Effects of an Intensive Predator Removal on White-tailed Deer Recruitment in Northeastern Alabama

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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 fawn-to-doe ratios before and after an intensive predator removal on an 800-ha study site in northeast Alabama. We estimated fawn-to-doe ratios 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. The September fawn-to-doe ratio increased from 0.18 to 0.24 and the February ratio 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 0.35, compared to a ratio of 1.10 after the removal. Similarly, web camera surveys indicated an increase in recruitment rates 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.

Key words: *Canis latrans*, coyote, fawn recruitment, predation, *Odocoileus virginianus*, white-tailed deer

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Most studies that have investigated predation impacts on white-tailed deer recruitment 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 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 have become recently sympatric, such as the eastern United States, 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, and this has generated speculation on the impacts this predator may have 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 United States. For example, the estimated statewide deer population in South Carolina declined by approximately 37% between 1997 and 2006 (Ruth 2008) concurrent with dramatic increases in the coyote population (South Carolina Department of Natural Resources, unpublished).

Our study area in northeastern Alabama has operated under Quality Deer Management guidelines (Hamilton et al. 1988, Miller and Marchinton 1995) since 1988, limiting the harvest to bucks ≥3.5 years old to increase buck age structure. Adult doe harvests ranged from 2.2 to 5.7 does/km2 during the period of 2001–2004 and were designed to reduce herd density to improve overall herd health and productivity (D. Smith, SNI Farms, personal communication). Spring herd health checks from 2000–2003 ($n = 4 - 8$ 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-

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doe ratio of 1.56. However, following a heavy doe harvest (5.7 deer/km2) in 2003 and an additional harvest of 3.5 does/km2 in 2004, the observed fawn-to-doe ratios dropped to 0.87 in 2005 and to 0.35 in 2006. 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. Additionally, a concurrent food habits study indicated that 37% of a sample of coyote scats collected between July and September 2006 contained fawn remains (VanGilder 2008). 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 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 (3418N, 853930 W). The area consisted of approximately 800 ha of privately owned land (SNI Farms) bordered to the west and south by Little River and to the north by Little River Wildlife Management Area. Elevation ranged from 183 m in the bottomland to 374 m at the highest point. Average precipitation was 140 cm 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 (T*riticum 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.

Peak fawning on our study area occurs during early to mid-August. Habitat management practices on the area included prescribed burning, thinning, clear-cutting, and herbicide treatments to enhance natural vegetation, and 40.5 ha of high quality foodplots to increase forage availability. No antlerless deer were harvested from the area during the study.

Methods

Relative Predator Abundance

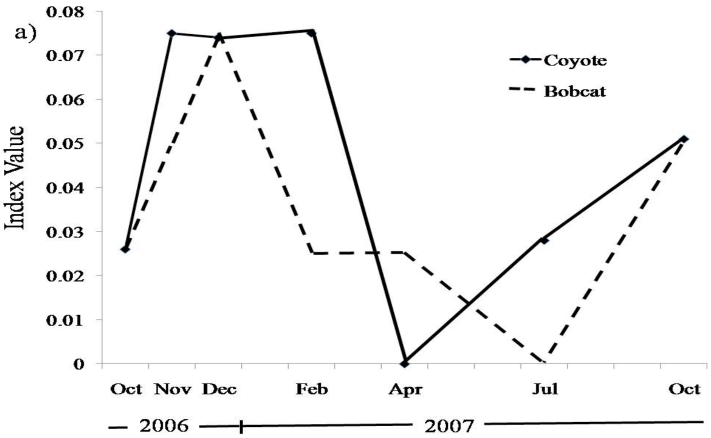
Beginning in October 2006, we monitored predator relative abundance approximately bimonthly throughout the study using scent stations and scat deposition rates. We established two 4.3-km scent station transects on unpaved roads. The minimum distance between transect lines was 0.8 km, but lines were separated by approximately 180 m in elevation. Each transect consisted of 10 scent stations at intervals of 0.5 km, 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 (USDA, Pocatello Supply Depot, Pocatello, Idaho) placed at the center (Linhart and Knowlton 1975). Transects were operated for two 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; *n* animal visits / *n* operable scent stations/nights operated). The RMA was calculated separately for coyotes and bobcats. Otherwise, our methods were consistent with Linhart and Knowlton (1975) as refined by Roughton and Sweeney (1982).

