JOHN CHRISTOPHER GRIFFIN
Bobcat Ecology on Developed and Less-developed Portions of Kiawah Island, South Carolina
(Under the Direction of ROBERT J. WARREN)

Kiawah Island is a 3,200 ha coastal barrier island located near Charleston, SC. Most of the island s western end (WE) has been developed into a recreational, resort community; the eastern end (EE) is mostly undeveloped. From December 1999 to January 2001, we monitored 14 radio-collared bobcats (*Lynx rufus*) (7 males and 7 females) to compare home and core range size, daily and seasonal movement rates, reproduction, survival, and dispersal between the 2 portions of the island. We found that WE bobcats have larger home and core range sizes as well as increased movement rates. During spring and summer 2000, we located dens to document reproduction and observed that 5 of 6 adult female bobcats produced litters of 2-3 kittens each, for a total of 12 kittens. Reproductive success did not differ between the WE and EE of the island. Three radio-collared bobcats died, all of which occupied the more developed WE of the island. In early 2001, a radio-collared EE juvenile male dispersed off Kiawah Island and moved to an adjacent island.

INDEX WORDS: Bobcat, development, home range, Kiawah Island, *Lynx rufus*, movement rates, radio-collar

BOBCAT ECOLOGY ON DEVELOPED AND LESS-DEVELOPED PORTIONS OF KIAWAH ISLAND, SOUTH CAROLINA

by

JOHN CHRISTOPHER GRIFFIN

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December 2001

We reached the wolf in time to watch a fierce green fire dying in her eyes. I realized then, and have known ever since, that there was something new to me in those eyes-something known only to her and to the mountain.

Aldo Leopold

ACKNOWLEDGMENTS

I would first like to thank Jim Jordan for all the voluntary sacrifices that made the project possible. I would like to sincerely thank my major professor, Bob Warren, for allowing me to work with him on this exciting project, and for his guidance and support with my thesis and program of study. I would also like to thank Drs. Jeff Jackson and Tim Harrington for their time and advice while serving as members of my committee.

I would like to thank the Town of Kiawah Island for funding and supporting the project in every way. Beverly Liebman was always there for me to support and defend the project. Thanks also to all other town councilpersons and mayor Jim Piet for their support. I d also like to thank Allison Harvey for always being there to challenge me. Thank you Shannon Begley, Anne Forbes, and Rosa Barnes for your friendship and all the kindness you showed me.

A special thanks goes to Tripp Lowe, without whom I never could have gotten through ARCVIEW. He is truly an asset to the school. Thanks to Craig White to dedicating an entire day to helping me with LOAS and an introduction to ARCVIEW. I d also like to thank Dr. Glen Ware for helping me with my statistics and for being so patient. I am so grateful to my friend Christa Dagley for putting up with my frustrations and helping me through my statistics. I am indebted to George Mueller of the Kiawah Island Natural Habitat Conservancy for taking time out of his busy schedule to help me with my habitat analysis.

I d like to thank Barbara and Harold Winslow for always being so good to me and making my time at Kiawah so memorable. Thank you Barbara for your company, friendship, and the many dinners you hosted. Thanks to Patrick Casey who on so many mornings helped me check traps in the early days of the project. I am grateful to Kent Wear for his valuable advice on trapping bobcats. Thanks to Vaughn Spearman for his help conducting scent station surveys. A very special thanks goes to Ben Kirkland of Chehaw Park in Albany, Georgia. It was Ben who took the time to teach me the basics of bobcat trapping that allowed me to have such a successful trapping effort.

My life changed for the better when I met Mac and Lynn Macaluso. I have never met 2 finer people, and their kindness to me will never be forgotten. I could never repay you for what you have done for me. I hope to see my friends soon.

I d like to thank Joel Rand for keeping the ol Chevy running for me and for coming to get me when it broke down. I don t know how I would have managed without Joel who always was there to help me out with any technical problem. I d also like to thank Rusty Lameo for always being there to assist me on the project and for always remembering to challenge me daily.

I am indebted to the help that I received from Liz King and her staff of Naturalists at the Kiawah Island Nature Center. Liz went out of her way to promote awareness of the bobcat project to her staff so that they could better educate the public about our research. Also, my experiences on the Kiawah river and creeks as a canoe and kayak guide are probably the most memorable moments of my time on Kiawah Island.

I would not be where I am today without the love and support of my parents, John and Janis Griffin. Thank you mom and dad for always being there for me. The lessons on hunting and appreciating the outdoors have allowed me to find my calling in life. I feel so lucky and fortunate to have the upbringing I had; I am forever grateful. I promise to pass on the same lessons to my own children someday.

I would like to thank my girlfriend, LeAnne Perry, for staying by my side through it all. Without her, I would not be where I am today, she has helped me reach for my goals and fulfill my dreams.

And finally, I would like to thank God. For whatever reason, he has always looked after me and guided me in the right direction. To my patron saint St. Jude, how many times have I prayed to you in my times of despair, and you have answered me every time, for this I am eternally grateful. And to St. Anthony, every time I have been lost, you have helped me find my way.

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INTRODUCTION, STUDY AREA, JUSTIFICATION, AND THESIS FORMAT

Residential development and mid-sized carnivores

Few studies have examined the impacts of residential development on mid-sized carnivores such as bobcats (*Lynx rufus*), foxes *(Vulpes* and *Urocyon* spp.), coyotes (*Canis latrans*). Most previous researchers have studied bobcats in relatively undeveloped areas (Marshall and Jenkins 1966, Hall and Newsome 1976, Buie and Fendley 1979, Griffith and Fendley 1982, Kitchings and Story 1984, Diefenbach, et al. 1993) which lead scientists to believe that bobcats generally avoided humans (Anderson 1987). Only recently have wildlife biologists started studying the effects that high human densities have on mid-sized carnivores, and still the influence of human activity is essentially unknown. Nielsen and Woolf (2000) reported that bobcats select core areas to provide retreat from human dwellings and activities. They felt that bobcats avoided areas inhabited by humans, and only occasionally did human activities benefit bobcats. They documented a female having a litter of kittens in a barn, and received complaints of bobcat depredation of pen-raised birds. A radio-telemetry study by Lovallo and Anderson (1996) revealed that bobcats avoided paved roads, and that buffer zones areas 100 m from paved roads contained less preferred bobcat habitat than roadless areas. These paved roads also greatly influenced movement patterns, suggesting that high road densities may be detrimental to viable populations of bobcats. Also, major interstate and state highways can have dramatic effects on juvenile dispersal of bobcats and foxes (Allen and Sargeant 1993).

A telemetry study of gray foxes (*Urocyon cinereoargenteus*) in New Mexico compared food habits, daily activity patterns, habitat use, home range size, and home range structure between a rural, residential area and an undeveloped area of similar natural habitat (Harrison 1997). The study concluded that gray foxes appear to be tolerant of residential development until resident density reaches >125 residences/km². Foxes may completely avoid these areas. A research project in the lower coastal plain of Mississippi examined the effects of timber operations on bobcat habitat use and home range sizes; bobcats were shown to be quite adaptable to these disturbances (Conner and Sullivan 1992, Conner and Leopold 1993 and 1996). A California study comparing competition between bobcats and foxes in urban and rural areas reported that bobcats avoided areas of dense human habitation, but foxes were more tolerant and even utilized these areas to escape bobcat predation (Riley 2000).

Coyotes have recently become an issue of concern because of livestock predation in urban areas with dense human settlement. Their omnivorous food habits have allowed them to become a highly successful predator, and they have adapted well to these new, but constantly expanding habitats (Atkinson and Shackleton 1991). Harrison (1993) reported that competiton from introduced species such as domestic dogs *(Canis domesticus*) and cats (*Felis familiaris*) had substantial negative impacts on mid-sized carnivores in rural-residential areas.

Study area

Kiawah Island is a 3,200-ha barrier island resort located off the coast of South Carolina near Charleston. The island is approximately 16 km (10 miles) long and averages about 1.6 km (1 mile) in width. Residential development on Kiawah Island began in 1974. People in households have increased from 718 in 1990 to 1,163 in 2000

(62.0%). Total households have increased from 320 in 1990 to 557 in 2000 (74.1%). Total housing units including hotels, villas, and households has increased from 2,043 in 1990 to 3,070 in 2000 (50.3%) (http://www.census.gov/population/census-data). Thousands of tourists vacation on Kiawah Island during the spring and summer each year. Currently, most residential development and housing units are confined to the western portion of the island. This portion of the island is characterized by 4 championship, 18-hole golf courses; heavy vehicular and pedestrian use; and numerous villas, cottages, townhouses, and private households. Despite this development, many natural habitats occur in undeveloped lots, tidal marshes, ocean beach and dunes, and scattered larger portions of undisturbed maritime forest. In addition, all development on the island is under strict rules to leave as many trees and other types of vegetation as possible. This creates excellent cover and travel corridors throughout the island for predators and prey alike. Upland sites are dominated by live oak *(Quercus virginiana*), water oak (*Quercus nigra*), and pine (*Pinus* spp.) Understories consist mostly of saw palmetto (*Seronoa repens*), wax myrtle (*Myrica cerifera*), and yaupon holly (*Ilex vomitoria*).

Kiawah residents are concerned that continued development will have adverse effects on the island s bobcat *(Lynx rufus)* population. Bobcats may not be able to adapt to the changes brought on by further development. Losing this predatory species may create an unbalance in the island s ecosystem and may allow the white-tailed deer *(Odocoileus virginianus)* population to increase, which in turn will increase human-deer conflicts. The less-developed eastern portion of the island likely will continue to be developed in the future.

To gather baseline biological and ecological data on the island s deer herd, the Town of Kiawah Island supported a University of Georgia deer research project that was conducted from l996-l998 (Jordan 1998). This study determined that the Kiawah Island deer herd was in excellent nutritional and reproductive condition. Jordan (1998) determined deer densities on the island were about 35 /km^2. He also determined that bobcat predation on fawns was one ecological force helping to remove deer from the herd. However, from scent-station surveys he noted that bobcats were more abundant in the less-developed eastern portion of the island than in the more-developed western portion. In addition, he showed that bobcats ate fewer deer fawns in the eastern versus western parts of Kiawah Island.

Bobcats were observed throughout Kiawah Island during the previous deer research project (Jordan 1998). More than 25 bobcat sightings were reported by deer field crews during 1997. In addition, a bobcat was observed in June 1998 attacking a fawn in a highly developed residential area. On one occasion during 2000, I witnessed a bobcat make a fawn kill near the River Course golf course. Some time later, some tourists and I watched for several minutes as this same bobcat stalked a fawn near Bank Swallow Lane behind a villa, and it would have been successful had not a tourist rushed to the fawn s aid. Residents also commonly report seeing bobcats, often in their own backyards and even on their porches.

With continued development on Kiawah Island, the island s bobcats are losing natural habitat. Because a relatively high bobcat population exists on the island, it seems that they have been able to adapt to these changes. However, future development may have a negative influence on bobcats. Kiawah Island may or may not yet have yet reached the critical point at which human influence is a critical limiting factor. In this research project, we hope to discover at what point this development may become detrimental and reduce the island s bobcat population.

