent policy decisions, litigation, and anecdotal encounters regarding black bears, red wolves, and coyotes in the APP draw the attention of the news media and the public nationwide, future land use by these predators hangs in a delicate balance. This study strives to shed light on the natural habitat and anthropogenic factors that will ultimately impact the presence and abundance of these three apex predators within the APP.

The RSF analysis suggests that the federal lands onto which red wolves were introduced and relocated are not optimal habitat relative to nearby, privately owned land areas. Private lands within the APP were characterized by greater travel corridors between the resources of higher elevated lands, food sources around agricultural edge habitats, and water sources, but management of these lands and any wolves that may inhabit them is limited. A successful red wolf management program on private lands requires additional outreach and landowner support and would perhaps benefit from the implementation of a landowner incentive program. This program would pay landowners to allow active management of animals that move across the privately- as well as publicly owned landscape in search of suitable habitat (Williams et al. 2014). Overall, large areas of suitable habitat for red wolves are present on the APP, even if the current habitat found on USFWS property is less supportive of red wolf success than the habitat on private land within the study area.

The HSI results show that the APP provides a great deal of habitat suitable to black bears, although the application of the HSI to the whole APP is limited by the dataset that was available for its calculation. If anything, we expect that the HSI underestimates how suitable the APP habitat is to supporting black bears. Additional analysis showed that the overall trend for bear habitat quality in the APP over fourteen years was general stability, with a slight decline. Despite this decline in habitat quality, our first-hand observations and recorded interviews described a thriving bear population. Based on the content of our interviews, it seems that people want the bears here. One limitation of the model proposed by Kindall and Van Manen (2007) was that anthropogenic and in-situ food and other variables were not taken into direct consideration. This model may also have been limited by the fact that all variables that were measured were considered independently without considering any potentially compounding effects. Future spatial analyses should consider inclusion of additional variables for greater resolution of HSI and RSF results, and a sensitivity analysis for confounding amongst variables.

Neither spatial models considered variables related to social perceptions. Greater social acceptance and favorability may affect long-term habitat suitability and relative success of conservation actions. Qualitative findings from our interviews with local residents showed that acceptance and favorability of black bears, red wolves, and coyotes differ within the study area. The interviewees, in general, had positive attitudes about black bears, neutral or slightly negative attitudes about red wolves, and overwhelmingly negative attitudes about coyotes. These attitudes were influenced by three factors: attitudes toward government, place identity, and experiences with the animals.

Our comparative approach provides new insight into how people perceive predators. We found that asking respondents about different predators allows for the ability to see how different underlying values can influence attitudes about each predator, and provides an advantage over traditional methods, which have lumped predators together.

Incorporating variables related to human perceptions and underlying values into future spatial habitat analyses could improve capacity to provide more holistic assessments of landscape fit for predators.

Our work reveals that the Albemarle Pamlico Peninsula is a matrix of both ecological and social features. Together, the qualitative interviews and spatial analyses of habitat quality and resources availability illustrate the variety and complexity of factors that contribute to how black bears, red wolves, and coyotes are finding their places in northeastern North Carolina.

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Appendix

Tables

Table 7. The calculated HSI's for black bears at specific CVS plots within the five county study area. Plot IDs reference CVS plots at specific locations (latitude and longitude). The HSI was adapted from Zimmerman (1995) to suit our study area.

Plot ID	Lat.	Long.	H.S.I.
2821	35.939707	-76.6872	0.795574603
2823	35.922187	-76.695589	0.796203175
2835	35.91124	-76.72044	0.404034186
2868	35.927192	-76.683933	0.796442241
2869	35.926419	-76.683455	0.793873514
2871	35.913972	-76.679072	0.836465216
2872	35.903355	-76.685968	0.716562055
2873	35.909015	-76.684316	0.772259791
2878	35.911046	-76.658032	0.709179856
2880	35.911631	-76.658626	0.676191781
2881	35.9387	-76.683772	0.796901587
2899	35.928928	-76.689526	0.803815873
2900	35.922768	-76.701861	0.28881127
2901	35.922831	-76.701941	0.281746032
2907	35.922238	-76.711323	0.409551989
2911	35.931395	-76.67768	0.803815873
6046	35.628238	-75.793874	0.687876968
6047	35.630224	-75.796301	0.782628776
6088	35.933665	-75.826144	0.142569347
6089	35.933058	-75.826514	0.342074958
6090	35.926347	-75.853858	0.794355556
6094	35.799277	-75.882597	0.796196825

