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Title:

Home range and habitat use of the eastern spotted skunk in the Ouachita Mountains.

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Executive Summary

The eastern spotted skunk (*Spilogale putorius*) was one a common and economically important furbearer, but is now listed as endangered, threatened, or a species of conservation concern throughout much of its historical range. In Arkansas the eastern spotted skunk was listed as a species of conservation concern in 2006. Because virtually nothing is known about the fundamental ecology of the species or the potential effects of forest management strategies on habitat use, we undertook a research project to elucidate home range dynamics and habitat selection of an eastern spotted skunk population in the Ouachita National Forest of western Arkansas. We conducted telemetry-based field work over a two year period , ultimately monitoring the movements and habitat selection of 33 eastern spotted skunks.

We used kernel-based utilization distributions, volume of intersection indices, and weighted compositional analysis to evaluate seasonal home range dynamics and habitat selection. We found large seasonal differences in the home range size of adult males, with ranges of between 76 and 175 (± 22-62 SE) ha during summer, fall and winter and home ranges of 866 (± 235 SE) ha during spring. Male home range increases in the spring were likely caused by questing behavior in search of reproductive females. Females maintained home ranges of 54 to 135 (± 7-30 SE) ha during all seasons. During each season, we observed selection of young shortleaf pine and hardwood stands over other available cover types, likely due to a preference for a dense, complex understory and a closed canopy overstory to reduce predation risk. Most habitats in the study region are managed for an herbaceous understory and an older, more open canopy, habitats that appear to be selected against by eastern spotted skunks in the Ouachita National Forest.

Denning and resting site use was investigated from May through August 2005 and 2006. We identified and characterized microhabitat and landscape characteristics of 127 resting and den sites. Sites were located in burrows (48%) excavated by other mammal species, in decayed or burned root systems (22%), in rocky outcrops (14%), in eastern woodrat nests (9%), or in ground level tree or log cavities (7%). Reuse of sites was common, but communal use of sites was rare. Contrasting used and putatively available dens and resting sites using discrete choice analysis revealed similar patterns to those observed during analyses of home range use and habitat selection. We found that sites were selected based primarily on increased vegetative cover, which supports thermal regulation and predator avoidance hypotheses. Higher rock and vine densities, younger pine forest stands, older hardwood stands, steeper slope, and smaller site entrance also positively influenced resting and den site selection. Therefore eastern spotted skunks select structurally complex sites, which may act to enhance protection from predators.

These landscape use and habitat selection results suggest that eastern spotted skunks are solitary carnivores that select structurally complex habitat that likely acts to reduce the risk of predation. The species may be vulnerable to forest ecosystem changes intended to create a more open canopy and herbaceous understory, a management strategy used extensively in parts of the Ouachita National Forest.

The framework for this Final Report is a thesis written by D. B. Lesmeister under the guidance of both M.E. Gompper and J.J. Millspaugh.

SPACE USE AND RESOURCE SELECTION BY EASTERN SPOTTED SKUNKS

IN THE OUACHITA MOUNTAINS, ARKANSAS

A Thesis presented to
the Faculty of the Graduate School
at the University of Missouri-Columbia

In Partial Fulfillment
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Master of Science

By

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Thesis Supervisors

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SPACE USE AND RESOURCE SELECTION BY EASTERN SPOTTED SKUNKS IN THE OUACHITA MOUNTAINS, ARKANSAS

Damon Brock Lesmeister

Drs. Matthew E. Gompper and Joshua J. Millspaugh, Thesis Advisors

ABSTRACT

Once a common and economically important furbearer, the eastern spotted skunk (*Spilogale putorius*) is now listed as endangered, threatened, or a species of conservation concern throughout much of its historical range. Virtually nothing is known about the fundamental ecology of the species or the potential effects of forest management strategies on habitat use. To elucidate home range dynamics and habitat selection, we conducted telemetry-based field work in the Ouachita National Forest of western Arkansas. During two years of field work we collected locations at 28-hour intervals for 33 eastern spotted skunks. Using kernel-based utilization distributions and the volume of intersection index analysis, we found significant seasonal and intersexual differences in the home range dynamics. Adult males maintained spring ranges of 866 (± 235 SE) ha, which were much larger than the 76 to 175 (± 22-62 SE) ha ranges during the nonbreeding season and the 54 to 135 (± 7-30 SE) ha ranges of females. We observed little home range overlap between adults, especially between adult females. Using weighted compositional analysis we determined that during each season young shortleaf pine and hardwood stands were selected over other available habitat types. A comparison of used and available resting and denning sites using discrete choice analysis revealed

similar patterns; selection for sites with young pine and old hardwood stands, higher canopy closures, rock and vine densities, steeper slopes, and smaller site entrances. These findings suggest that eastern spotted skunks are solitary carnivores that select structurally complex habitat that enhances protection from predators. The species may be vulnerable to forest ecosystem changes intended to create a more open canopy and herbaceous understory, a management strategy used extensively in parts of the Ouachita National Forest.

