COYOTE AND BOBCAT FOOD HABITS AND THE EFFECTS OF AN INTENSIVE PREDATOR REMOVAL ON WHITE-TAILED DEER RECRUITMENT IN NORTHEASTERN ALABAMA

by

CORY L. VANGILDER

(Under the Direction of Karl V. Miller)

ABSTRACT

This project was designed to investigate the seasonal diets of potential white-tailed deer (*Odocoileus virginianus*) predators and quantify their impact on deer recruitment in northeastern Alabama. I inferred predation impacts by comparing recruitment data before and after an intensive predator removal on a 2,000-acre study site. After predator abundance (as shown by scat deposition rates and a scent station index) on the site was reduced by intensive removal, fawn-to-doe ratios (as indicated by camera surveys, hunter observations, and web camera observations) increased on average 189%. Seasonal diets of coyotes (*Canis latrans*) and bobcats (*Lynx rufus*) indicated that coyotes consumed deer significantly more than bobcats, particularly during the fawning season. Overall, bobcats primarily consumed rodents, whereas the coyote diet was more diverse and varied temporally as seasonally abundant food items, including fawns, insects, and soft mast became available. Our results suggest predation, particularly by coyotes, on fawns may reduce recruitment in some areas of the Southeast. Intensive predator removals prior to fawning may be effective at increasing recruitment in some areas where herd productivity does not meet management objectives.

INDEX WORDS: Bobcat food habits, coyote food habits, *Canis latrans*, *Lynx rufus*, *Odocoileus virginianus*, predation, predator removal, white-tailed deer

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CHAPTER 1

INTRODUCTION, JUSTIFICATION, THESIS FROMAT, LITERATURE REVIEW, AND STUDY AREA

INTRODUCTION

Recent evidence has suggested declining trends in white-tailed deer (*Odocoileus virginianus*) recruitment in certain areas of the Southeast concurrent with increasing coyote (*Canis latrans*) populations. Although the importance of coyote predation on white-tailed deer recruitment has been demonstrated in Texas (Knowlton 1964, Cook et al. 1971, Beasom 1974) and Oklahoma (Stout 1982), few studies have investigated direct predation impacts on recruitment in the Southeast.

In the Southeast, coyotes and bobcats (*Felix rufus*) represent the most common predators of white-tailed deer fawns, although black bear (*Ursus americanus*) are important predators in some regions. Coyotes have recently expanded into the southeastern U. S., due in part to range expansion, but aided largely by humans through escape of captive coyotes and the release of coyotes for sport hunting (Hill et al. 1987). Increasing coyote populations have led to growing speculation among hunters and wildlife managers in this region regarding the potential impacts this predator is having on other wildlife, especially white-tailed deer (Kilgo et al. 2007).

JUSTIFICATION

White-tailed deer are highly valued, both emotionally and economically, as a natural resource. In 2006, 12.5 million hunters (including 10,100,000 deer hunters) in the United States collectively spent $22.9 billion on hunting related expenditures (USFWS 2006). Thus, deer hunting is economically important in many regions of the U.S. and their management is important. Bobcats and coyotes are known predators of deer and have been implicated as the cause of high fawn mortality in certain areas of their range (Cook et al. 1971, Garner et al. 1976, Roberts 2007). However, predation on white-tailed

deer by coyotes and bobcats is highly variable across studies and regions, ranging from being a major regulating factor of some herds (Cook et al. 1971, Beasom 1974, Stout 1982, Roberts 2007) to no apparent detrimental effects (Ozoga and Harger 1966, Fritts and Sealander 1978). Furthermore, few studies outside of Texas have investigated direct predation impacts on white-tailed deer recruitment. I designed a study to examine the diets of coyotes and bobcats and determine their impact on white-tailed deer recruitment on a property in northeastern Alabama that is primarily managed for white-tailed deer.

The primary objectives of this study were to investigate the impacts of predators on white-tailed deer recruitment. My specific objectives were to:

1) describe seasonal variations in the diets of coyotes and bobcats in northeastern Alabama, and

2) evaluate the impact of an intensive predator removal (specifically coyotes and bobcats) on white-tailed deer recruitment.

Because coyotes are recent additions to the fauna of the Southeast, this study will assist in understanding the role of this predator in white-tailed deer population dynamics, and thereby provide valuable information to deer managers in this region for making future management decisions regarding white-tailed deer harvest, habitat, and predation.

THESIS FORMAT

This thesis is written in the manuscript format. Chapter 1 is an introductory chapter that summarizes past research on coyote food habits, bobcat food habits, impacts that predators have on white-tailed deer populations in certain regions, and provides a detailed study site description. Chapters 2 and 3 are prepared for submission to scientific journals and follow the style required by the appropriate journal. Chapter 2 investigates

the effects of an intensive predator removal prior to the fawning season, to determine the impacts predators have on white-tailed deer recruitment. Chapter 3 examines the diets of coyotes and bobcats based on the analyses of scats and stomach contents. Chapter 4 provides general conclusions of my research findings and their management implications. Additional data inappropriate for journal manuscripts are included in the Appendices.

LITERATURE REVIEW

Food Habits of the Coyote—Coyotes are generalist predators, and their diet exhibits significant variation both regionally and seasonally (Litvaitis and Shaw 1980, McCracken 1982, Bowyer et al. 1983, Andelt et al. 1987). They are omnivorous and forage opportunistically, consuming seasonally important food items that include small mammals, fruit or mast, and have been known to have significant impacts on fawn survival in certain regions of the country. Lagomorphs and rodents have been reported as staple food items across the coyotes range. Leporids were the most common food item eaten in Missouri (55% occurrence; Korschgen 1957), California (66.5% occurrence; Cypher et al. 1994), and Texas (79.6% occurrence; Clark 1972). Generally, highest utilization of lagomorphs and small mammals occurs in winter and they become less important during the spring when fruits and fawns become available. Some researchers have noted a bimodal pattern of fruit use in the coyote diet, peaking in spring and fall in synchrony with the respective fruiting seasons of individual plant species (Meinzer et al. 1975, Andelt et al. 1987). In particular, high utilization of persimmon (*Diospyros* spp.) during the fall has been reported across studies and regions including Arkansas (Gipson 1974), Texas (Andelt et al. 1987), and Oklahoma (Litvaitis and Shaw 1980). Numerous food habit studies have noted the occurrence of deer in the coyote's diet (Knowlton 1964,

Harrison and Harrison 1984, Andelt 1985, Patterson et al. 1998, Schrecengost et al. 2008). However, other coyote food habits studies including (Korschgen 1957) and (Ozoga and Harger 1966) indicated that deer did not make up a significant amount of the coyotes' diet except during or immediately following hunting season, likely representing carrion.

In the southeastern United States, coyote food habit studies have reported high occurrences of deer coinciding with the peak fawning period. For example, Blanton and Hill (1989) with study areas distributed in Mississippi, Alabama, Kentucky, and Tennessee, indicated that during fawning deer were the most frequent (74 %) major food item in areas with high deer density. Similarly, on study areas in Mississippi and Alabama, deer occurred most frequently in summer and fall with the highest use (71.4 %) in August coincident with peak fawning (Wooding 1984). These studies suggest that predation could potentially impact white-tailed deer recruitment. However they are unable to quantify the impact predators were having on the population dynamics of deer on their study areas

Food Habits of the Bobcat—Bobcats (*Felix rufus*) are opportunistic predators known to forage on insects, reptiles, amphibians, birds, and small mammals, although the majority of their diet is composed of mammals. Several food habit studies have indicated that throughout much of their range, rodents and lagomorphs represent their principal food items, including studies conducted in Arizona (Jones and Smith 1979), Arkansas (Fritts and Sealander 1978), West Virginia (Fox and Fox 1982), Oklahoma (Rolley and Warde 1985), Maine (Litvaitis et al. 1984, Litvaitis and Harrison 1989), Florida (Maehr and Brady 1986), and Alabama (Miller and Speake 1978). However, research has

provided evidence for predation on both adult and fawn white-tailed deer by bobcats through direct observations (Petraborg and Gunvalson 1962, Garner et al. 1976, Labisky and Boulay 1998). Others have recorded the presence of deer in the diet of bobcats using analysis of scat and stomach contents. These reports represent evidence of either direct predation or carrion, especially in the northeastern U.S. (Pollack 1951, Westfall 1956), coastal barrier islands along the Atlantic Coast (Baker et al. 2001, Roberts 2007), and elsewhere (Progulske 1955, Blankenship 2000). On the Welder Wildlife Refuge in southern Texas, from 1993-1998 deer were present in 32% and 24% of bobcat scats in June and July coincident with peak fawning on the Refuge (Blankenship 2000). However, some food habit studies, particularly from the northeastern U. S. (Pollack 1951, Litvaitis et al. 1984) have suggested that the presence of deer in the diet from this area may be related to carrion associated with winter mortality.

Studies that have examined bobcat food habits in areas where coyotes are not present have reported higher occurrences of white-tailed deer, particularly during fawning season. For example, in a study conducted on 2 coastal barrier islands north of Charleston, South Carolina, bobcats preyed extensively on fawns (Epstein et al. 1983). Similarly, Baker et al. (2001) reported high year-round use of white-tailed deer on Cumberland Island, Georgia. This may be a result of reduced competition for resources among bobcats and coyotes and could have altered the feeding habits of bobcats on the islands. Research has noted the influence of sex and age regarding differences in prey selection among bobcats (Fritts and Sealander 1978, Litvaitis et al. 1984, McLean et al. 2005). In Arkansas, Fritts and Sealander (1978) reported that females consumed more small rodents than did males. Additionally, research conducted in New Hampshire

(Litvaitis et al. 1984) and Nova Scotia (Matlock and Evans 1992) reported that male bobcats consumed more white-tailed deer than did females. Differences in food habits between male and female bobcats may decrease the intraspecific competition within bobcat populations. However, in areas where coyotes and bobcats are sympatric, the presence of deer in the bobcat diet in most cases is associated with carrion from winter and hunter-related mortality. Research conducted in areas recently colonized by coyotes in the eastern U.S. has indicated that bobcats contract their food habits once coyotes became established (Litvaitis and Harrison 1989). For example in Florida, ungulates, including deer, were the most commonly eaten foods by coyotes, while bobcats primarily consumed rodents (Thornton et al. 2004). In Maine, Litvaitis and Harrison (1989) speculated that a decline in the bobcat population was due to competition with coyotes for white-tailed deer during winter because of limited availability of other prey during this time. However, because significant evidence documents that bobcats may prey on white-tailed deer, they should be taken into consideration when excessive predation on fawns is suspected in an area.