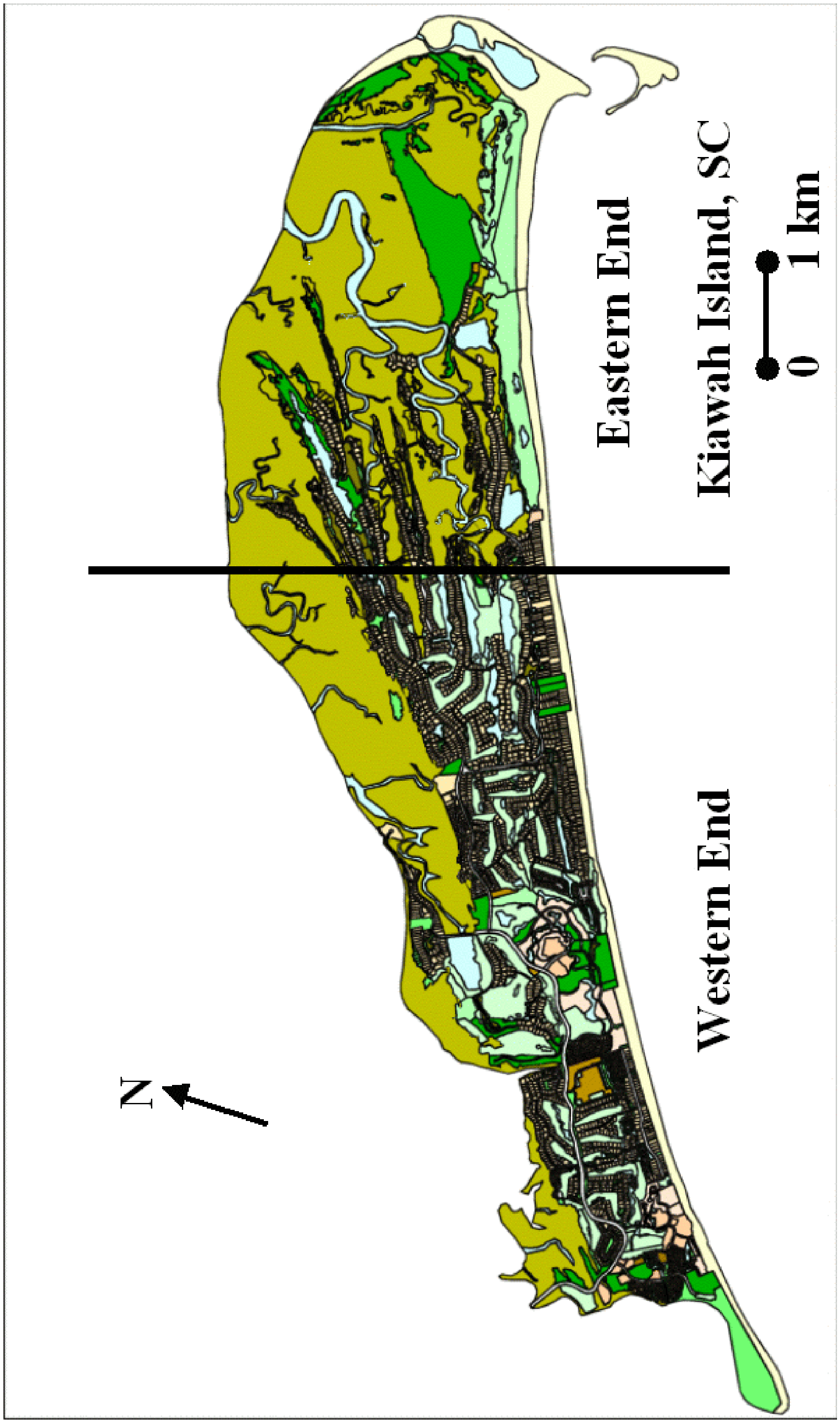
For the purpose of this research project, Kiawah Island was divided into 2 portions based on the level of development: the more-developed western end (WE) and the less-developed eastern end (EE) (Figure 1.1). The primary objective of this project was to determine if population and ecological characteristics of bobcats on these 2 portions of Kiawah Island differed. The specific objectives of this project were as follows:

1. To compare habitat use, home range sizes, daily and seasonal movement and activity patterns, dispersal, mortality factors, and survival of bobcats on the EE and WE portions of Kiawah Island during 2000-2001.
2. To study the social organization of the island s bobcat population by determining age structure, sex ratios, and nutritional condition (age-specific body weights).
3. To continue the seasonal scat collection from the deer research project (Jordan 1998) for food habits analysis.
4. To estimate bobcat abundance on the EE and WE portions of Kiawah Island by use of scent-station index in winter 2000 and 2001.

Thesis format

This study was designed to examine the effects on bobcats of development on Kiawah Island, South Carolina. Radio-telemetry allowed us to gather data on home

Figure 1.1. A map of Kiawah Island, South Carolina showing the division between the more-developed western end (WE) and the less-developed eastern end (EE).


N
Eastern End
Western End
Kiawah Island, SC
0
1 km

range, habitat use, movement patterns, bobcat abundance, mortality factors, denning activities, and juvenile dispersal. The island was divided into 2 parts so that comparisons could be made between the more-developed western end (WE) and the lesser-developed eastern end (EE) (Figure 1.1). This information was used to make management options and suggest habitat conservation guidelines to ensure the continued presence of bobcats on Kiawah Island.

I am using the manuscript-style format for my thesis. Chapter 1 of my thesis discusses impacts and responses of bobcats to residential development and human encroachment on their habitat throughout the United States. It also presents relevant background information of the bobcat and development on Kiawah Island. Chapter 2, Bobcat Ecology on Developed and Less-Developed Portions of Kiawah Island, South Carolina, presents and discusses all of the data gathered on bobcats during 1999-2001 and makes comparisons between the more-developed and lesser-developed areas of the island. It is intended to be a separate publishable manuscript. Chapter 3 summarizes all of my findings and offers future management and conservation guidelines for the use by the Town of Kiawah Island.

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CHAPTER 2

BOBCAT ECOLOGY ON DEVELOPED AND LESS-DEVELOPED PORTIONS OF KIAWAH ISLAND, SOUTH CAROLINA[1]

[1]Griffin, J. C., J. D. Jordan, and R. J. Warren. To be submitted to Journal of Wildlife Management.

Introduction

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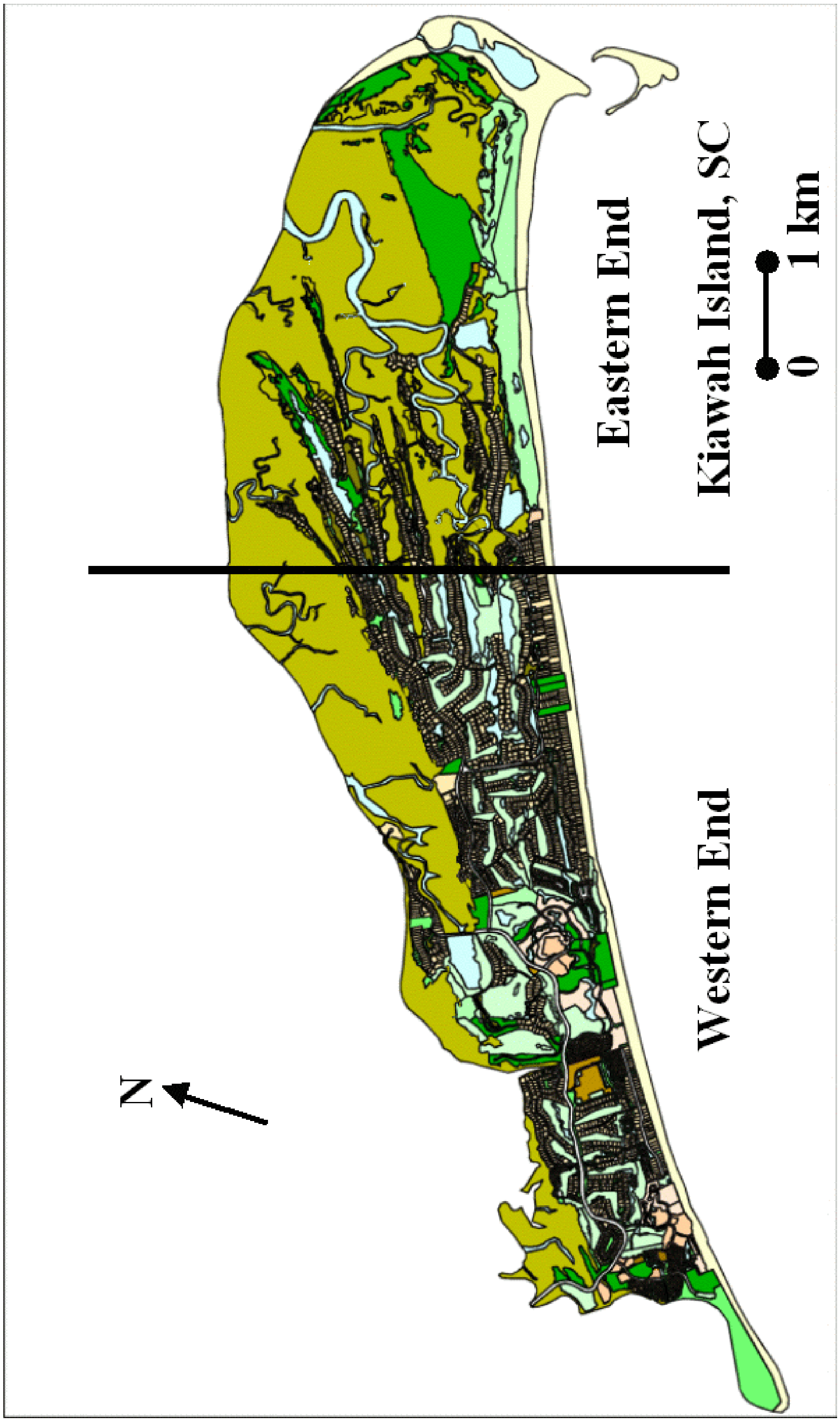
For the purpose of this research project, Kiawah Island was divided into 2 portions based on the level of development: the more-developed western end (WE) and the less-developed eastern end (EE) (Figure 2.1). The primary objective of this project was to

Figure 2.1. A map of Kiawah Island, South Carolina showing the division of the island between the western end (more developed) and eastern end (less developed), 2000.


Eastern End
Kiawah Island, SC
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Western End
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Study area

Kiawah Island is a 3,200-ha resort barrier island located off the coast of South Carolina near Charleston. The island is approximately 16 km (10 miles) long and averages about 1.6 km (1 mile) in width. Residential development on Kiawah Island began in 1974. According to the U. S. Census Bureau, Census 2000, people in households have increased from 718 in 1990 to 1,163 in 2000 (62.0%). Total households have increased from 320 in 1990 to 557 in 2000 (74.1%). Total housing units including hotels, villas, and households has increased from 2,043 in 1990 to 3,070 in 2000 (50.3%) (http://www.census.gov/population/census-data). Thousands of tourists vacation on Kiawah Island during the spring and summer each year. Currently, most of these housing units and development are confined to the western portion of the island. This portion of the island is characterized by 4 championship 18-hole golf courses, heavy vehicular and pedestrian use, numerous villas, cottages, townhouses, and private households. There are over 1300 houses, 20 villa and cottage complexes, 8 sports and recreation facilities, a straw market, a town municipal center, and a large hotel on the WE, compared to approximately 100 houses and 1 18-hole golf course on the EE. Lot sizes also tend to be larger on the EE which increases natural habitat for wildlife. In addition, the island has approximately 88 km (167.0 acres) of paved road throughout the island, with over 90% occurring on the WE. A road that runs from north to south through the island creates a sharp boundary line between the WE and EE. Despite the heavy development on the WE, many natural habitats occur in undeveloped lots, tidal marshes, ocean beach and dunes, and scattered larger portions of undisturbed maritime forest. In addition, all development on the island is under strict rules to leave as many trees and other types of vegetation as possible. This creates excellent cover and travel corridors throughout the island for predators and prey alike. Upland sites are dominated by live oak *(Quercus virginiana*), water oak (*Quercus nigra*), and pine (*Pinus* spp.) Understories consists mostly of saw palmetto (*Seronoa repens*), wax myrtle (*Myrica cerifera*), and yaupon holly (*Ilex vomitoria*).