6099	35.890488	-75.919986	0.515446913
6100	35.890675	-75.919102	0.572925446
6103	35.62898	-75.796597	0.752921081
6104	35.628223	-75.793784	0.769394532
6105	35.81455	-75.788332	0.669762431
6106	35.819273	-75.784405	0.721223504
6109	35.855448	-75.757472	0.281746032
6110	35.874677	-75.769088	0.2381135
6111	35.874828	-75.772213	0.232943465
6115	35.79614	-75.884898	0.796215873
6116	35.945727	-75.828875	0.496804559
6119	35.855214	-75.757437	0.281746032
6120	35.874903	-75.769001	0.237430845
6121	35.874933	-75.772646	0.232020894
6126	35.814968	-75.7893	0.617898172
6127	35.821713	-75.783665	0.794292063
6136	35.933107	-75.82596	0.349626951
6139	35.945466	-75.83007	0.548584536
6240	35.802354	-76.613163	0.654299453
6242	35.936035	-76.384154	0.27341476
8546	35.712166	-76.195652	0.492622572
8547	35.677176	-75.795574	0.793714286
8562	35.918927	-75.794585	0.319456104
8563	35.919083	-75.794276	0.318477393
8564	35.472256	-76.928658	0.227790266
8567	35.361305	-76.11101	0.281746032
8568	35.362533	-76.411408	0.281746032
8570	35.361672	-76.4118	0.281746032
8571	35.362114	-76.411819	0.281746032

8572	35.361799	-76.412562	0.281746032
8574	35.361918	-76.412355	0.281746032
8580	35.734351	-76.441094	0.223208112
8581	35.734251	-76.439611	0.495433885
8582	35.734292	-76.438473	0.494107352
8584	35.731416	-76.554418	0.866397943
8585	35.802969	-76.454362	0.282084853
8586	35.776521	-76.398686	0.759923153
8587	35.803164	-76.454698	0.364116641
8588	35.734338	-76.438385	0.493982064
8589	35.744328	-76.308856	0.860330159
8590	35.623681	-76.349653	0.235177129
8591	35.936613	-76.361151	0.430986049
8592	35.885572	-76.285619	0.740878583
8593	35.889176	-76.30665	0.779460431
8595	35.679114	-75.794223	0.803815873
8597	35.671914	-75.909606	0.753412698
8598	35.735167	-75.908843	0.799371429
8602	35.437274	-76.39601	0.296467302
8603	35.472303	-76.928009	0.397996492
8604	35.839056	-75.901833	0.801904762
8605	35.745393	-76.079883	0.781146603
8607	35.361162	-76.110865	0.281746032
8608	35.361768	-76.412121	0.281746032
8615	35.473304	-76.928496	0.268271545
8616	35.527851	-75.979096	0.255616547
8618	35.871655	-76.353492	0.653029208
8620	35.826382	-75.889512	0.807631746
8621	35.679084	-75.920009	0.794355556

8626	35.914049	-76.533082	0.490846602
8627	35.915416	-76.532676	0.499234541
8628	35.433019	-76.715018	0.494132055
8629	35.914446	-76.534464	0.502789684
8630	35.933133	-76.363563	0.903879341
8631	35.935181	-76.358654	0.819688911
8633	35.855721	-76.397895	0.760879086
8933	35.436724	-76.396827	0.281746032
12315	35.710152	-77.185295	0.895901129
12322	35.460571	-76.90265	0.437360249
12337	35.70939	-77.184069	0.898762689
12338	35.712194	-77.186025	0.769017044
24719	35.792626	-75.878446	0.709153968
24720	35.874543	-76.359578	0.777643518
24722	35.875552	-76.361999	0.48400913
24723	35.611294	-75.923284	0.534478341
24724	35.712162	-76.190633	0.57236178
24733	35.724481	-76.193857	0.538598205
24734	35.795509	-75.88369	0.723093968

Interview Guide

OBXFS 2016 Interview Guide

v. 2016 September 27

Materials

Consent document, iPad (R*eminder: check battery life*), pen/pencil, clipboard

Introduction

Ask the interviewee to read the consent document. Make sure s/he doesn't have any questions and ask if they agree to participate and be recorded. While you set up the recorder (*Reminder: keep the ipad volume low to avoid any feedback*.), brief them about the study. Ask her/him mark the recording by stating her/his name, the date, where you are.