In addition, we used four 1.6-km 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 two and four weeks after clearing to count and remove any new scat. We then calculated a scat deposition rate index of abundance every other month (*n* 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 (novice and youth hunters were excluded from data collection) 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., they included repeated observations of individual deer), we believe they provide a useful index to these ratios for comparison among years.

The study area contains a series of web cameras ($n = 11$) which are mounted on poles over established foodplots. These cameras are connected by fiber optic cable and are accessible via an In-



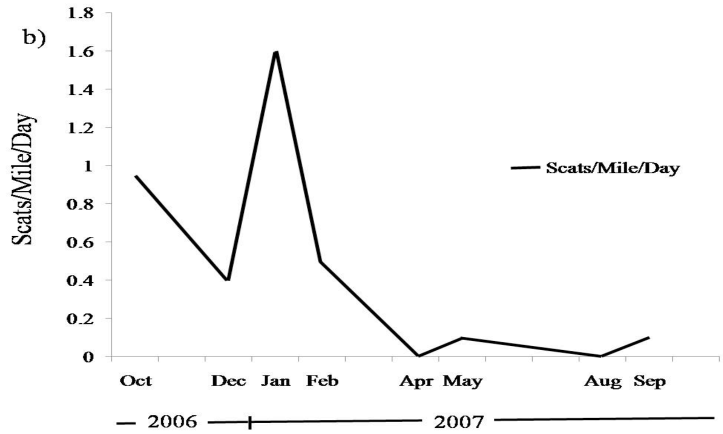


Figure 1. Indices of predator abundance before and after an intensive predator removal from February through July 2007 on SNI Farms, Cherokee County, Alabama: (a) Scent station (*n* animal visits/*n* operable scent stations x nights operated) from October 2006 through October 2007; (b) Scat deposition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

ternet connection. We selected cameras at random and accessed them when deer activity in the foodplots would be greatest (early morning and late evening) during October, November, and January (2006–2007—preremoval; 2007–2008—postremoval). Cameras were viewed every day during this period, except in instances of extreme weather (lightning, etc.), which could potentially damage the cameras. Deer were observed in foodplots within one hour after sunrise and one 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 could not be identified were categorized as unknowns.

We conducted camera surveys (Jacobson et al. 1997) in September 2006 and February 2007 (preremoval) and September 2007 and February 2008 (postremoval). We used 12 Stealth Cam (Stealth Cam LLC, Grand Prairie, Texas) digital trail cameras at a density of approximately one camera per 65 ha. Cameras were set on a four-minute delay between photographs. The camera was placed 1.3 m 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 began. Surveys were conducted for 14 days, and bait piles were refreshed as needed. Analysis of pictures was similar to McKinley et al. (2006) 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. KB compound 5.5, four-coil spring foothold traps (KB Manufacturing, Fort Plain, New York) were used 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 using 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. Coyote RMA declined from 0.075 during November 2006 through February 2007 to near zero by April (Figure 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 (Figure 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 during fall 2006 revealed

Table 1. Fawn-to-doe ratios before and after an intensive predator removal (Feb-Jul 2007) on a 800-ha study site in northeastern 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 camera/65 ha.