Materials and methods

Bobcat capture and handling

We used 2 trapping methods to capture bobcats for the study: foot-hold and cage traps. All procedures were approved by the University of Georgia Institutional Animal Care and Use Committee (IACUC #A990159). A special scientific collection permit was granted by the South Carolina Department of Natural Resources (SCDNR). Trapping began on 30 December 1999 and continued until mid-February 2000. A second much less intensive trapping session took place in October-November 2000 in an attempt to capture and place radio-collars on bobcat kittens. No. 1.75 Victor, laminated, offset jawed foot-hold traps were used to capture most bobcats. These traps were placed along bobcat travel routes using the utmost caution to keep them out of sight of residents and their pets. We were concerned about the potential for the public to complain about trapped animals or accidently trapping pets. We used dirt-hole and flat sets with commercial trapping lures such as bobcat urine and bobcat gland lure. Bobcat scat was also used as an attractant. Two to 3 sets were made at each trapping site. Before trapping began, 6 road-killed deer were collected and placed into a freezer for our future use. These deer were placed at different places throughout the island with dirt-hole or flat sets made around them.

Chicken wire was used to construct separate compartments baited with a live chicken at the end of Tomahawk cage traps (Tomahawk Live Trap Company, Tomahawk, WI). Diefenbach et al. (1992) recommended using 2 cage traps abutted with a bait well containing a live chicken, preferably a bantam rooster. We tested this method as well as single traps with a bait well using both roosters and hens as bait. During the October-November trapping session, cage traps were used exclusively so as to not harm kittens when captured.

Traps were checked early each morning. We took every precaution to minimize stress to captured animals by moving slowly and quietly to each captured bobcat. Animals that were caught in foot-hold traps were restrained with the use of a 2' X 1.5' piece of plywood mounted to the end of a 5' piece of 2 X 4. This device worked to gently squeeze the bobcat against the ground while the ketamine hydrochloride (10-15 mg/kg of body weight) could be injected by hand intramuscularly (IM) into the hind quarter muscle (Seal and Kreeger 1987). We visually estimated the weight of the bobcat to estimate and administer the proper dose.

I designed an iron-welded device with bars that slid down through the top of the cage trap to restrain bobcats in cage traps. This device was lowered down through the trap when the animal was pushed to the back. The handle on this device could then be swung to squeeze the bobcat to the back of the trap, allowing the drug to be injected. The bobcat was immediately left after drug administration and given 15 minutes for the drug to take effect. To ensure the full effectiveness of the drug, we left the area far enough so that our voices and other noises would not disturb the animal. After the bobcat was immobilized, we then followed an established protocol (Diefenbach et al. 1990, unpubl.). The animal was first taken from the trap and placed into shade and examined for any injuries or abnormalities. The dentition of the animal was then checked for overall wear and to confirm whether the animal was a juvenile or adult (Jackson et al. 1988). We recorded the sex of each animal, body weight, total body length (nose to tip of tail), tail length, and length of hind foot (calcaneus to toes). The final step was to fit each animal with a radio transmitter mounted on an adjustable radio-collar. Each radio-collar was checked to make sure it was functioning properly and frequency was recorded. When this was accomplished, the bobcats were placed into a cage and left for several hours so that the effects of the drug would wear off. They were left in a very shaded area and out of sight from people so as to minimize stresses. The bobcats were then released that afternoon or evening from the capture location

Radio-telemetry

Telemetry was conducted from 23 February 2000 to 31 December 2000. We obtained daily locations for each bobcat using a hand-held, 3-element collapsible yagi antenna and a scanning receiver (Advanced Telemetry Systems, Inc., Isanti, MN). The starting times of our daily monitoring periods were shifted 2 hours each day. We also alternated our starting positions between the EE and WE of the island for each daily telemetry monitoring period. The shifting of starting times and areas allowed us to gather both diurnal and nocturnal locations on all bobcats. Since the objective of the study was to compare EE and WE bobcats, this strategy provided equal representation to both sides of the island and resulted in more equal home range data. Radio frequency, time, date, bearings, locations of telemetry stations, and any unusual or interesting behaviors were recorded for each bobcat. Compass bearings were triangulated from 2-3 telemetry stations. The approximate coordinates (± 5 m) of the telemetry stations were determined by using a hand-held global positioning system (Trimble Explorer) and the Columbia, South Carolina base station.

Home range and habitat use

Bobcat radio frequency, telemetry station coordinates, and date and time of bearings were entered into program Microsoft EXCEL. We created an output file of these data and imported them into program LOAS (Ecological Software Solutions, Sacramento, California, USA) which converted the compass bearings from the telemetry stations to X-Y coordinates based on the Universal Transverse Mercator (UTM) system.

We used the Animal Movement Extension in ARCVIEW (Environmental Systems Research Institute, Redlands, California, USA) with the 95% and 50% Adaptive Kernal (AK) method and the 95% Minimum Convex Polygon (MCP) method of Mohr (1947) to determine annual and seasonal home range sizes. Area observation curves (Odum and Kuenzler 1955) conducted on 2 randomly chosen adult bobcats in each area indicated adequate numbers of triangulated locations for seasonal home range comparisons. Seasonal home ranges were calculated for the periods of breeding/gestation (Jan 1-Mar 31), gestation/denning (Apr 1- Jun 30), kitten-rearing (Jul 1-Sep 30), and juvenile dispersal (Oct 1-Dec 31) (James 1992). A 2-sample t-test was performed to test for significant (*P* 0.05) differences in home range sizes between the WE and EE portions of the island for each period and the annual home range. In addition, the annual home and core range for each bobcat was overlain on a habitat map of the study site prepared by the Kiawah Island Natural Habitat Conservancy (KINHC) to determine areas of preferred habitat and to examine territorial overlap among females.

Movement rates

In addition to obtaining daily locations, once per season we intensively monitored and recorded a location for each bobcat every 2 hours for a 24-hour period to acquire movement rates during breeding/gestation (Jan 1-Mar 31), gestation/denning (Apr 1- Jun 30), kitten-rearing (Jul 1-Sep 30), and juvenile dispersal (Oct 1-Dec 31) (James 1992). We used ARCVIEW to calculate the straight-line distance between successive locations.

Movement rates were then determined by dividing distance by elapsed time. A 2-sample t-test was performed to test for significant (P 0.05) differences in movement rates between the WE and EE portions of the island.

Denning activities

The techniques used to locate bobcat dens were similar to those used by Ragsdale (1993), but differed in that we used only 1 person equipped with a radio-telemetry receiver instead of 3 people to locate the den site. We found that use of a single observer was very effective at finding dens. Suspicion that a female was denning would begin when her day-to-day movements were suddenly restricted to a small area. This change in her behavior was very obvious when conducting daily radio-tracking. If a female remained in the same vicinity for 4-5 consecutive days, then we assumed she was denning. A single observer would then locate the den by following the radio signal using a radio-telemetry receiver and antenna. It was important to walk in very slowly and as quietly as possible so as to not frighten the female away from the kittens. If the den was to be found, she must remain with the kittens until a person is within a few meters so that the observer can see her leave the den. It is also important to listen for sounds made by kittens, because a nervous female in the den is often restless, which disturbs the kittens. If a female does not have kittens in the area, she will usually leave the area before getting very close to her.

Once the den was located, each kitten was counted and sex was determined. Latex gloves were used to handle kittens so as to minimize human scent. This was done as quickly as possible so as to minimize disturbance to the den. Notes were also taken on den location and characteristics. Each time a den was found and disturbed, the female would move the kittens to a new den site by the next morning.

Bobcat abundance

Scent station transects were conducted in February 2000 and January 2001. Individual stations were placed at 0.32-km (0.2-mi) intervals throughout the island. Each station location was flagged and marked on a map. It took 3 days to run scent station surveys. We spent the first day clearing a 1-m diameter area at each flagged location. Each cleared station was sprinkled with a covering of powdered white, hydrated lime. Then, a Scented Predator Survey Disk (SPSD) (U. S. Department of Agriculture, Pocatello Supply Depot, Pocatello, Idaho) was placed into the center of each station.

Scent stations were checked the following 2 mornings, and all furbearer tracks seen were recorded. Stations with tracks were smoothed over and sprinkled with new lime. The tablet was also replaced if it had been removed or chewed. If a station was damaged by vehicular traffic, sprinklers, or falling debris, it was not included in the calculation of total station nights.

At completion of field work, scent station indices (SSI) were determined using the following equation (Diefenbach et al. 1994):

$$SSI = \frac{\text{no. visits}}{\text{no. of operable stations x 1,000}}$$

A different SSI value was determined to calculate an estimate of bobcat abundance by using an equation set up by Diefenbach et al. (1994). The equation used was:

$$SSI = \frac{\text{no. of operable stations}}{\text{no. of independent bobcat visits}}$$

An individual visit was defined as a group of stations separated from another group of stations by >2.9 km visited by bobcats, or visits within the same group separated by >0.64 km (Diefenbach et al. 1994). A regression formula was used to yield the population estimate. This equation was (Diefenbach et al. 1994):

$$SSI = 110.83 - 2.448 (N)$$

Bobcat food habits

We collected bobcat scats during summer (Jun-Aug 2000), winter (Dec 2000-Jan 2001), and spring (Mar-Apr 2001). I was able to collect the majority of these scats simply by watching for them on my travels around the island while radio-tracking bobcats. The remainder were collected by walking or bicycling on golf cart paths, bike paths, roads, dunes, and deer trails. These features served as travel routes for bobcats, and scat often were left there to warn other bobcats of the same sex of their presence and territorial ownership (Bailey 1974, Kight 1962). Upon finding a scat, it was immediately placed into a plastic storage bag and labeled with date and location. The scats were then frozen until they could be analyzed in a lab.

I collected the majority of the scats, but I did receive some scats from a group of naturalists who worked on the island. I discarded the scats from this source that were questionably of bobcat origin. This allowed me to analyze a large sample size, and classify 100% of them as definitely of bobcat origin. Approximately 70-90 scats were collected throughout the island during each of these seasons so that about 60 of the freshest scats could be selected and analyzed. This allowed me to compare approximately 30 scats from the WE to 30 scats from the EE end of Kiawah Island.

I followed the same procedure that Jordan (1998) used to analyze scat. Before analysis, scats were removed from the freezer and allowed to thaw at room temperature. When completely thawed, they were kept in plastic bags and placed into a drying oven at 60°C for 72 hours (Baker 1991). To begin the analysis procedure, dried scats were first weighed to the nearest gram. Then a scat was placed into a dissecting pan and viewed under a large dissecting magnifying glass. The scat was pulled apart using 2 pairs of forceps while examining hairs and separating them into groups based on size, color, length, banding patterns, and overall appearance. Pieces of bones and skulls were also separated and identified by comparison with a reference collection. The high magnification allowed most groups of hairs to be identified with a high degree of accuracy. However, a sample of several hairs from each group was placed onto a microscope slide and examined under a light microscope at 450X to confirm the identification. A drop of rubbing alcohol was added to the hair to help clean it of dust and dirt, and then a cover slip was added. The microscope allowed examinations of the structure and pattern of the medulla of the hairs. Hairs were identified by comparing them to Spier s (1973) key and reference hairs from study skins. Comparisons were also made with a set of reference photographs made from the same hairs taken under a light microscope. When a match was determined from these references, the group of hairs in question was placed into 1 of 5 categories and the percentage of the scat which it represented was recorded. The 5 categories were deer, rodent, rabbit, bird, and other. I used these broad categories because our main objective was to quantify the amount of deer in the bobcat s diet.

Percent occurrence, defined as the number of occurrences of a single prey item divided by the total number of occurrences of all prey items, was calculated seasonally and between WE and EE portions (Baker 1991). These results were compared to scat analyses done in 1997 (Jordan 1998), and 1998 and 1999 (Jordan, unpublished). Prior to the analysis of variance (ANOVA) an arc sin square root transformation was applied on prey occurrence to insure normality of the residual variances. Prey occurrence was then subjected to ANOVA using PROC GLM in SAS (SAS Institute Inc., Cary, NC) to test for significant (P 0.05) differences among prey, portion, season, and their interactions. Multiple comparisons of least-square means from ANOVA were performed with Bonferroni adjusted probabilities.