Impacts of predators on white-tailed deer recruitment—Predation on fawns by coyotes and bobcats varies among areas and among years across their range. Most studies that have monitored fawn mortality (Cook et al. 1971, Huegel et al. 1985, Nelson and Woolf 1987, Brinkman et al. 2004) have been limited to regions outside the southeastern U. S. In the intensively farmed areas of the Midwestern U.S., studies have reported lower fawn mortality than in other regions, including 16% mortality in Minnesota (Brinkman et al. 2004), 21% in Iowa (Huegel et al. 1985), and 30% in Illinois (Nelson and Woolf 1987). In contrast, reports of fawn mortality from Texas (Cook et al.

1971) and Oklahoma (Garner et al. 1976, Bartush and Lewis 1981) have commonly exceeded 70%, primarily due to coyote predation. Nelson and Woolf (1987) found that predation on fawns was related to age, with most mortality on their study site in southern Illinois occurring as fawns became more active, particularly in the absence of the doe. Additionally, it has been suggested that fawns with adequate cover are largely free from predation until flushing age at approximately 10-15 days old (Carroll and Brown 1977). Most studies that have examined bobcat predation on white-tailed deer have shown the impact to be negligible, with minor occurrences of deer in their diet (Beasom and Moore 1977, Maehr and Brady 1986). In south Texas, Cook et al. (1971) reported bobcats accounted for only 3% of mortalities for 58 radiocollared fawns, but coyote predation accounted for 79%. However, some studies have reported significant impacts from bobcats on fawn survival (Epstein et al. 1983, Roberts 2007). On Kiawah Island, South Carolina, a developed barrier island, bobcats were responsible for 57-82% of fawn mortalities from 2002-2005 (Roberts 2007), with 97% of bobcat predation occurring within 5 weeks of parturition. This is the highest rate reported for bobcat predation on fawns in the U.S. Additionally, on 2 coastal barrier islands north of Charleston, South Carolina, Epstein (1983) reported bobcats were responsible for 29% of all mortalities not associated with capture.

Studies of the impacts of bobcat and coyote control (Beasom 1974, Stout 1982) have reported increased fawn survival. In Oklahoma, Stout (1982) found a 154% increase in fawn-to-doe ratios following 2 years of coyote removal. Similarly, in South Texas, fawn loss to predation was 74% and 61% higher in consecutive years on the control area (without removal) versus the experimental area with intensive predator

removal (Beasom 1974). In a Texas white-tailed deer population, Kie et al. (1979) erected a 391 hectare exclosure and reduced the coyote population inside. Deer densities inside the exclosure tripled compared to deer density outside, however after 2-3 years the forage was depleted and the deer densities declined within the exclosure comparable to densities found outside.

Predator control has been used to limit depredations on domestic livestock since the pioneer days. Additionally, it is also been used by wildlife managers to increase game populations. However, predator control does not always result in increased game populations. In their review of the literature, Ballard et al. (2001) found several similarities among studies in which predator removal effectively increased deer productivity: 1) removal was implemented when the deer population was below habitat carrying capacity, 2) predation was identified as a limiting a factor in the deer population, 3) removal significantly reduced the predator population (>70%), 4) removal efforts were timed to be most effective (predator vulnerability at peak), and 5) removal was done on small (<259 sq/mi^2) scale areas.

Results from past studies suggest that coyote predation on a white-tailed deer population may depend on the physiographic region and be influenced by several factors. For example, in the Wichita Mountains of Oklahoma, fawn mortality of 90% has been reported, primarily due to coyote predation (Bartush & Lewis 1981). Furthermore, only 27% of 852 fawn bed sites were in savanna and edge habitat, but 58% of the deaths due to predation occurred in that habitat (Bartush & Lewis 1981), suggesting that habitat type influenced predation rates. On the Oklahoma study site, coyotes did not form large packs, but evidently developed efficient hunting techniques for locating and capturing

young fawns by utilizing regular inspection of single does, followed by a thorough search for fawns in their immediate vicinity (Garner & Morrison 1980). This indicates possible specialization by coyotes by shifting their predation due to availability of prey found in an area.

The effect that predators have on game populations, as shown in various studies, has been highly variable. This may be a function of prey selection by predators, which can be highly variable from year to year, based on different climate conditions, prey abundance, predator abundance, and the variety of prey that are present in a region. Therefore, site specific data is needed to determine the role of predation. The relatively recent range expansion and subsequent increasing coyote populations in the southeastern U.S. have resulted in an increased need for research examining their impacts on white-tailed deer in this region.

STUDY AREA

The study was conducted in Cherokee County, Alabama, in the Ridge and Valley region of northeast Alabama (34°18′N, 85°39′30′′W). The area consists of approximately 2,000 privately owned acres (SNI Farms), bordered to the west and south by Little River and to the north by Little River Wildlife Management Area. The area is topographically diverse, ranging from mountain top, steep slopes with bluffs, flat rolling terrain, to bottomland swamp. Elevation ranges from 600 feet in the bottomland to 1226 feet at the highest point. Average precipitation is 55 inches per year, although drought conditions persisted from 2006-2008.

Dominant land cover consisted of mixed pine/hardwoods (52%), planted pines consisting of loblolly (*Pinus taeda*) and longleaf (*P. palustris*) at various ages (32%),

bottomland hardwoods, open grassland (primarily fescue, *Festuca arundinaceae*), and approximately 5% in high quality food plots to provide optimum nutrition for deer year-round (Figure 1.1). Foodplots consisted of corn (*Zea mays*), soybeans (*Glycine max*), clover (*Trifolium repens*), wheat (*Triticum aestivum*) and grain sorghum (*Sorghum vulgare*). Dominant species in the mixed pine/hardwoods were Virginia pine (*P. virginiana*), chestnut oak (*Quercus prinus*), sweetgum (*Liguidambar styraciflua*) and blueberry (*Vaccinium* spp.). Blackberries (*Rubus* spp.) were also common in the understory. In the bottomland, frequently occurring species included water oak (*Q. nigra*), Chinese privet (*Ligustrum sinense*), persimmon (*Diospyros virginiana*), and fescue.

The area is primarily managed for deer and has been operating under Quality Deer Management (Hamilton et al. 1988, Miller and Marchinton 1995) guidelines for the last 10 years. Spring herd health checks from 2000-2003 indicate that the property has a productive deer herd with fetal rates averaging approximately 2 fawns per doe (Figure 1.2). However, two successive years of substantial doe harvests in 2003 and 2004 (Figure 1.3) to reduce herd density resulted in a precipitous decline in fawn recruitment based on hunter observation data (Figure 1.4). This led to a growing concern about the role of predation and its impact on fawns after parturition, since predation is likely the only factor that is highly selective towards fawns in an otherwise healthy deer population.

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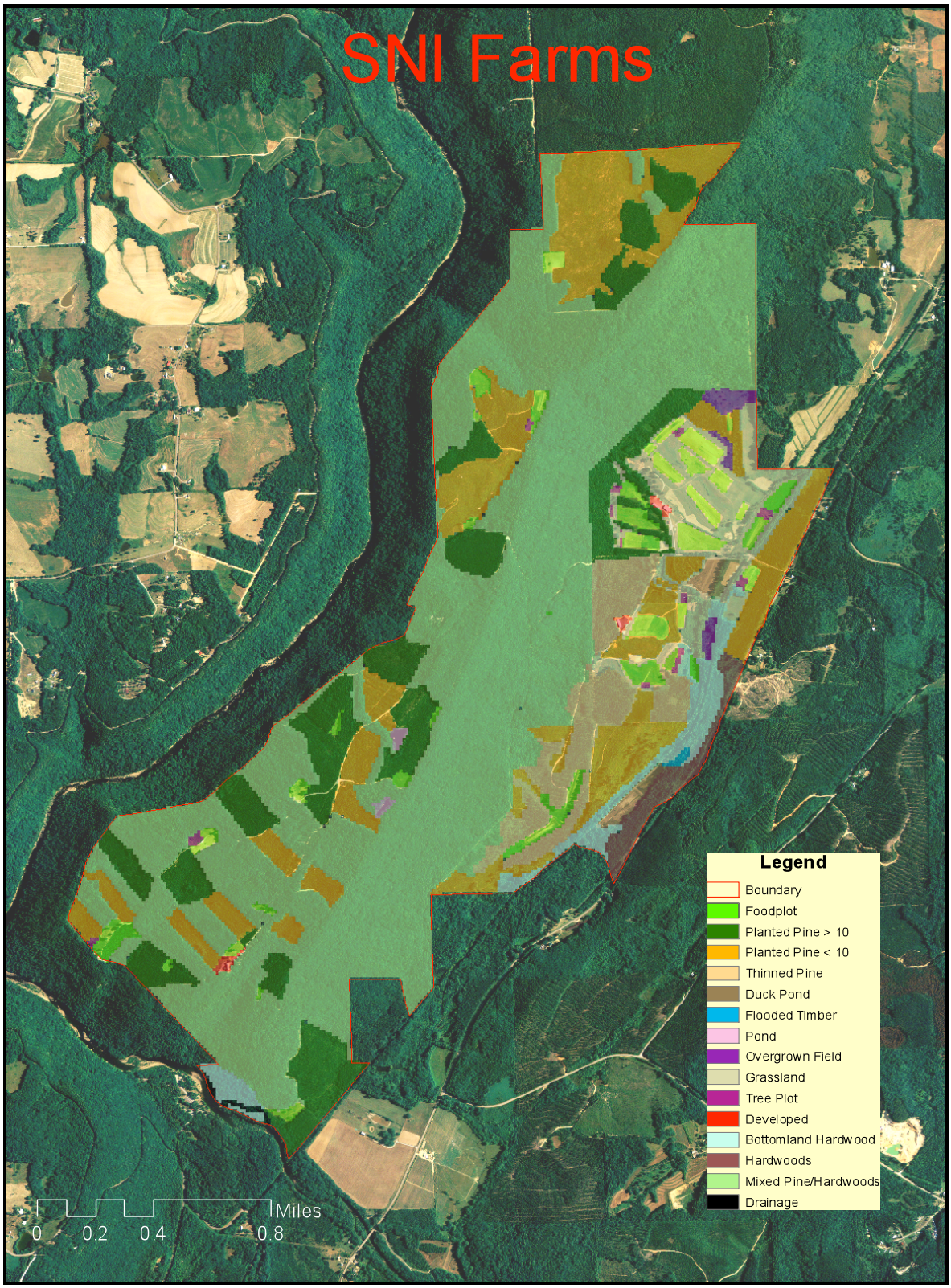

Figure 1.1 Dominant land cover types on SNI Farms, Cherokee County, Alabama, 2007.