1. *Background and Environment*

- Tell me a bit about your history here in eastern North Carolina (*or substitute* Hyde County/Tyrrell County).
    - Have you always lived here?
        - Y: Can you tell me about your family roots in this area?
        - Y: What about this place keeps you here?
        - N: When did you first come to this area?
        - N: What brought you here?

- Tell me about the work you do.
    - How did you get into it?
    - How long have you done it?

- How would you describe *XXX* County to someone who had never been here before?
    - *Areas to prompt*: resources, landscape features, people/community life

- What do you value about the landscape in *XXX* County?

- How has the landscape changed since you got here/when you were growing up?
    - If s/he only mentions negative changes, ask about any positive changes.
    - If s/he only mentions positive changes, ask about any negative changes.
        - How do you feel about those changes?

Transition: I'd like to talk to you about some of the large mammals that live around here.

2. *Bears*

- Have you had any encounters with bears?
    - Can you tell me about that?
        - How do you feel when you see a bear?
    - What about any family members or other people you know?
    - Have you noticed any seasonal patterns to these encounters?
    - Have there been increases in encounters in the past 10 years?
    - Farmer:
        - Do bears come on your farm?
        - What are they doing there?
        - How do you feel about them being on your land?
        - Is there a situation in which you would choose to shoot at one of these predators?
    - Guide:
        - Can you describe how bears are a part of your guiding business?
    - How have these experiences affected your perceptions about bears?

- How informed would you say you were about black bears?
    - Do you think more information would affect your perception of bears?
        - Y: What would you like to know about them?

- What do you believe should be done to manage the black bear population?

- Would you say that bears are a part of the local culture?
    - Y: In what ways?
    - N: How come?
    - N: What other animals are more a part of the local culture?

- What do you value about having a black bear population?

Transition: Now I'd like to ask you about wolves.

3. *Wolves*

- Have you had any direct experiences with wolves?
    - Can you tell me about that?
    - How did it affect you? [Listen for losses/benefits]
    - Have these experiences changed over time?

    - Do you have extra concern when your pets are out?
    - How have these experiences affected your beliefs about wolves?

- How informed about red wolves would you say you are?
    - Do you think more information would affect your perception of wolves?
        - Y: What would you like to know about them?

- Has your land or business been impacted by the reintroduction of the wolves?
    - Can you describe how?

- Have you heard about the recent decision made by U.S. Fish and Wildlife about the Red Wolf Reintroduction program?
    - What are your thoughts about this?
        - Do you agree with the decision?
            - If not, what do you think should have been done?
    - How has the reintroduction program, before the decision and now, impacted the community?

- Would you say that wolves fit into the local culture?
    - Y: In what ways?
    - N: How come?

- What do you value about having red wolves in this area?

- If I'd asked you about the wolves 10 years ago, what do you think you would have said about them then?

Transition: I'd also like to talk to you about coyotes.

4. *Coyotes*

- What has been your experience with coyotes?
    - Have you had any direct encounters with coyotes?
        - Can you tell me about that?
    - Farmers/Landowners:
        - Do coyotes come on your land?
        - What do they do there?
        - Does their presence change how you do things?
        - How do you feel about having them on your land?

    - Guides:
        - How have coyotes affected your guiding?

- What do you believe should be done to manage the population?
    - How do you think landowners feel about the night hunting ban on coyotes?

- Do coyotes fit into the local culture?
    - Y: In what ways?
    - N: How don't they fit?

- Does having coyotes around here have value to you?
    - How so?

5. *Management*

- There's a good deal of acreage in this area that is public land – refuges, preserves, the bombing range. Has that been a good thing?
    - Y or N: How so?

- What value do these public lands have for you?

- What is the relationship like between wildlife management agencies and the community?

6. *Closing*

- Is there anything I haven't asked you about black bears, red wolves and coyotes that you would like to tell me?

- Is there anything else about this part of eastern North Carolina you think I should know?

- That's all the questions I have for you. Do you have any questions for me?

- THANK YOU and invite to the presentation.
    - We will be compiling the findings of our study, along with the results of our natural science research, in a report and giving a public presentation about them at the end of the semester. If you'd like to attend, the presentation will

be on December 15th at 2 pm, that's a Thursday, at the Coastal Studies Institute in Wanchese.

- Now that you've seen what the interview is all about, can you recommend any other people that you think it would be good for us to talk to?
  - (You can mention specific "types" of people we're interested in interviewing if you think that would help prompt their thinking.)

- When I go back and listen to the recording, if I have any questions or would like to clarify anything you've said, would it be OK if I contact you again?

- Thank you for your time.