Results

Bobcat capture

During the period of 30 December 1999 to 13 February 2000, 5 male and 7 female bobcats were captured and fitted with radio-transmitter collars in 1044 leg-hold (75 trap nights/bobcat) and 415 cage (83 trap nights/bobcat) trap-nights. We obtained 9 bobcats using foot-hold traps and 3 with cage traps. Three of the males were determined to be adults, whereas 2 were juveniles (<1 year old at time of capture). Six of the females were adults and 1 juvenile. One of the adult females appeared to be relatively old, based on extensive tooth wear. All other adults appeared to be in prime condition and looked very healthy with fine teeth. Six of these bobcats were later recaptured, with one being recaptured twice. Nearly equal numbers of bobcats were captured on the WE and EE. Three males and 3 females were captured on the WE, compared to 2 males and 4 females on the EE. Weights were recorded for each bobcat, yielding a range of 6.3-12.6 kg (14-28 lbs). Total length ranged from 83-96.5 cm, hind foot length 15-17 cm, and tail length 14-18.5 cm

A second trapping effort using only cage traps was made between mid-October to mid-November with the goal being to capture radio-collar 5-6 month old kittens. During this time, a 9.7 kg adult male and a 5.9 kg 6-month old male bobcat were captured on the WE and fitted with radio-transmitter collars. A table summarizing all data collected on each bobcat is presented in Table 2.1.

We found that foot-hold traps were more efficient than cage traps because multiple foot-hold traps can be taken into the field, they are quick to set, require less maintenance, had greater capture success, and were less expensive to purchase. In some instances, we saw minor abrasions and localized edema in the paw of bobcats captured in foot-hold traps. However, injuries to bobcats in cage traps were limited to scraped noses.

A number of non-target species were also captured during our trapping sessions. During 30 December 1999 to 13 February 2000, we captured 111 raccoons (*Procyon lotor*), 72 opossums (*Didelphus virginianus*), and 2 gray foxes. We captured 64 raccoons and 27 opossums during our second trapping session which went from 15 October to 15 November 2000. A catch pole was used to release all species unharmed.

Table 2.1. Data collected from 12 bobcats captured between 30 December 1999 and 13 February 2000, and 2 bobcats captured between 15 October and 15 November 2000, Kiawah Island, South Carolina.

End	Cat #	Sex	Age	Weight (kg)	Total length (cm)	Heel length (cm)	Tail length (cm)
WE	933	Male	Adult	9.9	92	16	16
	714	Male	Adult	9.7	93	16	16
	894	Female	Adult	9.1	95	17	16
	674	Female	Adult	8.2	85.5	15.5	14.5
	733	Female	Adult	8.3	91	17	17
	813	Male	Juvenile	6.8	83	16	14
	973	Male	Juvenile	5.9	80	15	15
	794	Female	Juvenile	7.2	87	16.5	16
EE	653	Male	Adult	11.6	96.5	17	18.5
	873	Male	Adult	12.6	96	17	17
	694	Female	Adult	8.4	84	15	16
	913	Female	Adult	9.7	96	17	15.5
	633	Female	Adult	8.1	86	15	17
	954	Male	Juvenile	6.4	84	15	16

Home range and habitat use

Using the AK method, the WE adult male bobcat had a 37% larger annual home range size and a 9 times larger core range size than the EE adult male (Table 2.2). Male bobcat 933 had a large diverse core range spanning neighborhoods and golf courses, but did utilize the large remote dune area on the WE of the island. Male bobcat 653 primarily used an undeveloped wooded tract surrounded by large lots with sporadic houses (Figure 2.2). Seasonally, the WE male had much larger home range and core range sizes during gestation/denning, kitten-rearing, and juvenile dispersal, respectively. The MCP method also demonstrated that the WE adult male has a substantially larger home range than the EE adult male.

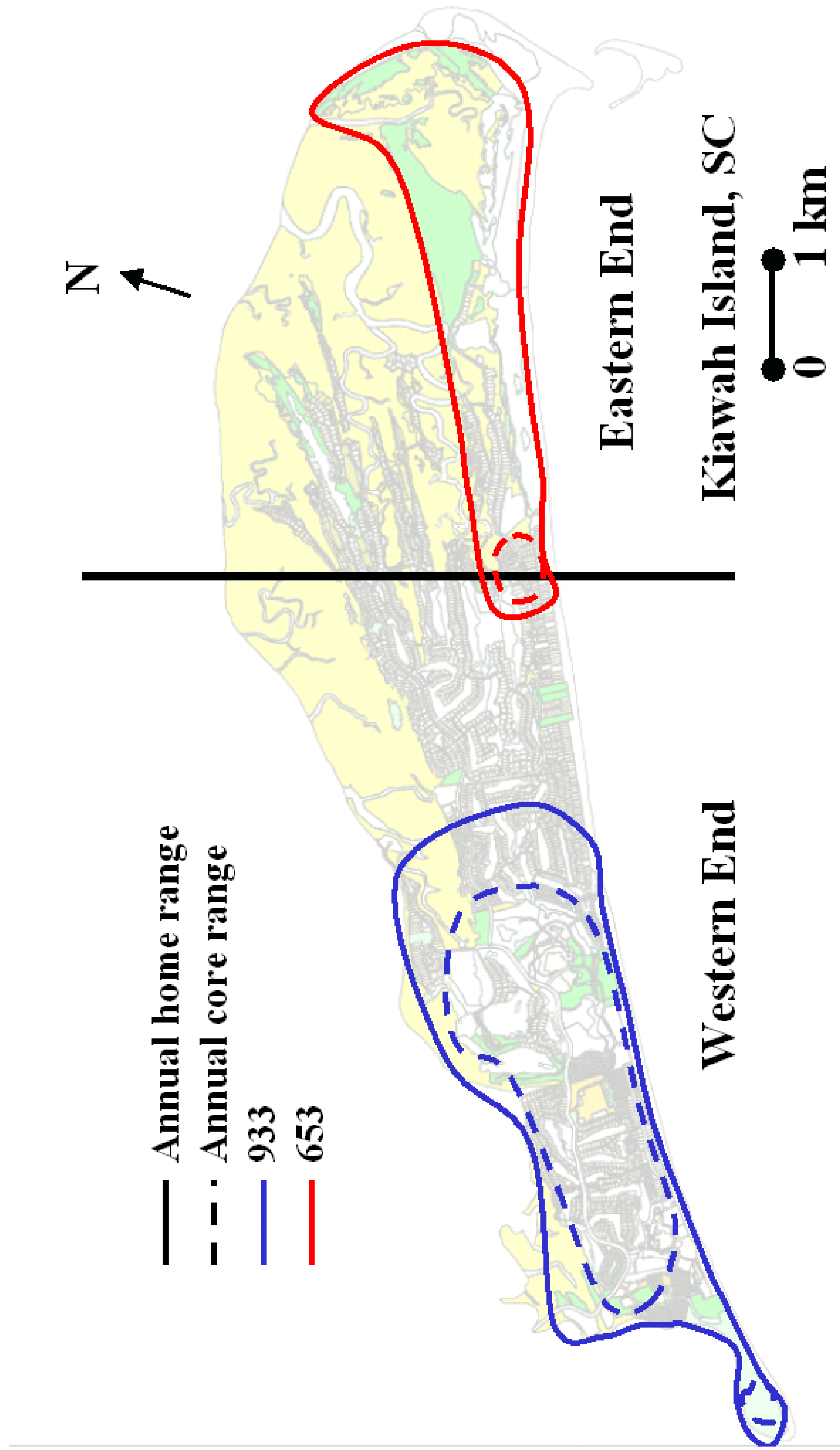
Average annual home range size for WE adult females was approximately 3 times (P = 0.089) as large and core range size was approximately 5 times (P = 0.099) larger than EE females (Table 2). Seasonally, WE adult females home range and core range size tended to be larger in gestation/denning (P = 0.335, P = 0.339), kitten-rearing (P = 0.100, P = 0.104), and juvenile dispersal (P = 0.070, P = 0.168), but differences were not significant. The MCP method also showed that WE adult females had a substantially larger average home range size annually and seasonally. WE females core ranges were large and contained diverse habitat, however, all core ranges centered around large undisturbed wooded or dune areas (Figure 2.3). Females on the EE concentrated their activities in large undeveloped wooded areas.

Table 2.2. Comparison of mean (± SD) annual and seasonal home range (HR) and core range sizes (km^2) using the 95 % (HR) and 50% (Core) Adaptive Kernal (AK) method and the 95% Minimum Convex Polygon (MCP) method of adult bobcats between the West End (WE) and East End (EE) portions of Kiawah Island, South Carolina.

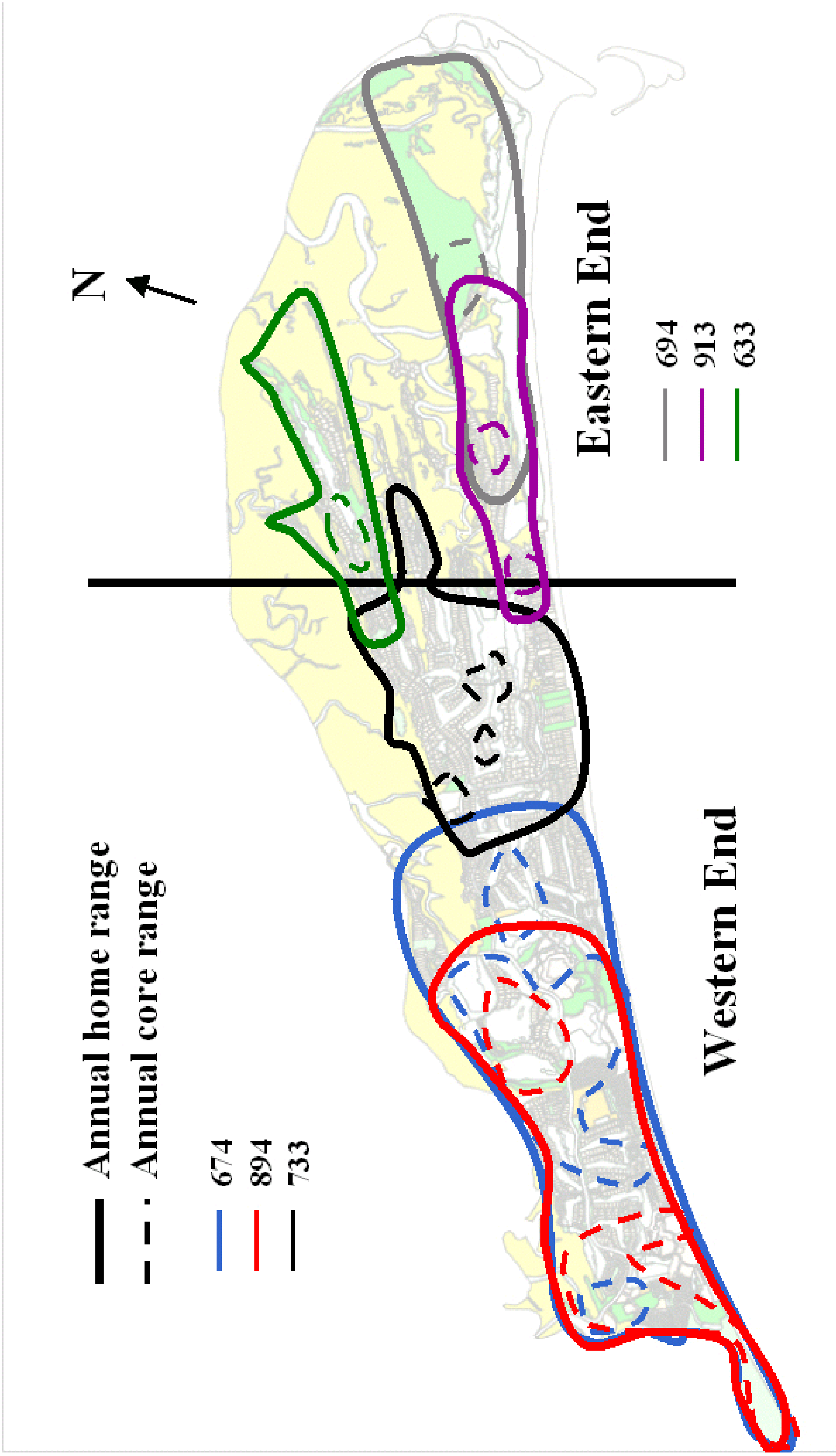
				Adaptive kernal				MCP	
End	Sex	n	Period	HR	SE	Core	SD	HR	SD
WE	Male	1	Annual	16.7	--	7.0	--	9.3	--
			Gestation/denning	15.6	--	3.3	--	7.9	--
			Kitten-rearing	19.4	--	6.7	--	8.8	--
			Juvenile Dispersal	19.7	--	6.4	--	6.6	
WE	Female	3	Annual	10.7	6.0	2.4	1.8	7.9	2.8
			Gestation/denning	5.8	4.2	0.7	0.5	4.7	1.9
			Kitten-rearing	10.0	7.3	2.3	1.9	5.9	3.2
			Juvenile Dispersal	12.6	6.32	2.5	2.5	5.7	2.2
EE	Male	1	Annual	10.5	--	0.8	--	6.8	--
			Gestation/denning	11.2	--	2.8	--	5.4	--
			Kitten-rearing	13.9	--	2.1	--	5.3	--
			Juvenile Dispersal	14.0	--	2.3	--	4.6	--
EE	Female	3	Annual	3.5	1.4	0.4	0.2	3.4	0.7
			Gestation/denning	4.5	2.4	0.5	0.2	2.7	1.0
			Kitten-rearing	2.0	1.2	0.2	0.1	1.7	1.0
			Juvenile Dispersal	4.0	0.3	0.7	0.3	1.9	0.6