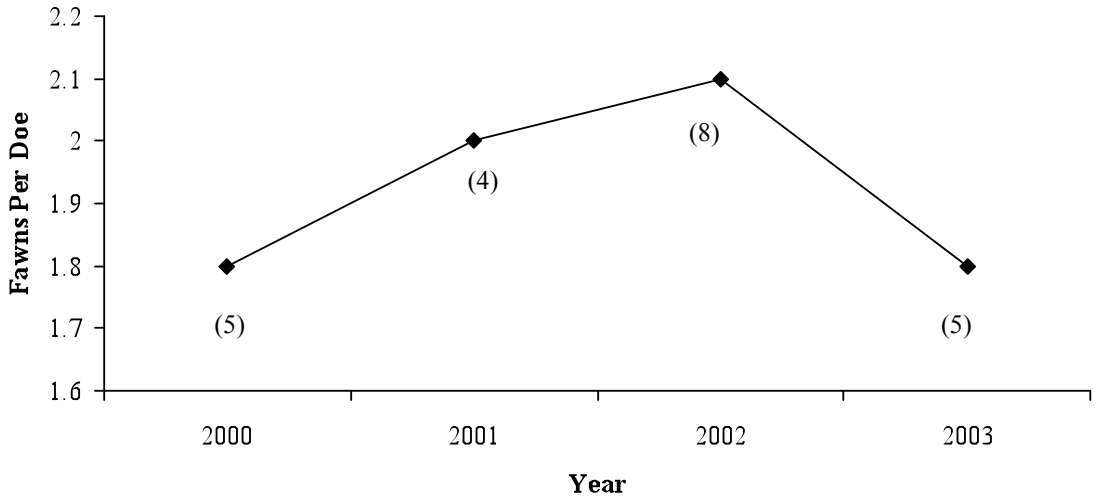

Figure 1.2. Fetal rates (# of fetuses/adult doe) at SNI Farms, Cherokee County, Alabama, obtained from spring herd health checks conducted from 2000-2003. Numbers in parentheses are sample sizes.

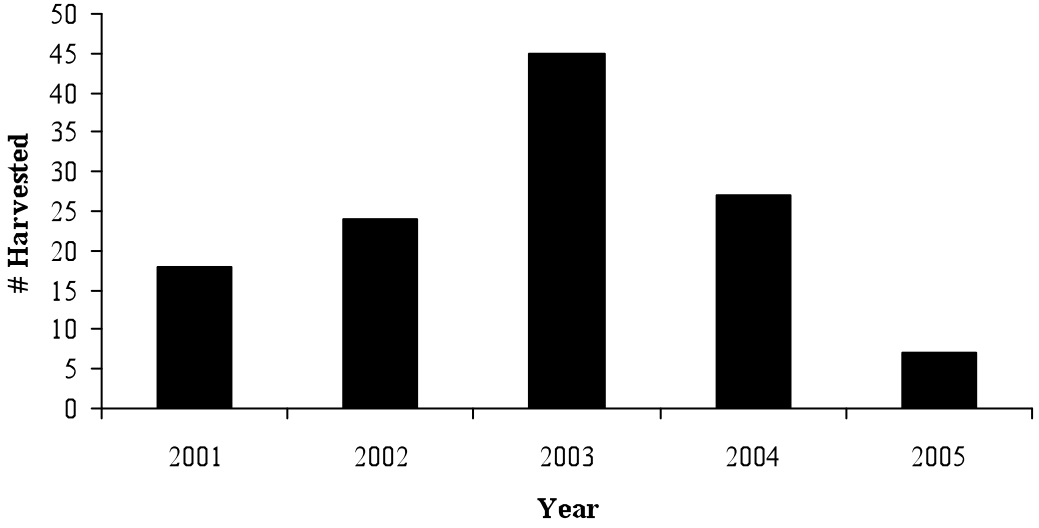

Figure 1.3. Number of adult does harvested on SNI Farms, Cherokee County, Alabama, during the 2001-2005 hunting seasons.

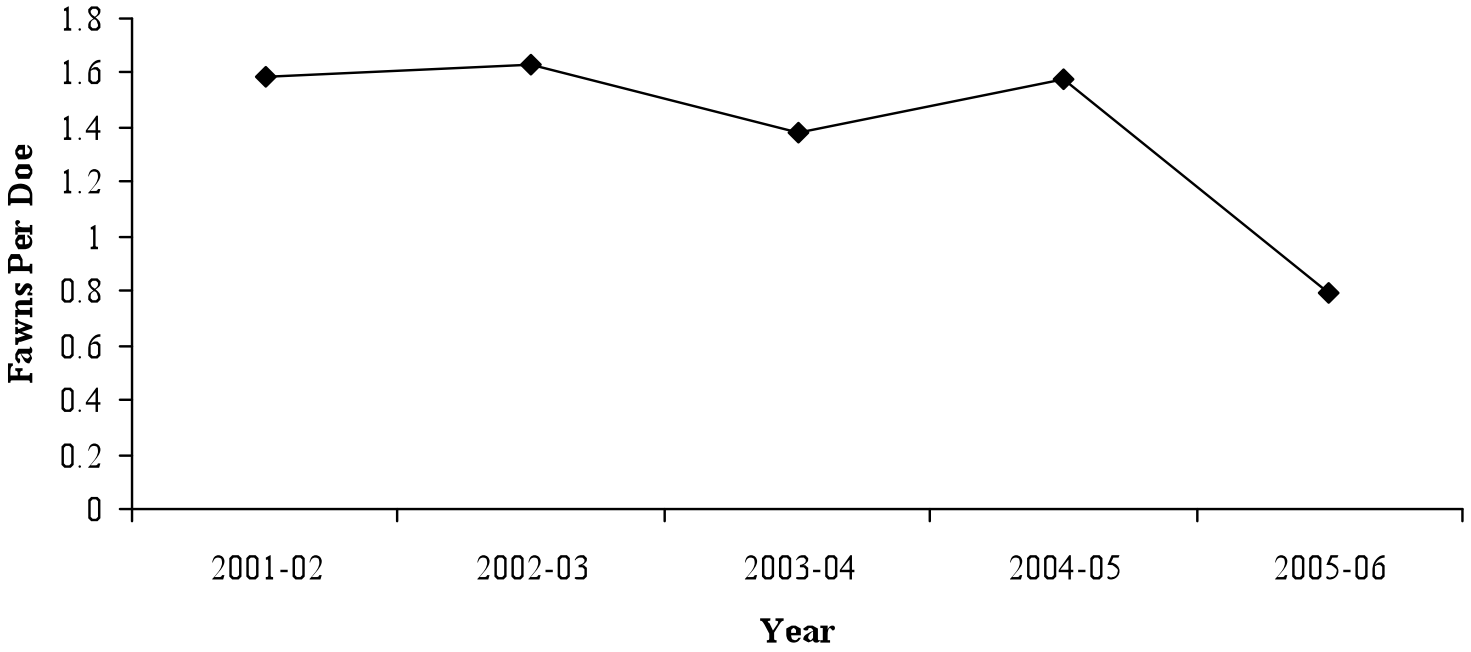

Figure 1.4. Fawn-to-doe ratios based on hunter observations from SNI Farms, Cherokee County, Alabama, during the 2001 through 2005 hunting seasons.

CHAPTER 2

EFFECTS OF AN INTENSIVE PREDATOR REMOVAL ON WHITE-TAILED DEER RECRUITMENT IN NORTHEASTERN ALABAMA[1]

[1]VanGilder, C. L., G. R. Woods, and K. V. Miller. To be submitted to the Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies.

ABSTRACT

Few studies have investigated the impacts of predators on white-tailed deer (*Odocoileus virginianus*) recruitment in the Southeast. We inferred predation impacts by comparing recruitment data before and after an intensive predator removal on an 800-hectare study site in northeast Alabama. We estimated fawn recruitment pre-removal using camera surveys in September 2006 and February 2007, hunter observations, and web based cameras (n=11) mounted over foodplots (October through January). We removed 22 coyotes (*Canis latrans*) and 10 bobcats (*Lynx rufus*) during February through July 2007. Predator populations, as indexed using scat deposition rates and scent station surveys, declined to near zero just prior to fawning season. September fawn-to-doe ratios increased from 0.18 to 0.24 and February ratios increased from 0.41 to 1.20 in the year following predator removal. Hunter observation data indicated a pre-removal fawn-to-doe ratio of 0.52, compared to a ratio of 1.10 after the removal. Similarly, web camera surveys indicated an increase in recruitment from 0.52 fawns per doe to 1.33 following the removal. Our results suggest that predation on fawns may reduce recruitment in some areas of the Southeast. Intensive predator removals prior to fawning season may be effective at increasing recruitment in some areas where herd productivity does not meet management objectives.

INTRODUCTION

Few studies have investigated predation impacts on white-tailed deer recruitment, and most have been limited to areas outside the Southeast (Cook et al. 1971, Beasom 1974, Kie et al. 1979, Stout 1982). Predation on white-tailed deer fawns has been identified as a significant source of mortality in certain regions, including South Texas (Beasom 1974) and Oklahoma (Stout 1982). However, the reported effect that predators have on deer recruitment and other game populations is highly variable and may be related to climate conditions (Andelt et al. 1987), prey abundance, predator abundance, and the presence of alternative prey in a region.

Coyote and bobcat predation on fawns is apparently site-specific, varying across studies and regions. Research conducted in the Midwest has reported low fawn mortality from predation (Ozoga and Harger 1966, Pusateri-Burroughs et al. 2006) compared to substantial predation on fawns (>70%) in Texas (Cook et al. 1971) and Oklahoma (Garner et al. 1976). Coyotes were the main cause of low fawn survival in these areas. In areas where coyotes and bobcats are recently sympatric, such as the eastern U.S., white-tailed deer are more commonly found in the coyote diet than in the bobcat's (Litvaitis and Harrison 1989, Thornton et al. 2004).