CHAPTER 1

HABITAT SELECTION AND HOME RANGE DYNAMICS OF EASTERN SPOTTED SKUNKS IN THE OUACHITA MOUNTAINS, ARKANSAS

ABSTRACT

Since the 1940s, eastern spotted skunks (*Spilogale putorius*) have declined dramatically throughout the Midwest and there is no universally accepted reason for the decline. One hypothesis is the loss of suitable habitat, although little is known about the ecological requirements of this species. To elucidate seasonal home range and habitat selection by these animals, we conducted telemetry-based field work in the Ouachita Mountains of western Arkansas. During two years of field work we collected radio locations (mean = 106 ± 13 SE) at 28-hour intervals for 33 eastern spotted skunks. We used kernel-based utilization distributions and weighted compositional analysis to evaluate seasonal home range size and habitat selection. We found large seasonal differences in the home range size of adult males, with ranges of between 76 and 175 (± 22-62 SE) ha during summer, fall and winter and home ranges of 866 (± 235 SE) ha during spring. Male home range increases in the spring are likely caused by questing behavior in search of reproductive females. Females maintained home ranges of 54 to 135 (± 7-30 SE) ha during all seasons. During each season, we observed selection of young shortleaf pine and hardwood stands over other available habitat types, likely due to a preference for a dense and complex understory and a closed canopy overstory to reduce predation risk. Most habitats in the study region are managed for an herbaceous understory and an older, more open canopy, in part to benefit red-cockaded woodpecker

(*Picoides borealis*) populations. Thus, management strategies for these two vertebrates are potentially at odds.

INTRODUCTION

The conservation of small cryptic carnivores depends on habitat preservation (Ginsberg 2001), so understanding the spatial ecology of such species is critically important for conservation management plans. Further, the local persistence of a species is not only a function of available habitat, but also the space use and ability of the species to traverse potentially inhospitable landscapes (Andren 1994, Rosenblatt et al. 1999, Crooks 2002). Species with large space use are thought to be vulnerable to local extinction because of risks associated with travel within the animals' home range (Woodroffe and Ginsberg 1998, Gehring and Swihart 2004) and is compounded for species with specialized habitat restrictions such as some small mammalian carnivores (Crooks 2002).

The eastern spotted skunk (*Spilogale putorius*) is a small (ca 0.4-1.5 kg) omnivorous mephitid which was historically found throughout much of the central and southeastern United States. Although currently localized in distribution, the species was once abundant throughout its range (Kinlaw 1995, Gompper and Hackett 2005). Harvest records for the Great Plains states in the early 20th century indicate that the eastern spotted skunk was a common and important furbearer, with annual multi-state harvests of >>100,000 animals (Gompper and Hackett 2005). However, during the 1940's a decline in harvest of the species occurred, and by the 1980's, harvests were <1% of those during pre-decline years. This decline likely reflects a real decline in the population, not merely an artifact of harvest effort (Gompper and Hackett 2005, Sasse and Gompper 2006). No reason has been identified as the primary cause of eastern spotted skunk decline. However, habitat change, pesticide and herbicide use such as dichlorodiphenyltrichloroethane (DDT) and Atrazine, modernization in agriculture (clean farming, improved grain storage, and the end of large haystack construction), over harvest, and disease outbreak have been proposed explanations for population declines (Choate et al. 1974, McCullough 1983, Schwartz and Schwartz 2001, Gompper and Hackett 2005). Due to the population decline, the eastern spotted skunk is currently listed as endangered, threatened, or a species of conservation concern throughout most of the Midwest and some southeastern states (DeSanty 2001, Gompper and Hackett 2005). In Arkansas, the species was listed as a species of conservation concern in 2007.

Management decisions for the eastern spotted skunk have been made based on a limited and often anecdotal understanding of the ecology and natural history of the species. Most previous studies of the species have been qualitative or primarily descriptive (Van Gelder 1959, Mead 1968, Dragoo et al. 1993). Information on the basic spatial ecology of the species is based on two studies: one conducted in Iowa on an agricultural landscape in the 1940s, during which time the species was common (Crabb 1948) and one that examined habitat use and home range size of four males in the Missouri Ozarks (McCullough and Fritzell 1984). Thus knowledge of habitat selection, such as whether the eastern spotted skunk is a forest, prairie, or edge-associated species, remains superficial. Crabb (1948) believed the species to be a prairie adapted species while McCullough (1983) suggested a preference for forest habitats. Location of four captures led Reed and Kennedy (2000) to believe the species to be associated with dense undergrowth. Mammal reference sources report wetlands and dense timber stands are avoided (Sealander and Heidt 1990, Nowak 1999) and that habitat is selected to avoid predators (Kinlaw 1995). Telemetry work in southern Missouri (McCullough 1983, McCullough and Fritzell 1984) provided some baseline information suggesting habitat selection of forest rather than open habitats, but this work was limited by small sample sizes. A more detailed assessment of the factors affecting space use by eastern spotted skunks is needed. The objective of this study was to quantify the seasonal home range dynamics and habitat selection of eastern spotted skunks in the Ouachita Mountains of western Arkansas.