		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	49	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

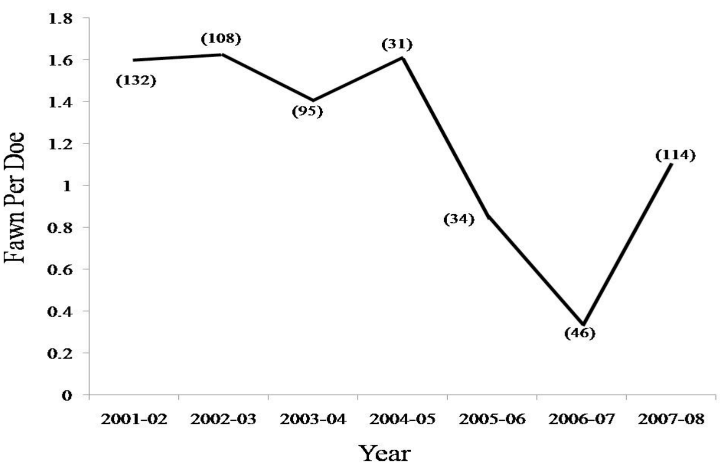


Figure 2. Fawn-to-doe ratios based on November hunter observations from SNI Farms, Cherokee County, Alabama, during the 2001–2007 hunting seasons. Sample sizes in parentheses.

similar fawn-to-doe ratios of 0.35 and 0.52 respectively. Following the intensive removal of predators, the September camera fawn-to-doe ratio increased to 0.24 (33.3% increase) and the February 2008 ratio increased 1.20 (193% increase) (Table 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 (Fig. 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 1).

Discussion

Intensive predator removal on our study area prior to fawning apparently resulted in increased fawn survival, 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 Oklahoma (Stout 1982). The greater fawn-to-doe ratio we observed following intensive predator removal suggests that predation may be an important factor impacting fawn recruitment on our study area. However, our study only included one year of postremoval data. Thus the long-term impacts of a predator removal program remain unknown. Nevertheless, our results suggest that a predator removal program conducted before the fawning season can greatly increase fawn survival for at least one year post-treatment.

Our September camera surveys resulted in low fawn-to-doe ratios. However, because peak fawning on our study area occurs during early to 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 six months after trapping (Beasom 1974). However, the increase in scent station visitation that we observed after trapping was terminated may be 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 low following the predator removal.

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 United States, 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 densities are reduced, predators could reduce recruitment rates due 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.

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Literature Cited

Andelt, W. F. and S. H. Andelt. 1984. Diet bias in scat deposition-rate surveys of coyote density. Wildlife Society Bulletin 12:74–77.

——— and P. S. Gibson. 1979. Home range, activity, and daily movements of coyotes. Journal of Wildlife Management 43:944–951.

———, J. G. Kie, F. F. Knowlton, and K. Cardwell. 1987. Variation in coyote diets associated with season and successional changes in vegetation. Journal of Wildlife Management 51:273–277.

Beasom, S. L. 1974. Relationships between predator removal and white-tailed deer net productivity. Journal of Wildlife Management 38:854–859.

Berg, W. E. and R. A. Chesness. 1978. Ecology of coyotes in northern Minnesota. Pages 220–297 *in* M. Bekoff, editor. Coyotes: biology, behavior, and management. Academic Press, New York.

Blanton, K. M. and E. P. Hill. 1989. Coyote use of white-tailed fawns in relation to deer density. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 43:470–478.

Cook, R. S., M. White, D. O. Trainer, and W. C. Glazener. 1971. Mortality of young white-tailed deer fawns in South Texas. Journal of Wildlife Management 35:47–56.

Garner, G. W., J. A. Morrison, and J. C. Lewis. 1976. Mortality of white-tailed deer fawns in the Wichita Mountains, Oklahoma. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 13:493–506.

Gipson, P. S. 1978. Coyotes and related *Canis* in the Southeastern United States with a comment on Mexican and Central American *Canis*. Pages 191–208 *in* M. Bekoff, editor. Coyotes: biology, behavior, and management. Academic Press, New York.

Hall, D. I. 1979. An ecological study of the coyote-like canid in Louisiana. M. S. Thesis, Louisiana State University, Baton Rouge.

Hamilton, R. J., L. O. Rogers, D. C. Guynn, and R. L. Marchinton. 1988. Quality Deer Management: past, present, and future. South Carolina White-tailed Deer Management Workshop 2:87–91.