In the Southeast, coyotes and bobcats are the primary predators of white-tailed deer neonates. The coyote, once associated with the open plains of North America, is a relatively recent invader of the Southeast (Gipson 1978). This invasion is due in part to range expansion, but has been aided largely by humans through escape of captive coyotes and release of coyotes for sport hunting (Hill et al. 1987). Little information is available about the ecological role of coyotes in the Southeast, which has generated speculation on

the impacts this predator is having on certain game species, especially white-tailed deer. Additionally, recent observations of declining recruitment rates among some populations of white-tailed deer coincide with increasing coyote populations in the southeastern U.S.

Our study area in northeastern Alabama has operated under Quality Deer Management guidelines (Hamilton et al. 1988, Miller and Marchinton 1995) for the last 10 years, limiting the harvest to bucks ≥3 ½ years-old to increase buck age structure. Doe harvests ranged from 15 to 37 does/km^2 during the period of 2001-2004 and were designed to reduce herd density to improve overall herd health and productivity (Smith, personal communication). Spring herd health checks from 2000-2003 (n=4 to 8 does/year) indicate that the property has a productive deer herd with fetal rates averaging 1.93 fawns per doe. Hunter observation data from the 2001 through 2004 hunting season indicated a mean fawn-to-doe ratio of 1.18. However, following a heavy doe harvest (37 deer/km^2) in 2003, observed fawn-to-doe ratios dropped to 0.87. Although the lowered recruitment rate may have been due, in part, to a reduction in the female age structure, anecdotal observations suggested that predators were also impacting deer recruitment. Therefore, we initiated a before-and-after experimental design and collected white-tailed deer recruitment data and predator abundance indices before and after an intensive removal of predators. Our specific objectives were to assess the impact of predation on white-tailed deer recruitment on our study site in northeastern Alabama and to evaluate the effect of an intensive predator removal prior to fawning on recruitment rates.

STUDY AREA

The study was conducted in Cherokee County, Alabama, in the Ridge and Valley region of northeastern Alabama (34°18′N, 85°39′30′′W). The area consists of

approximately 800 privately owned hectares (SNI Farms), bordered to the west and south by Little River and to the north by Little River Wildlife Management Area. Elevation ranges from 183 meters in the bottomland to 374 meters at the highest point. Average precipitation is 140 centimeters per year, although drought conditions persisted from 2006 through 2008.

The area is topographically diverse, ranging from mountain top, steep slopes with bluffs, flat rolling terrain, to bottomland swamp. Dominant cover types consisted of mixed pine/hardwoods (52%), planted pines consisting of loblolly (*Pinus taeda*) and longleaf (*P. palustris*) at various ages (32%), bottomland hardwoods, open grassland (primarily fescue, *Festuca arundinaceae*), and approximately 5% in high quality food plots to provide optimum nutrition for deer year-round. Foodplots consisted of corn (*Zea mays*), soybeans (*Glycine max*), clover (*Trifolium repens*), wheat (*Triticum aestivum*) and grain sorghum (*Sorghum vulgare*). Dominant species in the mixed pine/hardwoods were Virginia pine (*P. virginiana*), chestnut oak (*Quercus prinus*), sweetgum (*Liquidambar styraciflua*) and blueberry (*Vaccinium* spp.). Blackberries (*Rubus* spp.) were also common in the under-story. In the bottomland, frequently occurring species included water oak (*Q. nigra*), Chinese privet (*Ligustrum sinense*), persimmon (*Diospyros virginiana*), and fescue.

Habitat management techniques including prescribed burning, thinning, clear-cutting, and herbicide treatments have been implemented to enhance natural vegetation, and 100 acres of high quality foodplots were established to increase forage availability. No antlerless deer were harvested from the area during the study.

METHODS

Relative Predator Abundance—We monitored predator relative abundance bi-monthly throughout the study using scent stations and scat deposition rates. We established two 4.3-kilometer scent station transects on unpaved roads. The minimum distance between transect lines was 0.8 kilometers, but lines were separated by approximately 600 ft in elevation. Each transect consisted of 10 scent stations at intervals of 0.5 kilometer, on alternating sides of the road to account for wind direction. Scent stations consisted of a 1.0-m diameter circle of powdered hydrated limestone with a fatty-acid scent tablet (U.S. Dept. Agric., Pocatello Supply Depot, Pocatello, ID.) placed at the center (Linhart and Knowlton 1975). Transects were operated for 2 consecutive nights and presence or absence of tracks was recorded each morning after activation. The scent station index was calculated using the relative mean predator abundance (RMA; the # of animal visits / the # of operable scent stations X 1 / nights operated). The RMA was calculated for both coyotes and bobcats. Otherwise, our methods were consistent with Linhart and Knowlton (1975) as refined by Roughton and Sweeny (1982).

In addition, we used a series of 4 1.6-kilometer permanently identified transects, located on roadways and distributed throughout the study area, to obtain a scat deposition index. Each transect was walked bi-monthly, in both directions, and cleared of all scats detected. Transects were revisited 2 and 4 weeks after clearing, to count and remove any new scat. We then calculated a scat deposition rate index of abundance every other month (number of scats deposited per kilometer per day).

White-tailed Deer Fawn-to-Doe Ratios—We estimated fawn-to-doe ratios before and after predator removal using hunter observation data, camera surveys, and web-based

camera observations. We selected experienced hunters who recorded all occurrences of deer observed during the hunting season (November to January). All deer observed were placed into categories including bucks, does, fawns and unknowns to obtain estimates of fawn recruitment. Because fawns are easiest to distinguish from yearling and adult does early in the hunting season, we only used data collected in November to estimate fawn-to-doe ratios. Although our fawn-to-doe ratios could not be based on independent observations (i.e., repeated observations of individual deer), they provide a valid index to these ratios for comparison among years.

The study area contains a series of webcams (n=11) which are mounted on poles over established foodplots. These cameras are accessible via an Internet connection. We accessed these cameras at random, primarily when deer activity in the foodplots would be greatest (early morning and late evening) during October, November, and January. Cameras were viewed every day during this period, except in instances of extreme weather (lighting etc.), which could potentially damage the cameras. Deer were observed in foodplots within 1 hour after sunrise and 1 hour before sunset. All deer were recorded and placed into categories (bucks, does, fawns) in the same manner as hunter observations. Most deer observed in the foodplots could be positively identified by the web cameras, which could pan nearly 360 degrees and zoom in 25X magnification. Individuals that couldn't be identified were categorized as unknowns.

Camera surveys (Jacobson et al. 1997) were conducted in September and February before and after the predator removals. We used 12 Stealth Cam (Stealth Cam LLC, Grand Prairie, TX) digital trail cameras at a density of approximately 1 camera per 160 acres. Cameras were set on a 4-minute delay between photographs. The camera was

placed 4 feet high on a tree facing north or south to avoid glare from sunlight and positioned over a bait pile of corn. Camera stations were pre-baited for approximately 5-10 days before surveys were started. Surveys were conducted for 14 days, and bait piles refreshed as needed. Pictures were analyzed similar to Demarais et al. (2000), and consisted of using antler and body characteristics to individually identify bucks to extrapolate the number of does and fawns.

We removed predators using Predator Control Group LLC during February through July 2007 prior to the 2007 fawning season. Foot-hold traps, primarily KB compound 5.5, four-coil spring traps (KB Mfg., Fort Plain, NY) were utilized to capture coyotes and bobcats. All traps had offset laminated jaws to minimize injury. A chain with swivels was attached to each trap and staked to the ground. Trapping was done in areas frequented by coyotes and bobcats. Most trap sets were made along dirt roads, road intersections, trails, or fire breaks utilizing either a scent post or dirt hole set. All animal handling procedures were approved by The University of Georgia Institutional Animal Care and Use Committee (Permit No. 2005-10203-0). After capture, predators were euthanized by a single .22 caliber round to the head.

RESULTS

We removed 22 coyotes and 10 bobcats from the study area prior to peak fawning in 2007. Average weight for coyotes was 14.3 kg for males (n=12) and 12.2 kg for females (n=10). Average weights from bobcats was 7.9 kg for males (n=6) and 5.0 kg for females (n=4).

Indices of predator abundance reflected the predator removal and confirmed the efficacy of the removal prior to fawning. Relative Mean Abundance declined from 0.075

during November 2006 through February 2007 to near zero prior to peak fawning (Fig. 2.1a). Scat deposition rates declined from a high of 1.6 scats per mile per day in January 2007 to near zero prior to and during peak fawning season (Fig. 2.1b).

Pre-removal camera surveys indicated fawn-to-doe ratios of 0.18 in September 2006 and 0.41 in February 2007. Pre-removal hunter and web camera observations revealed similar fawn-to-doe ratios of 0.35 and 0.52 respectively. Following the intensive removal of predators, the September camera fawn-to-doe ratios increased to 0.24 (33.3% increase) and ratios in February 2008 increased 1.20 (193 % increase) (Table 2.1). Hunter observation data collected in November 2007 following the predator removal indicated that the fawn-to-doe ratio increased 217 %, rising to 1.11 fawns per doe in the 2007-2008 hunting season (Fig. 2.2). Observations of the fawn-to-doe ratios obtained from the web camera surveys increased an average of 156 % between pre- and post-predator removal (Table 2.1).

DISCUSSION

Intensive predator removal on our study area prior to fawning resulted in increased fawn survival, this is consistent with results from studies in other regions (Beasom 1974, Stout 1982). Following removal, fawn-to-doe ratios from camera surveys, experienced hunter observations, and web camera observations combined increased 189%, which is more than double the 74% increase reported in South Texas (Beasom 1974) but similar to the 154% increase in an Oklahoma study (Stout 1982).

Coyotes have been implicated as important predators of fawns in several areas in the Southeast (Wooding 1984, Blanton and Hill 1989, Schrecengost et al. 2008). The high fawn survival we observed following intensive predator removal suggests that

predation may be an important factor impacting fawn recruitment on our study area, and perhaps other areas in the Southeast.

Our September camera surveys resulted in low fawn-to-doe ratios. However, because peak fawning on our study area occurs during mid-August, we suspect that this can be attributed to the limited mobility of fawns at this time of the year. Fawn recruitment data from early fall camera surveys in areas where the fawning season occurs in late summer should be viewed with caution. Our February camera surveys provided results consistent with those obtained from hunter observations and web camera surveys.