Figure 2.2. The spatial orientation of annual home and core ranges for 2 adult male bobcats on Kiawah Island, South Carolina, 2000.

Figure 2.3. The spatial orientation of annual home and core ranges for 6 adult female bobcats on Kiawah Island, South Carolina, 2000.



Annual home range
Annual core range
933
653
N
Eastern End
Western End
Kiawah Island, SC
0
1 km


N
Annual home range
Annual core range
674
894
733
Western End
Eastern End
694
913
633

Movement rates

Movement rates were greater for the WE adult male than the EE adult male for each females designated season (Table 2.3). Average movement rates were also greater for WE adult during each seasonal monitoring period, but t-tests (= 0.05) failed to show significantly greater movements during breeding/gestation (*P* = 0.221), gestation/denning (*P* = 0.336), kitten-rearing (*P* = 0.393), and juvenile dispersal (*P* = 0.159).

Denning activities

During April, June, and July of 2000, we were successful at locating 5 den sites containing a total of 12 kittens, 8 females and 4 males (Table 2.4). We found dens for 5 of 6 radio-collared adult females. Two dens containing 5 kittens (3 female, 2 male) were found on the WE and 3 dens containing 7 kittens (5 female, 2 male) were found on the EE of Kiawah Island. In the spring and summer of 2001, we were successful at finding 2 dens containing 3 kittens (2 male, 1 unknown) on the WE and 1 den with 1 unknown kitten on the EE. Den locations during 2000 and 2001 are shown on Figure 2.4.

Bobcat abundance

Scent station indices (SSI) for bobcats were 21.9 in January 2000 and 38.6 in January 2001. Population estimates calculated from each survey using a regression equation were determined to be 26.6 bobcats in 2000 and 34.6 bobcats in 2001. In the 2000 survey, all visits to scent stations were confined to the EE of the island. Visits were more evenly distributed over the EE and WE in the 2001 survey, with one extra visit on the EE. Population estimates were similar to December 1997 (Table 2.5).

Table 2.3. Comparison of mean (± SD) movement rates (m/hr) of male and female bobcats during periods of breeding/gestation (Jan 1-Mar 31), gestation/denning (Apr 1-Jun 30), kitten-rearing (Jul 1-Sep 30), and juvenile dispersal (Oct 1-Dec31) between West End (WE) and East End (EE) portions of Kiawah Island, South Carolina.

End	Sex	n	Period	Movement rate (m/hr)	SD
WE	Male	1	Breeding/gestation	472	--
			Gestation/denning	252	--
			Kitten-rearing	497	--
			Juvenile dispersal	452	--
WE	Female	3	Breeding/gestation	195	19
			Gestation/denning	55	24
			Kitten-rearing	197	77
			Juvenile dispersal	120	92
EE	Male	1	Breeding/gestation	226	--
			Gestation/denning	204	--
			Kitten-rearing	19	--
			Juvenile dispersal	393	--
EE	Female	3	Breeding/gestation	155	70
			Gestation/denning	43	39
			Kitten-rearing	181	46
			Juvenile dispersal	46	54

Table 2.4. Date, number and sex of kittens, and den locations for each female bobcat during spring and summer 2000 and 2001 on Kiawah Island, South Carolina.

End	Female	Date	No. of kittens	Location
WE	894	5/5/00	2 female, 1 male	Dunes east of Beachwalker Park
	733	5/6/00	1 female, 1 male	Vanderhorst Plantation
EE	633	6/27/00	1 female, 1 male	Preserve
	694	6/29/00	2 females	Cougar Island
	913	7/29/00	2 females, 1 male	22 Ocean Course Drive
WE	674	5/7/01	l male	Dunes east of Beachwalker Park
	894	5/14/01	1 male, 1 unk.	16 Green Meadow Lane
EE	694	6/25/01	1 unknown	25 Ocean Course Drive

Figure 2.4. A map of Kiawah Island, South Carolina showing den locations during 2000 and 2001.

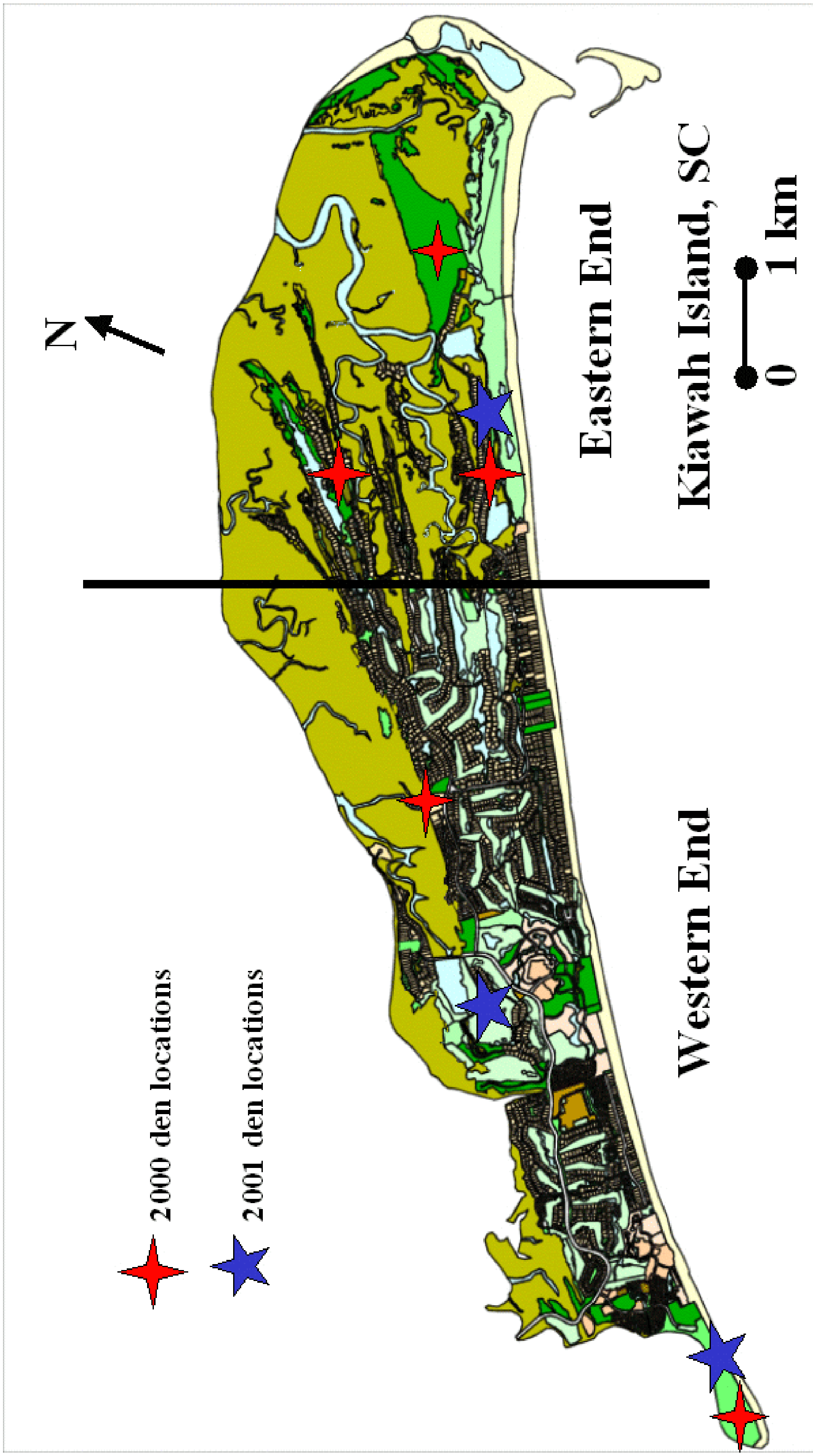

2000 den locations
2001 den locations
N
Western End
Eastern End
Kiawah Island, SC
0
1 km

Table 2.5. Bobcat scent station indices (SSI) and population estimates determined from scent station surveys conducted winter 1997, 2000, and 2001 on Kiawah Island, South Carolina.

Date	SSI	Population Estimate
December 1997[a]	36.7	34.3
January 2000	21.9	26.6
January 2001	38.6	34.6

[a]Data from Jordan (1998).

Bobcat food habits

Significant (P = 0.0001) differences were found in prey use that were independent of season or portion. In addition, significant (P = 0.0020) differences were found due to the interaction of prey and season. Deer use by bobcats remained relatively constant between the EE and WE, but was slightly higher in the EE during winter and spring, and slightly greater in the WE in summer (Table 2.6). Rodents, primarily cotton rats, made up the bulk of the bobcat s diet on the EE and WE each season (P < 0.0001) except winter when birds were used heavily. Bird use exceeded rodent use in the EE during winter. Bird use was significantly lower (P = 0.002) during all other seasons. Rabbit use remained relatively constant between the EE and WE during all seasons, but was highest in spring. Prey items grouped in the other category, such as raccoons, opossums, snakes, lizards, fish, and insects also remained relatively constant between the EE and WE, but winter use was significantly (P = 0.050) lower than in spring and summer.

Deer use in summer 2000 was greater in the EE and WE than in summer 1997 and in summers 1998 and 1999 (Table 7). Deer use was also higher in winter 2001 and spring 2001 than in spring and winter 1997 (Table 2.7).

Discussion

Home range

Average home range sizes for Kiawah Island bobcats, especially WE bobcats, were larger than previously reported in other southeastern studies. Home range size estimates of female bobcats in the Southeast have varied from 1.0 km^2 (Hall and Newsome 1976) to 2.5 km^2 (Marshall and Jenkins 1966). Female home range sizes on the WE of Kiawah

Table 2.6. Comparison of percent occurrence of prey items in bobcat scats collected seasonally during summer 2000, winter 2000-2001, and spring 2001 between West End (WE) and East End (EE) portions of Kiawah Island, South Carolina.