Harris, C. E. 1983. Differential behavior of coyotes with regards to home range limits. PhD. Dissertation. Utah State University, Logan.

Harrison, D. J. and J. A. Harrison. 1984. Foods of adult Maine coyotes and their known-aged pups. Journal of Wildlife Management 48:922–926.

Hill, E. P., P. W. Sumner, and J. B. Wooding. 1987. Human influences on range expansion of coyotes in the Southeast. Journal of Wildlife Management 15:521–524.

Holzman, S., M. J. Conroy, and J. Pickering. 1992. Home range, movements, and habitat use of coyotes in southcentral Georgia. Journal of Wildlife Management 56:139–146.

Jacobson, H. A., J. C. Kroll, R. W. Browning, B. H. Koerth, and M. H. Conway. 1997. Infrared-triggered cameras for censusing white-tailed deer. Wildlife Society Bulletin 25:547–556.

Kie, J. G., M. White, and F. F. Knowlton. 1979. Effects of coyote predation on population dynamics of white-tailed deer. Proceedings of the Welder Wildlife Foundation Symposium 1:65–82.

Linhart, S. B. and F. F. Knowlton. 1975. Determining the relative abundance of coyotes by scent station lines. Wildlife Society Bulletin 3:119–124.

Litvaitis, J. A. and D. J. Harrison. 1989. Bobcat-coyote niche relationships during a period of coyote population increase. Canadian Journal of Zoology 67:1180–1888.

——— and J. H. Shaw. 1980. Coyote movements, habitat use, and food habits in southwestern Oklahoma. Journal of Wildlife Management 44: 62–68.

McKinley, W. T., S. Demarais, K. L. Gee, and H. A. Jacobson. 2006. Accuracy of the camera technique for estimating white-tailed deer population characteristics. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 60:83–88.

Miller, K. V. and R. L. Marchinton, editors. 1995. Quality whitetails: the why and how of Quality Deer Management. Stackpole Books, Mechanicsburg, Pennsylvania.

Ozoga, J. J. and E. M. Harger. 1966. Winter activities and feeding habits of northern Michigan coyotes. Journal of Wildlife Management 30:809–818.

Patterson, B. R., L. K. Benjamin, and F. Messier. 1998. Prey switching and feeding habits of eastern coyotes in relation to snowshoe hare and white-tailed deer density. Canadian Journal of Zoology 76:1885–1897.

Pusateri-Burroughs, J., H. Campa, III, S. R. Winterstein, B. A. Rudolph, and W. E. Mortiz. 2006. Cause-specific mortality and survival of white-tailed deer fawns in southwestern lower Michigan. Journal of Wildlife Management 70:743–751.

Roughton, R. D. and M. W. Sweeney. 1982. Refinements in scent station methodology for assessing trends in carnivore populations. Journal of Wildlife Management 46:217–229.

Ruth, C. R. 2008. 2007 South Carolina deer harvest report. South Carolina Department of Natural Resources, Columbia.

Stout, G. G. 1982. Effects of coyote reduction on white-tailed deer productivity on Fort Sill, Oklahoma. Wildlife Society Bulletin 10:329–332.

Sumner, P. W., E. P. Hill, and J. B. Wooding. 1984. Activity and movements of coyotes in Mississippi and Alabama. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 38:174–181.

Thornton, D. H., M. E. Sunquist, and M. B. Main. 2004. Ecological separation within newly sympatric populations of coyotes and bobcats in south-central Florida. Journal of Mammalogy 85:973–982.

VanGilder, C. L. 2008. Coyote and bobcat food habits and the effects of an intensive predator removal on white-tailed deer recruitment in northeastern Alabama. M. S. Thesis, University of Georgia, Athens.

Wooding, J. B. 1984. Coyote food habits and the spatial relationship of coyotes and foxes in Mississippi and Alabama. M.S. Thesis. Mississippi State University, Mississippi State, Mississippi.