Predator abundance indices indicated that our trapping efforts significantly reduced coyote and bobcat presence on the study area prior to fawning. Scent station indices declined to zero prior to fawning, but increased quickly after trapping ceased. Other studies that have conducted intensive predator removals indicate that coyotes can achieve pre-removal levels approximately 6 months after trapping (Beasom 1974). However, the increase in scent station visitation that we observed after trapping was terminated is more likely attributable to transient animals that are more likely to visit the scent stations (Harris 1983). This is supported by the scat deposition rate index, which remained near zero through the fawning season.

In the Southeast, coyotes have smaller home range sizes (Hall 1979, Sumner et al. 1984, Holzman et al. 1992) compared to western regions (Berg and Chesness 1978, Andelt and Gibson 1979, Litvaitis and Shaw 1980), likely due to more abundant prey resources. The presence of abundant alternative prey may increase predation rates on fawns by supporting greater coyote densities. Patterson et al. (1998) found that coyote populations supported at high densities by alternate prey will continue to feed

preferentially on deer, regardless of deer density. Conversely, the presence of alternate prey species may act as a buffer on deer predation (Harrison and Harrison 1984, Andelt et al. 1987). However, Andelt and Andelt (1984) reported that fruits were nutritionally inferior to mammalian prey because they tend to be less digestible. This is especially important considering that fawning coincides with coyote pup-rearing, which requires energetically more profitable food items.

MANAGEMENT IMPLICATIONS

In the southeastern U.S., coyotes have been implicated in food habits studies (Wooding 1984, Blanton and Hill 1989) as a potentially important source of fawn mortality. Coyote predation on fawns may be of minor significance when deer densities are high. However, when deer density is reduced, predators could reduce recruitment rates due to the lag in the numerical response of coyotes leading to a high ratio of coyotes to deer. The improvements in fawn-to-doe ratios (mean = 189% increase) in this study after predator removal indicate that deer managers in the Southeast should be aware of the potential limiting effects of predation on deer recruitment when recommending harvest quotas. This has become increasingly important due to the increased acceptance of alternative management strategies, such as Quality Deer Management, that promote management at reduced deer densities in many areas. Following aggressive antlerless harvests to reduce deer densities, limited recruitment due to fawn predation may delay population recovery and limit the numbers of animals available for harvest.

ACKNOWLEDGEMENTS

We thank David Smith for funding this research and SNI Farms personnel for helping with data collection. We thank Clint Locklear and Predator Control Group LLC

for taking care of our trapping needs. We acknowledge Alabama Department of Conservation and Natural Resources for their cooperation in issuing the proper permits. We thank David Osborn for supplying necessary equipment to conduct our research.

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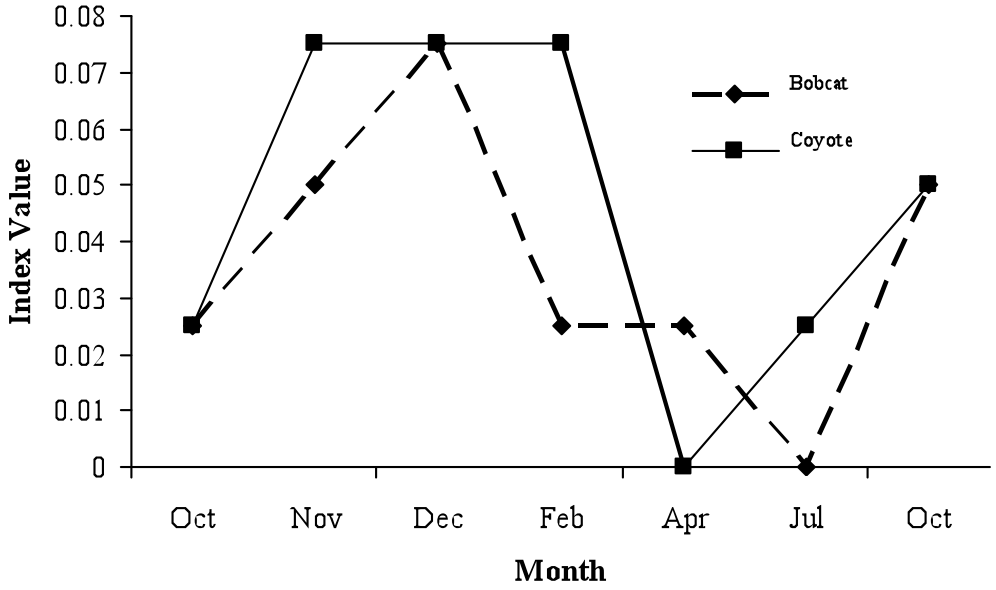
Figure 2.1. Indices of predator abundance before and after an intensive predator removal from February through July 2007 on SNI Farms, Cherokee County, Alabama: a) Scent station (# animal visits / # operable scent stations X 1 / nights operated) from October 2006 through October 2007; b) Scat deposition rate obtained along 4, 1.6-kilometer long transects from October 2006 through September 2007. Predator removal was conducted from February through July, 2007.

a)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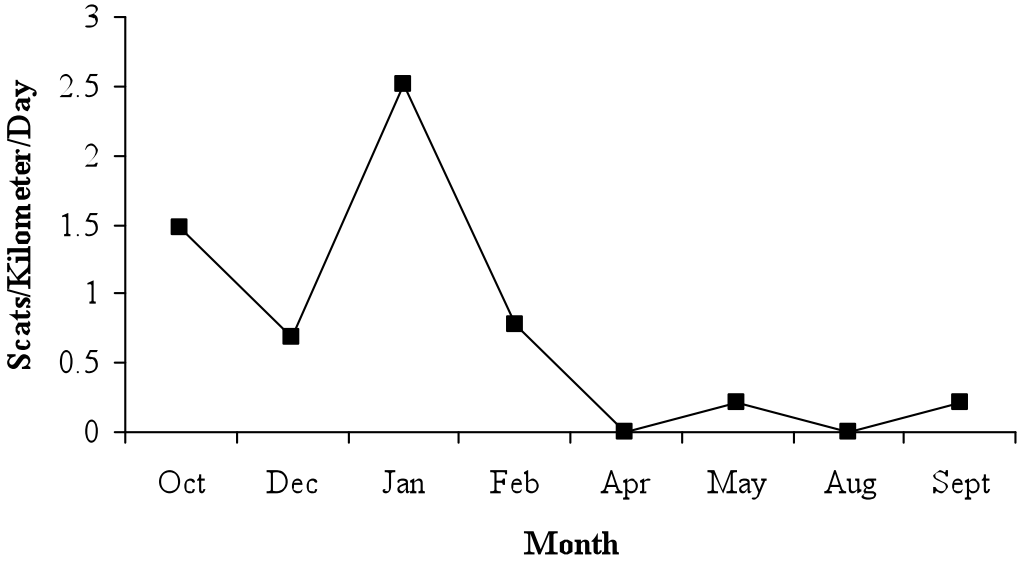
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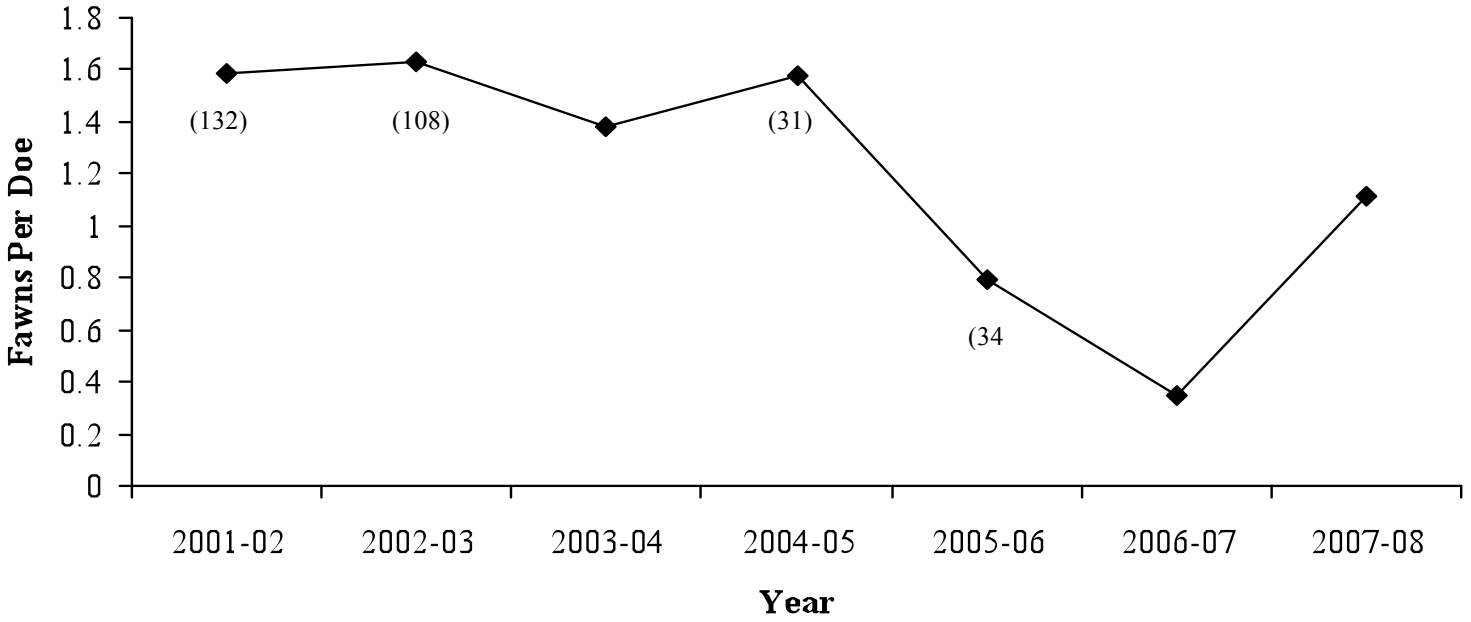

Figure 2.2. Fawn-to-doe ratios based on hunter observations from SNI Farms, Cherokee County, Alabama, during the 2001-2007 hunting seasons.

Table 2.1. Fawn-to-doe ratios before and after an intensive predator removal (Feb-Jul 2007) on a 800-hectare study site in northeast Alabama. Web camera surveys were derived using 11 remote cameras over established food plots. Camera surveys were conducted over 14 days at a camera density of 1/65 hectares.