Prey Item	Summer (Jun-Aug)		Winter (Dec-Jan)		Spring (Mar-Apr)	
	EE (n=30)	WE (n=30)	EE (n=28)	WE (n=31)	EE (n=30)	WE (n=30)
Deer	19	23	14	11	23	22
Rodent	48	46	37	46	41	40
Rabbit	17	16	8	12	25	18
Bird	2	5	39	28	4	4
Other	14	10	2	3	7	16

Note: All columns sum to 100%.

Table 2.7. Comparison of percent occurrence of deer in bobcat scats collected during summers 1997, 1998, 1999, and 2000, and winter and spring 1997 vs. winter and spring 2001 between West End (WE) and East End (EE) portions of Kiawah Island, South Carolina.

Year	Summer		Winter		Spring	
	EE	WE	EE	WE	EE	WE
1997[a]	22	3	3	0	0	2
1998[b]	13	7				
1999[b]	12	13				
2000	19	23				
2001			14	11	23	22

[a]Data from Jordan (1998).
[b]Unpublished data from J. D. Jordan, Kiawah Island, South Carolina

Island averaged 8.0 km^2, compared to 3.5 km^2 for EE females. Male bobcat home ranges have been estimated at 3.0 km^2 (Miller 1980) and up to 4.9 km^2 (Hall and Newsome 1976). In our study, the WE male bobcat averaged a 10.0 km^2 home range size while the EE male averaged 7.0 km^2. Because bobcats are considered territorial, larger home range sizes may reflect low bobcat density and poorer quality habitat as documented on the Savannah River Site in South Carolina (Buie and Fendley 1979, Griffith and Fendley 1982). Smaller home range sizes in eastern Kentucky reflected a high bobcat density, perhaps as a result of higher quality habitat (Whitaker et al. 1987). During all scent station surveys conducted on Kiawah Island since 1997, there have been more bobcat visits on the EE than the WE, suggesting that bobcats are more abundant on the EE. This higher quality habitat may be able to support more animals. Bobcats may be forced to utilize more of the poorer quality habitat on the WE for survival.

Male home ranges generally are twice as large as female home ranges and will often overlap 2 or more female territories (Hall and Newsome 1976, Miller and Speake 1978, Buie and Fendley 1982, McCord and Cardoza 1982, Whitaker et al. 1987). We saw this same trend on Kiawah Island. Both the WE and EE adult males home ranges almost completely encompassed the home ranges of 2 females.

Female home range is governed by diversity and abundance of prey populations while male home range is regulated by prey availability and mating opportunity, and is consequently determined by the number of females in the area and the size of their home ranges (Anderson 1987, Sandell 1989). Until recently, females were thought to seldom enter the home ranges of other females. Chamberlain and Leopold (2000) documented extensive sharing of home ranges and core areas by females. We also observed this previously unreported behavior. Adult WE female bobcats 674 and 894 exhibited home range overlap around 64% and core range overlap 35% during all seasons. There was no core range overlap in spring during the denning and kitten-rearing periods for 894. Adult EE female bobcats 694 and 913 exhibited home range overlap around 40% but no core range overlap during all seasons. Lack of quality habitat on the WE may be forcing bobcats to share the limited amount of remaining higher quality land as shown by the extensive core range overlap. No overlap of core range in EE female bobcats may mean less competition because of higher quality and quantity of habitat. We feel that this territorial sharing behavior is more common than previously thought, perhaps because previous studies did not have a major portion of the population radio-collared. We made an intense trapping effort and attempted to capture and radio-collar all bobcats on our study area. Our sample size left no voids, or areas without radio-collared bobcats. In addition, we had 7 recaptures from the 12 bobcats we captured. Therefore, we believe that most adult male and female bobcats were being monitored on Kiawah Island.

Movement

Daily and weekly distances moved by bobcats vary considerably between males and females (Anderson 1987). Kitchings and Story (1979) observed daily movements in eastern Tennessee averaging 4.5 km for males and 1.2 km for females. Marshall and Jenkins (1966) calculated the average daily movements of bobcats in west-central South Carolina for males and females as 4.8 and 2.6 km, respectively. On Kiawah Island, the daily distance traveled by the WE adult male averaged 10 km and averaged 5 km for the

EE adult male during all seasons. WE females traveled an average 3.4 km while EE females traveled 2.5 km daily during all seasons.

Anderson (1987) felt that slower female movement rates may indicate more intensive hunting strategies. WE male and female bobcats exhibited increased total daily movements and movement rates compared to EE bobcats. The highly developed WE may be causing these animals to work harder and exert more energy at finding and capturing prey. WE bobcats seem to be quite tolerant of humans, but certainly human disturbance influences and restricts their movements and may decrease hunting success. During spring and summer months, tourists flock to the island to enjoy the island s many activities such as bike riding, golf, and tennis. Any bobcat moving anywhere on the WE is constantly coming into contact with people. Therefore, it seems logical that WE bobcats are forced to range further than EE bobcats that are not subject to this level of daily harassment. Bobcats are considered crepuscular, with the majority of their activity centered around sunrise and sunset (Buie and Fendley 1982). This behavior was confirmed on Kiawah, with the greatest movement rates occurring during the 2 hours before and after sunrise and sunset.

Dispersal

Dispersing juvenile bobcats are reported to have traveled various distances. Robinson and Grand (1958) reported juveniles moving 6.6 km to 37 km. Juveniles moved an average of 33.4 km with a maximum of 75.2 km before establishing new home ranges in Missouri (Hamilton 1982). Juveniles tend to disperse before the litters of the following year are born (Griffith et al. 1981, Kitchings and Story 1984, Anderson 1987). An EE juvenile male radio-collared in early 2000, left Kiawah Island in early 2001 and moved about 20 km to the adjacent Seabrook Island where it established its own territory and remains today. On the Savannah River Site, South Carolina, Griffith et al. (1981) tracked the dispersal of 2 juvenile males. These 2 males exhibited a nomadic movement pattern and occupied areas for 30-60 days before moving to the next area. Before this EE juvenile male left Kiawah Island, it exhibited this nomadic movement pattern as it moved west across the island. As it moved west, it would remain in an area for a week or two and then move on, apparently attempting to establish a territory of its own.

Scent station surveys conducted since 1997 showed a very stable island wide-bobcat population. Stability means few openings for young males looking for a territory of their own. There were no void areas, or areas without a radio-collared adult male, on Kiawah Island. The combined home ranges of our 3 adult males cover the entire island. These 3 males were also in the prime of life, healthy, young, and in excellent condition. For this reason, we expect high juvenile dispersal off the island.

Kiawah Island may also receive transient bobcats from time to time. We captured and radio-collared one such animal in October 2000. Transient bobcats are described as a floating population that coexists with the residents (McCord and Cordoza 1982). After his capture, this 10-kg young adult male roamed throughout the island for several weeks and then left the island and moved to the adjacent Seabrook Island. Transient animals live a nomadic life. They tend to be dispersing juveniles or young adults attempting to establish a territory, and they are quick to fill any voids that appear due to the death or removal of a resident animal (McCord and Cordoza 1982). This bobcat may have filled a void on Seabrook Island where it is still alive today, leaving Kiawah Island because no territory could be established.

Denning activities

The breeding season for bobcats may differ from region to region. In the southern United States, Fritts and Sealander (1978*b*) reported that the peak of the breeding season occurred between December to February, but breeding may occasionally occur during any month of the year. A study on Cumberland Island, Georgia saw the peak of the breeding season in February and March (Ragsdale 1993). Compared to other regions of the United States, breeding in the South appears to begin earlier and last longer (Blankenship and Swank 1979). We observed a difference in denning times between the WE and EE of Kiawah Island. On the WE, kittens were born in late April and early May, which made the peak breeding dates in late February and early March, because bobcat gestation periods average about 62 days (McCord and Cordoza 1982). On the EE, kittens were born in late June and July, which made peak breeding time during April and May. We are unsure about the reason for this difference in breeding and denning dates, but many factors can influence the time of the breeding season such as prey availability, nutritional condition, and age composition (McCord and Cardoza 1982).

Litter sizes are relatively consistent from region to region in the U. S., and have ranged from 1 to 6 kittens (Gashwiler et al. 1961), but average litter size has been estimated from 2.5 to 3.9 (McCord and Cordoza 1982). A Florida study reported litter sizes from 2-5 kittens with an average of 3.3 (Winegarner and Winegarner 1982). Beeler (1985) estimated the average litter size was 2.5 in Mississippi. Bobcats on Cumberland

Island, Georgia had litter sizes that ranged from 2-3 kittens (Ragsdale 1993). Litter sizes ranged from 2-3 kittens for each adult female during 2000 on Kiawah Island. We located dens for 5 of 6 radio-collared adult females, and we think that the remaining WE female also had a litter of kittens, but for reasons unknown they did not survive the first few days of life. We believe this because this female had 1 kitten in 2001 that was born in the same area that she was exhibiting denning behavior the year before. She remained in this area for a week in 2000 before we finally decided she was denning, but when we attempted to locate the den, she abandoned the area and did not return.

Denning success was similarly high between both areas of Kiawah Island. We did not expect to see such high success in an area with such an abundant and stable bobcat population. Ragsdale (1993) saw decreased reproductive success on Cumberland Island, Georgia the second year after bobcats were reintroduced to the island, even though food and suitable denning habitat were abundant. She proposed that some sort of density-dependent inhibition of reproduction was involved in regulating the population to prevent it from exceeding carrying capacity. We believe reproductive success is so high on Kiawah Island because of such high juvenile dispersal and mortality.

Mortality was especially high in the WE. Our 3 mortalities all occurred on the WE, and it is important to mention that not one of these animals would have been discovered had it not been radio-collared. Two of these 3 deaths were due to automobile collisons. Larger home range sizes, increased movement rates, heavy vehicular traffic, and a very developed road system greatly increased the risk of WE bobcats being struck by automobiles.

Disease also played an important role in regulating the bobcat population on Kiawah Island. In 1999, a dead bobcat was found and submitted to SCWDS for diagnostic testing, and it was found to have died from feline panleukopenia, a deadly bobcat disease, especially affecting juveniles. Our other radio-collared juvenile bobcat likely died from the same fate. On the day of the bobcat s death, a resident watched from his back porch while the bobcat exhibited nervous discoordination such as convulsions and incoordination. It was in an overall morbid state and showed no wariness to people.

Bobcat abundance

How many bobcats are there on Kiawah Island? The bobcat s secretive nature makes it difficult to estimate its abundance. The scent-station technique has been used in many studies to estimate population size and trends (Linscombe et al.1983, Diefenbach et al.1994, Chamberlain et al.1999*b*). Hatcher and Shaw (1981) compared 2 types scent-station surveys to mail questionnaires, and found that the mail questionnaire was a better technique for estimating furbearer abundance when populations were low. Chamberlain et al. (1999*b*) reported that track transects can be used as a suitable alternative to scent stations for indexing bobcats.

Most scent-station surveys have used olfactory stimuli such as urine or fatty acid scent (FAS), while visual or auditory stimuli have rarely been used, but bobcats rely mostly on sight and hearing to hunt their prey (McCord and Cordoza 1982). Morrison et al. (1981) reported that using white agricultural lime as a tracking surface significantly increased bobcat visits when compared with natural soil. An Alabama study showed that bobcats responded better to stations using a cottontail rabbit (*Sylvilagus floridanus*) distress call than to stations treated with olfactory stimuli (Sumner and Hill 1980). Chamberlain et al. (1999*b*) also found that bobcat visitation rates occurred at stations with audio attractants. Therefore, scent-station surveys using olfactory stimuli to estimate bobcat population or relative abundance may be biased. When reporting results from scent-station surveys, all studies warn that caution should be used when interpreting results. Diefenbach et al. (1994) warn that their results are only applicable on Cumberland Island, Georgia, and should only be used as minimum guidelines for designing scent-station surveys.