		Pre-removal (2006-2007)				Post-removal (2007-2008)			
Survey		Total deer	Adult does	Fawns	Fawn:Doe	Total deer	Adult Does	Fawns	Fawn:Doe
Web Camera									
	Oct	53	32	18	0.56	40	12	17	1.42
	Nov	90	35	18	0.51	70	29	40	1.38
	Jan	62	38	19	0.50	43	18	24	1.33
Camera Survey									
	Sept	6101*	3234	579	0.18	3324*	1901	442	0.24
	Feb	4129*	2462	1016	0.41	9219*	3678	4417	1.20

* excludes individuals that couldn't be positively identified by sex or age class

CHAPTER 3

FOOD HABITS OF COYOTES AND BOBCATS IN NORTHEASTERN ALABAMA[1]

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[1]VanGilder, C. L., G. R. Woods, and K. V. Miller. To be submitted to the Southeastern Naturalist.

ABSTRACT

Diets of *Canis latrans* (coyote) and *Lynx rufus* (bobcat) vary regionally and seasonally. Therefore, site-specific data are requisite to understanding their ecological roles. We assessed the seasonal diets of these mesomammalian predators by analyzing scat (coyote n = 150; bobcat n = 36) and stomach contents (coyote n = 16; bobcat n = 5) collected on a study area in northeastern Alabama during July 2006 and June 2007. *Odocoileus virginianus* (white-tailed deer) were common in the diet of both the coyote and bobcat and occurrence peaked coincident with the fawning and deer hunting seasons. During July through September, fawns were the most common food item (37.5% of scats) in the coyote's diet; bobcats used deer less frequently (8.4% of scats). Seasonally abundant soft mast and insects were common in the coyote diet. Birds were frequently consumed by bobcats during July through September, (35.8% of scats) and January through March, (14.3% of scats). Small mammals were the most common food item for both coyotes (33.3% of scats) and bobcats (63.9% of scats). Coyote diets were more diverse and varied temporally as seasonally abundant food items became available. High occurrence of fawns in coyote scats suggests that they have a greater impact on fawn mortality than bobcats.

INTRODUCTION

Coyotes are a recent invader of the Southeast (Gipson 1978, Hill et al. 1987), and now occur sympatrically with native bobcats in this region. An increasing trend in coyote populations has led to a growing speculation regarding the potential impacts this predator is having on other wildlife, particularly white-tailed deer (Kilgo et al. 2007). Numerous studies have examined the diets of these mesomammalian predators across their range (Korschgen 1957, Clark 1972, Fritts and Sealander 1978, Litvaitis and Shaw 1980, Maehr and Brady 1986), although few have investigated their diets simultaneously, particularly in regions where coyotes and bobcats have recently become sympatric (Litvaitis and Harrison 1989, Chamberlain and Leopold 1999, Thornton et al. 2004).

The diet of coyotes is generally more diverse than that of the bobcat. Coyotes are seasonally omnivorous, allowing them to exploit seasonally abundant food resources including fluctuating small mammal populations, soft mast, insects, white-tailed deer fawns, and carrion. However, coyotes exhibit significant variation in their diet regionally and seasonally (Litvaitis and Shaw 1980, McCracken 1982, Bowyer et al. 1983, Andelt et al. 1987).

Throughout much of their range bobcats have been reported to consume primarily rodents and lagomorphs, although studies conducted in the Northeast (Litvaitis et al. 1984, Major and Sherburne 1987) and on coastal barrier islands off the eastern coast of the U.S. (Baker et al. 2001) have reported high use of deer by bobcats. Prey selection among bobcats appears to be age and sex related (Fritts and Sealander 1978, McLean et al. 2005). For example, in the Northeast males consumed more deer than did female bobcats (Litvaitis et al. 1984, Matlock and Evans 1992).

Studies conducted in areas of the eastern U.S. that have been recently colonized by coyotes provide conflicting results on the impact of coyotes on the diet of native bobcats. In the Northeast, Litvaitis and Harrison (1989) indicated that bobcats contracted their food habits when coyotes became established. However, in Mississippi, Chamberlain and Leopold (1999) found bobcats and coyotes displayed variable dietary overlap and suggested there was low interspecific competition between sympatric bobcats and coyotes on their study area. In Florida, Thornton et al. (2004) suggested that interspecific competition might be less important between bobcats and coyotes in mild climates with a more stable prey base than in northern areas which experience seasonal restrictions in prey abundance. They also speculated that the effect of coyote expansion on bobcat populations is variable and dependent on the nature of resource limitation and diversity.

Coyote and bobcat predation on white-tailed deer has been a concern among sportsmen and wildlife managers. White-tailed deer are common in the diet of these predators, particularly during the fawning season (Knowlton 1964, Baker et al. 2001, Schrecengost et al. 2008). On study sites in Mississippi, Alabama, Kentucky, and Tennessee, Blanton and Hill (1989) indicated that during fawning, deer were the most frequent (74%) major food item in areas with high deer density. Similarly, in Mississippi and Alabama, deer occurred most frequently during summer and fall with the highest use (71.4%) in August coincident with peak fawning (Wooding 1984).

Although some studies have simultaneously examined the diets of recently sympatric populations of coyotes and bobcats (Chamberlain and Leopold 1999, Thornton et al. 2004), no such study has been conducted in the mountainous regions of the

Southeast. Because coyotes are known to exhibit significant variation in their diet both regionally and seasonally, our objectives were to describe the seasonal diet of coyotes and bobcats on a study site in the Ridge and Valley Province of northeastern Alabama.

STUDY AREA

The study was conducted in Cherokee County, Alabama, in the Ridge and Valley region of northeastern Alabama (34°18´N, 85°39´30´´W). We conducted the study on SNI Farms which consists of approximately 800 privately owned hectares, bordered to the west and south by Little River and to the north by Little River Wildlife Management Area. Elevation ranges from 183 meters in the bottomland to 374 meters at the highest point. Average precipitation is 140 centimeters per year. However, during the study from 2006 through 2008 the region experienced severe drought conditions.

SNI Farms is topographically diverse, ranging from mountain top, steep slopes with bluffs, flat rolling terrain, to bottomland swamp. Dominant land cover consisted of mixed pine/hardwoods (52%), planted pines consisting of *Pinus taeda* (loblolly pine) and *P. palustris* (longleaf pine) at various ages (32%), bottomland hardwoods, open grassland (primarily *Festuca arundinaceae*, fescue), and approximately 5% in high quality food plots for white-tailed deer. Foodplots consisted of *Zea mays* (corn), *Glycine max* (soybeans), *Trifolium repens* (clover), *Triticum aestivum* (wheat) and *Sorghum vulgare* (grain sorghum). Habitat management techniques including prescribed burning, thinning, clear-cutting, and herbicide treatments have been implemented to enhance the forage abundance and diversity. Dominant species in the mixed pine/hardwoods were *P. virginiana* (Virginia pine), *Quercus prinus* (chestnut oak), *Liquidambar styraciflua* (sweetgum) and *Vaccinium* spp. (blueberries). *Rubus* spp. (blackberries) was also

common in the under-story. In the bottomland, frequently occurring species included Q. *nigra* (water oak), *Ligustrum sinense* (Chinese privet), *Diospyros virginiana* (persimmon), and fescue.

METHODS

We collected 155 coyote and 33 bobcat scats opportunistically along roads on SNI Farms from July 2006 through June 2007. Scats were placed in individually marked plastic bags, which included a number and the date and frozen to prevent further decomposition until analysis. For analysis, scats were oven dried at 65° C for 48 hours to kill any bacteria, parasites, or eggs. The contents of each scat were separated manually for species identification. Food items were identified macroscopically from tooth, claw, hair, hoof fragments, and plant residues (primarily seeds). Hair samples that could not be identified macroscopically were identified microscopically by comparing cuticular scale patterns to reference slides prepared from the University of Georgia mammalian collection. Plant residues (primarily seeds) were identified through reference manuals and by comparison to collections of known specimens. Due to the possibility of error in identification of small mammals and birds, these species were placed into general categories of small mammals and Aves. The occurrence of each food was recorded for each scat. We categorized the year into four seasons for analysis (July-September, October-December, January-March, and April-June).

From February 2007 through July 2007, 22 coyotes and 10 bobcats were trapped on the study site and euthanized; stomachs were collected from these animals for examination of food content. All animal handling procedures were approved by The University of Georgia Institutional Animal Care and Use Committee (Permit No. 2005-

10203-0). Stomachs were removed, placed in individually marked plastic freezer bags, and stored frozen. Food items were identified and recorded in the same manner as scats. However, because three stomachs were empty and seven contained only debris, analyses were conducted using 16 coyote stomachs and five bobcat stomachs.

Frequency data have been used widely for quantifying carnivore scat and stomach contents; however the data have been variously reported (Kelly 1991). We chose to define "percent of scats" and "percent of stomachs" as the percent of a sample of scats/stomachs in which a prey species occurs (# of times a prey species occurs/# of scats/stomachs examined X 100) , and "percent of occurrence" as the number of times a prey species occurs as a percent of the total number of occurrences for all prey species (# of times a prey species occurs/total number of occurrences of all prey species X 100; see Kelly 1991, Wagner 1993, Schrecengost et al. 2008).

RESULTS

We identified the contents of 155 coyote and 33 bobcat scats along with 16 coyote and five bobcat stomachs collected between July 2006 and June 2007. Twenty-two food items were recorded from coyote scats and stomachs during the period, whereas only 9 items were recorded from bobcat scats and stomachs (Table 3.1).

The coyote diet was primarily composed of mammalian food items in each season (Figure 3.1), although percent occurrence of individual prey items varied seasonally (Table 3.1). White-tailed deer occurred in 37.5% of scats during July through September coincident with peak fawning in this region (Adams 1960). Deer remains occurred in 29.3% of scats during January through March and in 46.2% of stomachs collected during the same period (Table 3.2). Small mammals consistently occurred in approximately

one-third of scats across all seasons. Rabbit use peaked from January through March, occurring in 19.0% of scats. Insects, primarily Orthoptera and Coleoptera, occurred in 42.4% of scats from April through June and were the most common food item in the spring.

Plant materials were most common in coyote scats during spring and fall. Fruit utilization occurred in synchrony with the fruiting of individual species, primarily blackberries and persimmon. Blackberries occurred in 12.5% of scats during summer and 9.1% of scats during spring. Persimmon usage was greatest during fall and was the most common food item during this time, occurring in 42.9% of scats. Poaceae (grass) occurred in 36.4% of scats during spring.