Jordan (1998) used the scent-station index to estimate and compare bobcat abundance on the WE and EE of Kiawah Island. He estimated an island-wide population at about 36, for a density of 1.4 bobcats/km^2. Other studies in the southeastern U. S. have estimated bobcat densities from 0.09 bobcats/km^2 to 1.16 bobcats/km^2 (McCord and Cordoza 1982). Roughton and Sweeney (1982) believe that scent-station transects are generally not considered valid for making comparisons between 2 different areas. Indeed, the WE and EE portions of Kiawah Island differ significantly. Sargeant et al. (1998) suggest that scent-stations are most suitable for examining broad temporal trends in furbearer populations, rather than precisely estimating abundance. They also report that scent-stations may be ill-suited for monitoring wide-ranging and rarely detected carnivores. I think the scent-station survey overestimates the number of bobcats on Kiawah Island, but I do believe it can be a useful technique to show bobcat trends over time. In our intense trapping effort, we attempted to capture and radio-collar every bobcat on the island. During this trapping effort, we had numerous recaptures. There are also no voids, or areas that do not contain a radio-collared bobcat on the island. The combined home ranges of the 3 adult males cover the entire island. The combined home ranges of all adult females covers the entire island. I believe that most of the adult bobcats on Kiawah Island were being monitored in 2000.

Bobcat food habits

The bobcat is the top mammalian predator on Kiawah Island, South Carolina, and the only important predator on deer. Other mortality factors affecting deer on Kiawah Island are gray foxes *(Urocyon cinereoargenteus),* alligators *(Alligator mississippiensis),* and automobiles. Our main purpose for studying bobcat food habits on our study site was to quantify the use of deer in the diet. Scat samples collected in summer 2000 and spring 2001 were full of fawn hair, indicating high bobcat predation on newborn fawns. In addition, these samples contained some adult deer hair. The fawning season on Kiawah Island occurs from March to July (Jordan 1998). This extended fawning period allows fawns to be available to bobcats for many months throughout the year. Bobcats not only prey upon small fawns, but are fully capable of preying on larger fawns and yearling deer (Labisky and Boulay 1998), which extends the period even more in which young deer are vulnerable to bobcat predation.

There are an estimated 400-500 deer on the island or 35 deer/km^2. This extremely high deer population provides a major food component of the bobcat s diet. In fact, bobcat predation on deer is believed to be the primary reason for the stability in the deer population level over the past several years. Deer on Kiawah Island are in excellent nutritional condition and have the potential for rapid population increase, but bobcat predation helps limit their reproductive potential and eliminates surplus deer.

Bobcats are strictly carnivorous, while foxes are seasonally omnivorous (Harrison 1997, Edwards 1996). Bobcats, gray foxes, and alligators have all been documented as feeding on white-tailed deer fawns in coastal South Carolina, with bobcats accounting for the majority of fawn mortalities (Baker 1991, Epstein et al. 1983, Epstein et al. 1985, Nelms 1999). On South and Cat Islands, South Carolina, 26 of 47 radiocollared fawns died from predation, in which bobcats accounted for 66.7% (Epstein et al. 1983).

Several other studies along the southeastern coast have shown that bobcats are an important limiting factor in many deer populations (Baker and Warren 1995, Nelms 1999). Indeed, predation on deer by a reintroduced bobcat population on Cumberland Island, Georgia has been shown to be the primary cause for a significant reduction in the deer population on that island and a concomitant recovery of the island s vegetation community from years of overbrowsing by deer (Nelms 1999). A study of radio-collared deer in the Florida Everglades found that bobcat predation accounted for 60% of fawn deaths and 17% of adult deer deaths (Labisky and Boulay 1998). A six-year study in Central Mississippi by Chamberlain and Leopold (1999*a*) reported that the occurrence of deer in the diet of bobcats consistently equaled or exceeded that of rodents, which supports the importance of deer in the bobcat diet.

Bobcats are opportunistic feeders and will attempt to kill almost any prey available (McCord and Cardoza 1982). In the southeastern U.S., marsh rabbits *(Sylvilagus palustris)* and cottontail rabbits (S. *floridanus)* are important prey items of bobcats, followed by gray squirrels *(Sciurus carolinensis),* hispid cotton rats *(Sigmodon hispidis*), and birds (Fritts and Sealander 1978*a*, Fox and Fox 1982, Maehr and Brady 1986). Rodents make up the bulk of the bobcat s diet throughout the year on Kiawah Island except during winter when it is equaled or exceeded by bird use. Bird use is low during all other seasons. Jordan (1998) saw this same trend in the 1997 food habit analysis.

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CHAPTER 3

SUMMARY AND MANAGEMENT RECOMMENDATIONS

Summary

Bobcats are one of Kiawah Island s most valuable ecological assets. They play a vital role as top mammalian predator in maintaining balance in the island s ecosystem. Bobcat predation is probably an important limiting factor that has contributed to the stability of the island s deer herd. Bobcat scat collected in summer 2000 and spring 2001 showed that deer made up approximately 20% of the bobcat s diet during these times and approximately 10% during winter 2000-2001. The extended fawning season from March to July allows young fawns to be available to bobcats over longer periods of time. In addition, bobcats are fully capable to preying on older fawns and yearling deer as well. Deer are a major issue to residents due to concern for deer-vehicle collisons and browsing of landscaping vegetation. Heavy predation on deer by bobcats on this continuously developing island has helped to alleviate these problems over the years. The loss of the bobcat from Kiawah Island s ecosystem would certainly allow the deer population to increase, and in turn, increase deer-human conflicts.

Unfortunately, the bobcat faces an uncertain future on Kiawah Island. Each year development increases and destroys valuable wildlife habitat. This research project was designed to study the effects of development on the island s bobcat population. A better understanding of how the bobcats are reacting to the high level of development on the West End (WE) will better allow us to predict the future of this valuable predator, and as a result allow us to better predict the future of the white-tailed deer on the island.

It is important to understand the nature of Kiawah Island s bobcats before we can envision the future. This study has shown us that these bobcats are adapted to this highly developed island and tolerate human presence very well. They are in no way going out of their way to avoid humans. Reports come in daily of residents and tourists observing these animals walking through their yards or hotel parking lots or even on their porches. Even when bobcats are aware of human presence and being watched, they often do not shy away but continue on their way as long as they are not approached. On one occasion, I stood in full view and watched from less than 10 m while a WE adult male, fully aware of my presence, conducted a 5-minute stalk and chase of a squirrel. On several occasions I stood in full view less than 10 m from bobcats and watched while they devoured squirrels they had caught. As long as I made no advances toward them, they hardly paid me any attention. On numerous occasions while conducting radio-telemetry sessions I located bobcats under houses, villas, and hotels. My guess is that these environments provided them a resting and hiding place to escape human encounters. So, bobcats on Kiawah Island have proved to be quite adaptable and tolerant of humans. And, if we rely on the trends that scent station surveys have shown us since 1997, we see that the current island-wide bobcat population has remained stable since 1997. However, the use of radio-telemetry has allowed us to look beyond this and estimate the effects of development.

This study has shown us that bobcats on the WE have much larger home range and core range sizes than those on the EE. Much of the critical habitat that a bobcat needs has been replaced by houses, villas, hotels, golf courses, and paved roads. In order to survive and adapt to these changes, the WE bobcats have increased their home range size to meet life requirements. More land has to be utilized in order to find sufficient prey. Increased movement rates of WE bobcats show that these animals move more and expend more energy on a daily basis to find prey as compared to EE bobcats.

The WE bobcat s population probably experiences higher mortality, especially among juveniles. We radio-collared 4 adult and 2 juvenile WE bobcats at the beginning of the study, and 3 have since died, which includes both juveniles. There have been no mortalities on the EE. Two mortalities have been caused by automobile collisions. The complex road system and heavy traffic on the WE makes these bobcats very susceptible to being hit. Anywhere a bobcat travels throughout the WE, it is constantly coming into contact with roads. We learned from radio-telemetry, that especially at night, bobcats used roadways as major travel corridors. These roads make it very easy for bobcats to travel to and from more productive and favorable hunting grounds. The more an animal comes into contact with roads and vehicular traffic, the greater the chance of a collision. It is also important to note that not one of these 3 animals would have been discovered had it not been fitted with a radio-collar. This demonstrates the complexity of wildlife population dynamics and how we will never fully understand exactly how a population operates.

For young animals making it through their first year, we expect high juvenile dispersal. At nearly 2 years of age in early 2001, a radio-collared EE young adult male dispersed off Kiawah Island and apparently established a territory of its own on the adjacent Seabrook Island. This young adult male was probably tolerated by territorial males on Kiawah Island until the breeding season began in February, and then was forced to disperse by these males to avoid competition for females. It will be important in the future to monitor the young WE adult male that was captured as a kitten in late 2000. It is likely that as the breeding season approaches, he too will be forced to disperse off island to search for a territory of his own. We expect to see this especially because he is a young male, and there are no areas without a territorial male on Kiawah Island. If one of these adult males was to die, it would be likely that he or another young male would fill this void.

Female bobcats are experiencing extraordinary reproductive success on Kiawah Island. Five of 6 adult females produced 12 kittens in 2000, with each having a litter of 2-3 kittens. First of all, when we captured and radio-collared bobcats, we examined them and found them in good nutritional condition from the abundant availability of prey. Necropsies done by SCDWS on the 2 bobcats killed by automobiles reported that they were both in excellent nutritional condition. Animals in this condition tend to have increased reproductive success. We believe that females are having many kittens because of high kitten and juvenile mortality as mentioned above. And since this population of bobcats on Kiawah Island is open, animals can disperse on and off the island. If there is no area to establish a territory on Kiawah Island, they can move until they find one.

Management recommendations

The bobcat is a highly efficient predator that has adapted to a variety of habitat types. This characteristic, coupled with its recently documented ability to tolerate human presence and development, has allowed it to thrive in a region where other predators such as the eastern cougar and the red wolf have long since been extirpated. However, there likely is a limit to the amount of human development the bobcat can withstand until it is negatively affected.

Generally, as development increases, understory grass, forb, and shrub vegetation decreases. According to the U. S. Fish and Wildlife Service (USFWS) habitat suitability index model (Boyle and Fendley 1987), ideal habitat for bobcats should be covered by about 50-70 % grass, forb, and shrub vegetation. Thus, one could make the argument that some degree of development may even benefit bobcats, especially in a maritime forest. Development creates openings which can diversify habitats and create niches for a wider variety of prey species for bobcats. However, excessive development may no longer be beneficial to bobcats. The most critical component to the survival of bobcats is forested habitat with a dense understory that provides a large number of prey species (Boyle and Fendley 1987). The maritime forest on Kiawah Island provides this prey abundance, along with essential cover, protection from severe weather, rest areas, denning sites, and escape from human disturbance.

The key to maintaining the presence of bobcats on Kiawah Island is to preserve and enhance as much of the remaining maritime forest as possible. Through radio-telemetry, we found that bobcats make extensive use of the small but numerous undeveloped lots scattered throughout the island. The few remaining larger undivided parcels of land throughout the WE are absolutely critical to bobcats. All core ranges contained or centered around these areas and it is here that bobcats spend most of their time. Unfortunately, there are plans to develop these areas in the future. One of these large key areas has recently been lost to make way for a hotel. The loss of these few remaining larger portions of undeveloped land may reduce the WE bobcat population from its current level.

Preserving maritime forest will ensure that bobcats have suitable denning sites in the future. All denning sites on Kiawah Island during 2000 and 2001 were located in areas surrounded by thick and almost impenetrable vegetation away from any human disturbance. Preserving these particular sites and the areas around them are important to the bobcat s future on Kiawah Island.

Dune areas are also vital components of a bobcat s home range. These areas serve as major travel corridors, hunting grounds, and denning sites. Kiawah Island has a relatively undisturbed dune area that runs along the southern edge of the entire island. This allows bobcats to travel without the presence of humans to different parts of their home range. These areas also offer excellent hunting grounds, because of the abundance of rodents, rabbits, and birds that flourish in this environment. Captain Sam s spit was utilized as a denning and kitten-rearing site during 2000 and 2001. This area was also heavily utilized by WE bobcats to escape human disturbance and for hunting purposes. Preservation and maintenance of this extensive dune system should be a priority. To maintain dunes indefinitely, dune plants must be present to stabilize the sand, so that erosion is avoided. Current regulations that prohibit people from entering dunes must be enforced, and designated walking paths or bridges should only be used to gain access to beaches.

Because property on Kiawah Island is so valuable, it is inevitable that development will continue. It may not be feasible to protect all of the remaining undeveloped subdivided lots and larger tracts of unsubdivided land. Therefore, individual property owners can manage their property to increase wildlife habitat that will help to offset losses to development. The Kiawah Island Natural Habitat Conservancy has a plan called Landscaping for the Legacy which will likely help ensure the bobcat s future presence on the island. The plan calls on the Town of Kiawah Island, the Kiawah Island Community Association, the Kiawah Island Resort, and the Kiawah Resort Associates to manage their properties to retain as much natural vegetation as possible. It also calls on these entities to work with property owners to develop management guidelines for individual properties. Remember, the most critical component to the survival of bobcats is forested habitat with a dense understory that provides a large number of prey species. Property owners who preserve native areas of maritime forest will encourage understory plants that provide valuable cover, habitat for prey species, and the seedlings that will ensure the future of the forest.

Officials and property owners on Kiawah Island have always placed a high priority on preserving wildlife habitat. This must continue. The future of the bobcat depends on the steps that are taken today. Even with continued development, each individual can play a part to maintain the island s character which will ensure that future generations can enjoy the natural beauty of Kiawah Island.

Literature cited

Boyle, K. A., and T. T. Fendley. 1987. Habitat suitability index models: bobcat. Biological Report 82, Fish and Wildlife Service, Research and Development, Washinton, D. C., USA.

APPENDIX 1

ANNUAL AND SEASONAL HOME RANGE (KM²) DATA USING THE 95% AND 50% ADAPTIVE KERNAL AND MINIMUM CONVEX POLYGON METHODS FOR ALL BOBCATS RADIO-COLLARED ON KIAWAH ISLAND, SOUTH CAROLINA

Annual and seasonal home range and core range sizes (km²) for all bobcats radio-collared on Kiawah Island using the 95 % and 50% Adaptive Kernal method and the 95% Minimum Convex Polygon (MCP) method.

End	ID #	Time	Adaptive Kernal Home range	Adaptive Kernal Core	MCP Home range
WE	933	Annual	16.7	7.0	9.28
		Gestation/Denning	15.5	3.3	7.85
		Kitten rearing	19.3	6.6	8.75
		Juvenile Dispersal	19.7	6.4	6.64
	894	Annual	14.1	3.6	8.46
		Gestation/Denning	7.1	1.0	3.89
		Kitten rearing	9.4	1.9	5.63
		Juvenile Dispersal	16.4	5.2	5.62
	674	Annual	14.3	3.1	10.37
		Gestation/Denning	9.1	0.9	6.82
		Kitten rearing	17.6	4.4	9.29
		Juvenile Dispersal	16.1	1.8	7.91
	733	Annual	3.8	0.4	4.85
		Gestation/Denning	1.1	0.2	3.25
		Kitten rearing	3.0	0.5	2.82
		Juvenile Dispersal	5.3	0.4	3.59
	794	Annual	5.7	0.7	5.94
		Gestation/Denning	6.5	0.9	4.10
		Kitten rearing	Dead		Dead
		Juvenile Dispersal	Dead		Dead
EE	653	Annual	10.5	0.8	6.75

End	ID #	Time	Adaptive Kernal Home range	Core	MCP Home range
		Gestation/Denning	11.1	2.7	5.39
		Kitten rearing	13.9	2.1	5.31
		Juvenile Dispersal	14.0	2.3	4.63
	633	Annual	2.7	0.4	2.91
		Gestation/Denning	2.8	0.4	1.96
		Kitten rearing	1.2	0.1	1.68
		Juvenile Dispersal	4.1	1.0	2.11
	694	Annual	5.1	0.6	4.23
		Gestation/Denning	7.2	0.7	3.87
		Kitten rearing	3.3	0.3	2.76
		Juvenile Dispersal	3.6	0.5	2.32
	913	Annual	2.6	0.3	3.17
		Gestation/Denning	3.3	0.4	2.40
		Kitten rearing	1.3	0.1	0.76
		Juvenile Dispersal	4.2	0.5	1.22
	954	Annual	6.8	0.5	6.53
		Gestation/Denning	5.5	0.6	2.32
		Kitten rearing	3.0	0.3	2.67
		Juvenile Dispersal	9.9	2.5	4.94
Both	873	Annual	12.3	3.1	8.87
		Gestation/Denning	13.7	4.1	7.24
		Kitten rearing	11.3	0.9	5.74
		Juvenile Dispersal	14.7	3.3	7.24

APPENDIX 2

MOVEMENT RATES (M/HR) COLLECTED SEASONALLY DURING PERIODS OF BREEDING/GESTATION (JAN-MAR), GESTATION/DENNING (APR-JUN) KITTEN-REARING (JUN-SEP), AND JUVENILE DISPERSAL (OCT-DEC) FOR ALL RADIO-COLLARED BOBCATS ON KIAWAH ISLAND, SOUTH CAROLINA

Movement rates (m/hr) collected during seasonal 24-hour monitoring periods for all radio-collared bobcats on Kiawah Island, South Carolina.

End	ID #	Time	Movement rate (m/hr)
WE	933	Breeding/gestation	472
		Gestation/denning	252
		Kitten rearing	497
		Juvenile dispersal	452
	894	Breeding/gestation	205
		Gestation/denning	40
		Kitten rearing	154
		Juvenile dispersal	209
	674	Breeding/gestation	173
		Gestation/denning	44
		Kitten rearing	285
		Juvenile dispersal	25
	733	Breeding/gestation	206
		Gestation/denning	83
		Kitten rearing	151
		Juvenile dispersal	126
	794	Breeding/gestation	51
		Gestation/denning	Dead
		Kitten rearing	Dead
		Juvenile dispersal	Dead
EE	653	Breeding/gestation	226
		Gestation/denning	204
		Kitten rearing	19

End	ID #	Time	Movement rate (m/hr)
		Juvenile dispersal	393
	633	Breeding/gestation	225
		Gestation/denning	82
		Kitten rearing	233
		Juvenile dispersal	108
	694	Breeding/gestation	84
		Gestation/denning	44
		Kitten rearing	146
		Juvenile dispersal	21
	913	Breeding/gestation	155
		Gestation/denning	4
		Kitten rearing	165
		Juvenile dispersal	10
	954	Breeding/gestation	147
		Gestation/denning	46
		Kitten rearing	40
		Juvenile dispersal	259
Both	873	Breeding/gestation	358
		Gestation/denning	402
		Kitten rearing	426
		Juvenile dispersal	223

APPENDIX 3.

DESCRIPTION OF 2000 AND 2001 BOBCAT DENNING ACTIVITIES AND LOCATIONS ON KIAWAH ISLAND, SOUTH CAROLINA

During April, June, and July of 2000, we were successful at locating 5 den sites containing a total of 12 kittens, 8 female and 4 male. We found dens for 5 of 6 radio-collared adult females. Two of these dens were found on the WE and 3 dens were on the EE of Kiawah Island. The first den was located east of Beachwalker Park about 0.5 km before Captain Sam s Inlet. This den contained 1 male and 2 female 2-3 week old kittens and was located under a wax myrtle tree in the dunes on an upraised sand hill next to the marsh. The second den was located in the woods under a fallen water oak tree in the southeastern corner of the front yard of the Vanderhorst Plantation house. This den contained 1 male and 1 female kitten approximately 1 week old. The third den was located on the Preserve in a thick stand of pine trees and contained 1 male and 1 female kitten approximately 1 week old. The den was under a medium-sized pine tree that was uprooted at a 30° angle to create a hollow cavity undemeath that was covered in pine straw to make it quite hard to see. Two 1-week old female kittens were found on Cougar Island in a hollow stump of a palm tree surrounded by thick greenbriar (*Smilax* spp.) and blackberry (*Rubus* spp). The last den was located in the vacant lot #22 Ocean Course Drive. One male and 2 female kittens were found under an upturned stump that created a hollow cavity underneath and surrounded by very thick vegetation. An unsuccessful den search was conducted on the only remaining adult female when she was exhibiting denning behavior near the River Course golf club.

In all cases females remained with their kittens until I was within a few meters from the den site before fleeing. On 1 of these occasions I saw the female leave the den, and on 2 occasions I did not see her leave but still found the den, because she let me approach so close before fleeing. On another occasion I crawled into a den located under a fallen tree watching the female the entire time. I was lying on the ground within 1 m of her as we stared at each other for at least 10 minutes before she finally lost her nerve and left the kittens. I had to stand over 1 female who was partially hidden with her kittens down in thick vegetation, and I was forced to lightly kick the vegetation to make her temporarily leave the kittens for my inspection.

In the spring and summer of 2001, we were successful at finding 3 dens. One male and 1 female kitten were found in the same area as 2000 east of Beachwalker Park by the same female. This den was located in a thick wax myrtle stand in the dunes. We found 1 male kitten with the only unsuccessful 2000 female in the same area that she was thought to be denning in 2000. Her den was near the River Course Golf Club under an upturned stump creating a hollow cavity underneath. One male kitten was found on Ocean Course Drive under an upturned stump surrounded by thick saw palmetto. One adult female died in early 2001, but dens have not been found for the remaining 2 females, but there were no attempts made to find them.

APPENDIX 4.

SUMMARY OF CASE HISTORY AND DIAGNOSIS OF 3 BOBCAT MORTALITIES ON KIAWAH ISLAND, SOUTH CAROLINA DURING 2000 AND 2001

Three radio-collared bobcats were found dead during the course of the study, the result of 2 collisions with automobiles and 1 death from disease. A WE juvenile male was first recovered on 5 March 2000, after detecting a mortality signal. Its last known location while alive was obtained on 2 March 2000. It was found submerged near the bank of a lagoon off Surfwatch Drive. An 8-foot alligator was seen approximately 5 m from the carcass. The carcass was immediately frozen and taken for necropsy to the Diagnostics Services Section of the Southeastern Cooperative Wildlife Disease Study (SCWDS) at the College of Veterinary Medicine, University of Georgia. The necropsy revealed that the skull had been crushed, and that fracture of the cervical vertebrae C1 and C2 completely separated the spinal cord. Hemorrhage was present over the skull fracture, spinal fracture, and subcutaneous tissue of the ventral abdomen. Lesions consistent with alligator bite wounds were not apparent. Final diagnosis was that the bobcat was hit by an automobile. The bobcat was considered in good body condition.

A juvenile female was found on June 14, 2000, submerged at the edge of Canvasback Pond at the corner of Surfsong Road and Glen Abbey Road. The carcass was removed from the water, but was discarded because poor condition would not allow a necropsy. It had apparently been fed upon by alligators, blue crabs, and fish. Alligator tooth marks were evident in the radio-collar. Its last known location while alive was 11 June 2000 and taken a short distance from where the body was recovered. We feel that death could have been caused by feline panleukopenia.

An adult female bobcat was discovered dead on 7 March 2000 near Flyway Drive and Royal Beach Drive after a mortality signal was heard. She was last detected alive approximately 1 week prior to that date. The carcass was immediately removed and frozen for future necropsy. The necrospy performed by SCWDS revealed extensive trauma including multiple fractured ribs, hemorrhage throughout body, fractured teeth, and multiple lacerations to the spleen. Final diagnosis was that the bobcat was hit by an automobile.