The bobcat diet was primarily composed of animal materials; grasses were the only plant material found in scats or stomach contents. Small mammals were the most common food item, occurring in 63.9% of the scats overall (Table 3.3). Birds (Aves) occurred in 35.8% of scats during summer and represented the second most common food item during this time. Rabbits occurred in 19.4% of the scats overall and was the third most common food item.

DISCUSSION

Overall, small mammals were the most common prey item consumed by coyotes, occurring in 25% of scats annually. Across its range, other studies have similarly found small mammals comprised a large dietary component of the coyote (Wilson 1967, Gipson 1974, Hall 1979, Litvaitis and Shaw 1980). High occurrences of lagomorphs have also been reported in Louisiana (53.5, Wilson 1967, 39.6%, Hall 1979;), and Missouri (55%; Korschgen 1957). Although rabbits were not consumed as frequently on our study area,

they were a staple food item and our observed occurrence was similar to that reported by Litvaitis and Shaw (1980) in Oklahoma.

Bobcat diets were almost exclusively composed of animal items, consistent with other food habit studies across the bobcat's range (Progulske 1955, Beasom and Moore 1977, Fritts and Sealander 1978, Miller and Speake 1978, Maehr and Brady 1986). In our study small mammals, birds, and lagomorphs were the three most commonly occurring food items in the bobcat diet. Bird use was greatest during the July through September period and the January through March period. Similar, high use of birds has been reported by other studies in the Southeast (Fritts and Sealander 1978, Miller and Speake 1978, Maehr and Brady 1986). Maehr and Brady (1986) suggested that the higher bird use in the southeastern U.S. compared to northern studies (Pollack 1951) may be due to the greater availability of wintering migrants.

White-tailed deer were present at low levels in the bobcat diet (6.9% of scats overall). The timing of these occurrences of deer was coincident with fawn availability and possibly the increased availability of carrion from unrecovered deer harvest. Our findings of low deer occurrence are similar to most studies conducted throughout North America (Progulske 1955, Beasom and Moore 1977, Fritts and Sealander 1978). Lower occurrences of deer by bobcats have also been reported in areas where coyotes have recently colonized (Litvaitis and Harrison 1989, Thornton et al. 2004).

White-tailed deer occurred in the coyote diet throughout the year, with the greatest occurrences during summer and winter, coincident with fawning and hunting seasons. Coyotes have been implicated as a major contributor to high fawn mortality in certain regions (Knowlton 1964, Beasom 1974, Garner et al. 1976), including the

Southeast (Wooding 1984, Blanton and Hill 1989, Schrecengost et al. 2008), with high dietary occurrences of deer coinciding with the peak fawning season. In northeastern Alabama, peak breeding of white-tailed deer occurs during the first half of December (Adams 1960) with subsequent fawning between mid-June and early July. Fawns were the most important component of the coyote diet during July through September (27.3% occurrence). Although small mammal occurrence was similar during this period, fawns likely were more energetically important due to their larger size. In Maine, Harrison and Harrison (1984) found that from weaning until they began to forage independently, coyote pups fed primarily on white-tailed deer, most likely fawns. They speculated that it was energetically less efficient to catch and transport small prey items to sustain litters than to prey on deer fawns. Diet selection is influenced not only by food availability, but also handling costs (time and effort needed to capture and ingest prey) and by the profitability of the prey (MacCracken and Hansen 1987). Andelt et al. (1987) found that the coyote exhibited a dramatic seasonal shift in their diet, feeding on fruits and insects in significant amounts when other food was available, suggesting that these items may buffer predation on other species such as fawns.

Coyote and bobcat food habits did overlap on our study area. However, the more diverse diet of the seasonally omnivorous coyotes suggests low interspecific competition between sympatric coyotes and bobcats. We concur with Thornton et al. (2004) that competition between coyotes and bobcats is likely inconsequential in mild climates due to more abundant and stable food sources. However, due to the abundant, diverse prey base found in the southeastern U.S., coyotes may achieve higher densities than in some

other portions of their range. Therefore, deer managers in this region should be aware of the potential impacts of coyotes on white-tailed deer recruitment in this region.

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Table 3.1. Percent of scats and percent of occurrence of common food items in 150 coyote scats at SNI Farms, Cherokee County, Alabama, by season from July 2006 through June 2007.

	Percent of Scats					Percent of Occurrence				
	Jul-Sep (n=32)	Oct-Dec (n=27)	Jan-Mar (n=58)	Apr-Jun (n=33)	Overall (n=150)	Jul-Sep (n=32)	Oct-Dec (n=27)	Jan-Mar (n=58)	Apr-Jun (n=33)	Overall (n=150)
Food Item										
Plants										
Diospyros virginiana	6.3	42.9			8.7	4.2	36.4			7.0
Phytolacca americana		7.4			1.3		6.1			1.0
Poaceae (grass)	9.4	7.4	10.4	36.4	17.3	6.8	6.1	11.6	20.4	12.0
Quercus spp. (acorns)			1.7		0.7			1.5		0.5
Rubus spp.	12.5			9.1	5.3	9.1			5.6	3.0
Vitis spp.		3.7			0.7		3.0			0.5
Zea mays	3.1		5.2		2.7	2.3		4.4		2.0
Other soft mast				6.1	1.3				3.7	1.0
Animals										
Aves	18.8	7.4	10.4	6.1	11.3	13.6	6.1	1.5	3.7	5.5
Canis latrans				6.1	1.3				3.7	1.0
Castor canadensis			3.5		1.3			2.9		1.0
Didelphis virginiana			3.5	3.0	2.0			2.9	1.9	1.5
Marmota monax				9.1	2.0				5.6	1.5
Mephitis mephitis			1.7	3.0	1.3			1.5	1.9	1.0
Odocoileus virginianus (adult)		7.4	29.3	3.0	13.3		9.1	24.6	1.9	10.5
Odocoileus virginianus (fawn)	37.5				8.0	27.3				6.0
Orthoptera/Coleoptera	3.1	3.7		42.4	10.7	2.3	3.0		25.9	8.0
Procyon lotor				9.1	2.0			4.4		1.5
Sciurus spp.	9.4	14.8	6.9	6.1	8.7	6.8	12.1	5.8	3.7	6.5
Small Mammal	37.5	29.6	31.0	36.4	33.3	27.3	24.2	26.1	22.2	25.0
Sylvilagus spp.	6.3	11.1	19.0	18.2	14.7	4.5	9.1	15.9	11.1	11.0
Urocyon cinereoargenteus				3.0	0.7				1.9	0.5

Table 3.2. Percent of occurrence and percent of stomachs of common food items in 16 coyote stomachs at SNI Farms, Cherokee County, Alabama, by season from January 2007 through June 2007.

	Percent of Stomachs			Percent Occurrence		
	Jan-Mar (n=13)	Apr-Jun (n=3)	Overall (16)	Jan-Mar (n=13)	Apr-Jun (n=3)	Overall (n=16)
Food Item						
Plants						
Poaceae (grass)	23.1		18.8	17.7		15
Animals						
Aves	15.4		12.5	11.8		10
Odocoileus virginianus (adult)	46.2	33.3	43.8	35.3	33.3	35
Small Mammal	15.4	33.3	18.8	11.8	33.3	15
Sylvilagus spp.		33.3	6.3		33.3	5

Table 3.3. Percent of scats and percent of occurrence of common food items in 36 bobcat scats at SNI Farms, Cherokee County, Alabama, by season from July 2006 through June 2007.

	Percent of Scats					Percent of Occurrence				
	Jul-Sep (n=14)	Oct-Dec (n=2)	Jan-Mar (n=17)	Apr-Jun (n=3)	Overall (n=36)	Jul-Sep (n=14)	Oct-Dec (n=2)	Jan-Mar (n=17)	Apr-Jun (n=3)	Overall (n=36)
Food Item										
Plants										
Poaceae (grass)	14.3			66.7	11.1	11.1			33.3	9.1
Animals										
Aves	35.8		14.3		22.2	27.8		16.7		18.2
Didelphis virginiana			7.1		2.8			5.6		2.3
Odocoileus virginianus (adult)				66.7	5.6			11.1		4.6
Odocoileus virginianus (fawn)	7.2				2.8	5.6				2.3
Orthoptera/Coleoptera				33.4	2.8				16.7	2.3
Sciurus spp.	7.2		11.8		8.3	5.6		11.1		6.8
Small Mammal	57.1	100.0	64.7	33.4	63.9	44.4	100.0	56.3	16.7	45.5
Sylvilagus spp.	21.4		11.8	66.7	19.4	16.7		11.1	33.3	15.9

Table 3.4. Percent of occurrence and percent of stomachs of common food items in 5 bobcat stomachs at SNI Farms, Cherokee County, Alabama, by season from January 2007 through June 2007.

	Percent of Stomachs			Percent Occurrence		
	Jan-Mar (n=2)	Apr-Jun (n=3)	Overall (n=5)	Jan-Mar (n=2)	Apr-Jun (n=3)	Overall (n=5)
Food Item						
Plants						
Poaceae (grass)		66.7	40		42.9	33.3
Animals						
Odocoileus virginianus (adult)		33.3	20		14.3	11.1
Small Mammal	50	33.3	40	50	14.3	22.2
Sylvilagus spp.	50		20	50		11.1
Other*		33.3	20		14.3	11.1

* includes snake

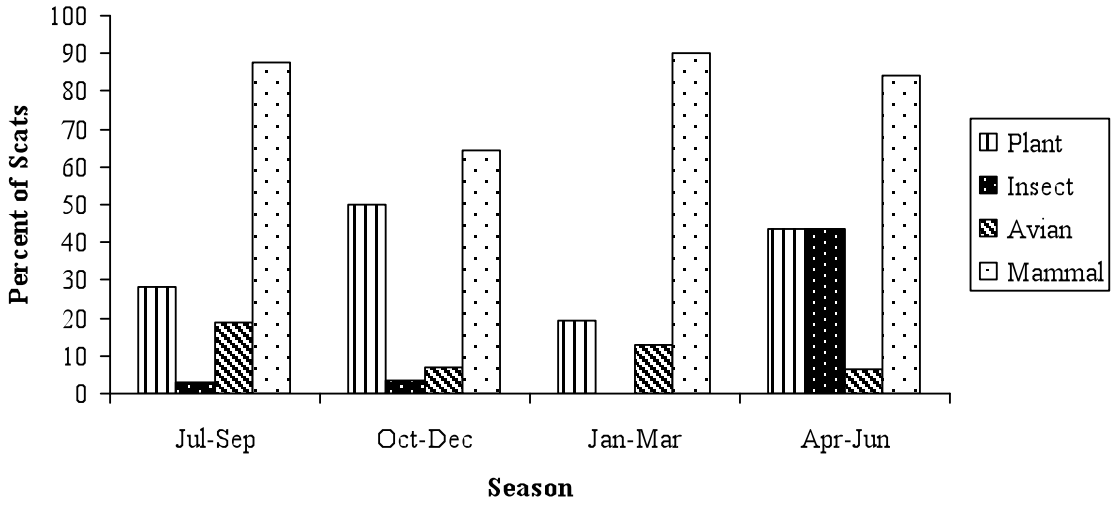

Figure 3.1. Seasonal percent of scats of 4 major food item groups found in coyote scats (n=150) collected on SNI Farms, Cherokee County, Alabama, July 2006 through June 2007.

CHAPTER 4

SUMMARY AND MANAGEMENT IMPLICATIONS

SUMMARY

I studied the food habits of coyotes and bobcats, while concurrently investigating their predation impact on white-tailed deer in northeastern Alabama from July 2006 through June 2007. I determined the annual and seasonal food habits of bobcats and coyotes throughout the study so that inferences could be made about the extent of predation on white-tailed deer in this region, specifically during fawning season. Baseline population data were collected for coyotes and bobcats (scent station and scat deposition rate indices) and white-tailed deer (observation data, camera survey, and web camera observations). After the baseline population data were collected, an intensive predator removal was initiated prior to the 2007 fawning season. I compared baseline population data collected before predators were removed to the population data collected after the intensive predator removal to quantify the impact coyotes and bobcats had on deer on the study area.

A total of 36 scats and 5 usable stomachs were collected from bobcats during the study. Bobcats were almost exclusively carnivorous; commonly occurring food items included small mammals, birds, and lagomorphs. Small mammals were the most important component in the diet of these predators. Occurrences of deer were coincident with the fawning and deer hunting seasons. However, while present, white-tailed deer made up a minor portion of the bobcat diet overall. Bobcats, likely are not an important predator of white-tailed deer in this area.

Dietary analysis of 150 scats and 16 usable stomachs revealed coyotes on the study area were opportunistic omnivores, feeding on a diversity of prey items. Small mammals were consistently utilized as staple food items during each season of the year. However, coyotes were highly adaptable and quickly exploited seasonally abundant food items, including fawns, insects, and soft mast. Deer occurrences were coincident with the fawning and deer hunting seasons.

High occurrences of deer following hunting season can likely be attributed to hunter-associated deer mortality from neighboring properties. During the fawning season, fawns were the most important food item. Coyote food habits revealed that predation by coyotes is a major fawn mortality factor and were shown to be limiting fawn recruitment in this area (see Chapter 2).

From February 2007 through July 2007, intensive predator removal was initiated, timed prior to the 2007 fawning season to limit predation during this time. Intensive predator removal on our study site dramatically increased fawn survival. Comparison of white-tailed deer fawn-to-doe ratios collected from hunter observation data, camera surveys, and web camera observations, before and after predators were removed increased on average 189% after predator removal.

The increases in fawn recruitment following predator removal, coupled with dietary analyses of the most likely deer predators (coyotes and bobcats) supports the conclusion that predators (primarily coyotes) are limiting fawn recruitment in this area. The presence of white-tail deer was significantly higher in the coyote diet in comparison to the bobcat, with the highest occurrence of deer during the fawning season.

PREDATOR MANAGEMENT IMPLICATIONS

Studies have reported that coyotes are significant predators on white-tailed deer (Cook et al. 1971, Beasom 1974, Present study). However, coyote predation on deer tends to be area-specific. On our study area coyotes preyed heavily on fawns, similar to findings from other southeastern U.S. studies (Wooding 1984, Blanton and Hill 1989). In Maine, Harrison and Harrison (1984) found from the time of weaning until they began to forage independently coyote pups fed primarily on white-tailed deer, most likely in the form of fawns. They speculated it was energetically and/or nutritionally less efficient to catch and transport sufficient quantities of

small prey items to sustain their litters than to prey and transport deer fawns. MacCracken and Hansen (1987) also noted that diet selection is influenced not only by food availability, but also handling costs (time and effort needed to capture and ingest prey) and by the profitability of the prey (energy and nutrients obtained). It is unknown at what level, if any, small prey populations or fruit abundance can reduce or "buffer" predation on white-tailed deer fawns. Harrison and Harrison (1984) reported adult coyotes attending offspring preyed more heavily on deer than do non-reproductive coyotes. Similarly, Young and Jackson (1951) noted increased livestock depredations during coyote denning. Several studies, including this one, have reported high incidences of deer in coyote diets during the fawning season (Knowlton 1964, Litvaitis and Shaw 1980, Wooding 1984, Blanton and Hill 1989).

Intensive predator removal in areas where fawn mortality due to predators is high has been shown to increase fawn recruitment (Beasom 1974, Stout 1982, present study). However, predator removal should be initiated only when sound data exists, other management strategies have failed, and increased numbers of game can be utilized by hunting efforts so that the habitat carrying capacity is not exceeded. Predators should not be removed in areas where deer are overabundant already and likely have a beneficial effect in these situations. Furthermore, the timing of predator removal is critical. In our case it was initiated prior to fawning to reduce predator numbers when young fawns are at their most vulnerable and predation has the greatest impact on the population.

Predator management is likely to become an increasingly important issue, particularly in the southeastern U.S. In the Southeast, coyotes may achieve higher densities than in their native range due to the abundant diverse food supply. Furthermore, deer management is becoming increasingly intensive across the country, sometimes requiring a significant reduction in deer

density to reach management goals. This could potentially lead to an imbalance in the predator-to-prey ratio, causing high levels of predation on deer. Patterson (1999) found coyotes supported at elevated densities by alternate prey will continue to feed preferentially on deer, regardless of deer density. The results of this study support this finding, with a high coyote-to-deer ratio dramatically reducing fawn recruitment on the study area. Deer managers in the Southeast should consider the limiting effects of coyote predation when establishing harvest limits, particularly in years when availability of alternate prey sources are not as abundant because of climatic (drought or flood) or ecological (disease) factors. Alternate prey populations (small mammals, soft mast) fluctuate in abundance annually and seasonally. Management strategies that incorporate habitat management to increase fawn survival by decreasing predator hunting efficiency (reducing travel corridors, increasing fawning cover, etc.) would be another option, in place of or in conjunction with intensive predator removal.

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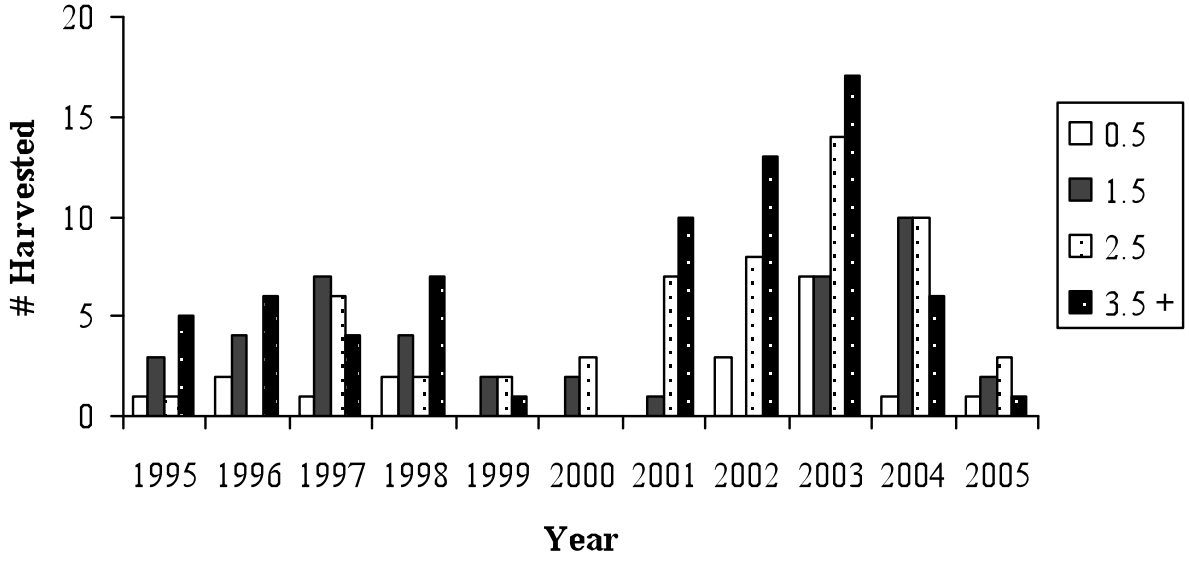
APPENDICES

APPENDIX I

HARVEST HISTORY OF FEMALE DEER BY AGE CLASS FROM 1995 THROUGH 2005 ON SNI FARMS, CHEROKEE COUNTY, ALABAMA



APPENDIX II

DATA COLLECTED DURING TRAPPING EFFORTS FROM COYOTES AND BOBCATS FROM FEBRUARY THROUGH JULY 2007 ON SNI FARMS, CHEROKEE COUNTY, ALABAMA

	Capture #	Age	Sex	Weight	Heartworm
Coyotes	1	<1	F	27	N/A
	2	2	M	33	Y
	4	2	F	29	N
	5	2	M	33	N
	6	<1	F	21	N
	9	1	F*	28	Y
	10	3	F	33	N
	12	<1	M	36	N
	13	<1	F*	26	N
	14	2	M	30	N
	15	4	M	29	N
	17	3	M	30	N
	18	<1	M	29	N
	19	2	F**	23	N
	20	<1	F	22	N
	21	<1	M	23	N
	22	1	F	27	N
	23	<1	M	34	N
	24	<1	M	37	N
	29	5	F**	32	N
	30	2	M	26	N
	31	2	M	38	N
Bobcats	3	3	M	24	
	7	5	F	11	
	8	1	M	14	
	11	8	F	13	
	16	<1	M	13	
	25	4	M	21	
	26	2	M	20	
	27	1	F	10	
	28	1	F	10	
	32	1	M	13	

* black color phase
** pregnant

APPENDIX III

LACTATION RATES OF FEMALE DEER HARVESTED FROM 1995 THROUGH 2005 ON SNI FARMS, CHEROKEE COUNTY, ALABAMA