STUDY SITE

This study was conducted in the Poteau Ranger District (PRD; 96,755 ha), Ouachita National Forest (ONF; 690,000 ha), Scott County, Arkansas (15 376663E 3852595N), where recent field work unrelated to skunks indicated an extant eastern spotted skunk population (B. Sasse, Arkansas Game and Fish Commission, personal communication; R. Perry, U.S. Forest Service, personal communication; Figure 1). The Ouachita Mountain physiographic region is located in west-central Arkansas and southeastern Oklahoma. Mountain ridges were formed from sedimentary rock formations compressed into great folds. Linear ridges reach maximum elevations of about 790 m and trend east-west. The climate is one of warm winters, hot, dry summers, an average temperature of 17° C, and average annual precipitation of 105 cm. The dry sandstone ridges and south and west aspects of the Ouachita Mountains are covered with as much as 40% shortleaf pine (*Pinus echinata*), and 73% of the study site is managed as shortleaf pine stands. Hardwoods (*Quercus* spp. and *Carya* spp.) dominate the rich alluvial soil bottom lands of the valleys and north aspects of the mountains (Bailey 1980).

The study site has been intensively managed to meet a shortleaf pine – bluestem (*Andropogon* spp and *Schizachyrium* spp) restoration objective. In 1979 the U.S. Forest Service (USFS) began a large-scale ecosystem management project to restore the shortleaf pine-bluestem grass ecosystem on 62,730 ha in the ONF (USDA 1996). To provide habitat for a recovered population of federally endangered red-cockaded woodpeckers (*Picoides borealis*), this management program creates an open canopy with dead debris and herbaceous vegetation in the understory (Lochmiller et al. 1994, Bukenhofer and Hedrick 1997, Masters et al. 1998). Ecosystem restoration and maintenance is accomplished by reducing tree basal areas through commercial and non-commercial thinning of shortleaf pine stands and increasing the use of prescribed fire (Bukenhofer et al. 1994, Bukenhofer and Hedrick 1997). Additionally, the USFS has increased shortleaf pine stand rotation age from 70 to 120 years, which increases the number of fungal heart rot (*Phellinus pinii*) infected shortleaf pine trees, an important habitat characteristic of the cavity-dependent red-cockaded woodpecker (USDA 1996, Bukenhofer and Hedrick 1997). Another management technique used in the PRD is the retention of streamside management zones (SMZs) within the intensively managed shortleaf pine stand mosaic. SMZs are managed natural hardwood forest stands retained along intermittent and perennial streams (Miller et al. 2004) and account for 87% of the hardwood management stands in the study site.

We defined the extent of the study area using a minimum convex polygon around the collection of study animal home ranges, resulting in an 8784 ha study site (Figure 2). We defined habitat patches within the study area based on age and forest management practices, which are homogenous with respect to the following variables: young (0-30 years old) shortleaf pine (23% of the study site), middle-aged (31-70 years old) shortleaf pine (6%), mature (>70 years old) shortleaf pine (44%), hardwood (16%), private (property not government owned; 7%), and other (those habitats occurring in low proportions; 4%). Private property is primarily young forest or open pasture land, and other habitat includes mixed pine (*Pinus* spp) – hardwood and loblolly pine (*Pinus taeda*) stands. The relatively low proportion of middle-aged shortleaf pine in the study site is a result of historical timber harvest practices (W. Montague, pers. comm.). These delineations are well defined and monitored by the USFS, and good historic data exists on their origin, exact location, and maintenance (Figure 2).

METHODS

Capture

We conducted a telemetry-based study from March 2005-January 2007 to determine resource selection and home range dynamics of eastern spotted skunks. We captured eastern spotted skunks, fitted them with radio transmitters, and tracked them for the duration of the study, or until mortality of the study animal occurred. If a radiocollared eastern spotted skunk died, we determined the cause of death and recorded the location. We attempted to capture an equal number of males and females for radio transmitter attachment and collect ≥30 locations per 3-month calendar season for each animal (Seaman et al. 1999, Leban et al 2001). For trapping, anesthetizing, and handling skunks, we followed University of Missouri Animal Care and Use Protocol #4039 and carried out all field work out under Arkansas Game and Fish Commission permit #111520042. We trapped eastern spotted skunks with Tomahawk #103 live traps (Tomahawk Live Traps, Tomahawk, WI 54487) dispersed throughout study site. We used burlap and leaf litter to cover traps and various canned fish and commercial fruit-scented paste lures as bait. We checked traps daily between 0600 and 0800. To anesthetize captured eastern spotted skunks, we used an intramuscular injection of a combination of 10:1 ratio ketamine hydrochloride (10 mg/kg) and xylazine (1 mg/kg), and ear tagged animals in each ear with 1005-1 ear tags (Hasco Tag Company, Dayton, KY 41074). We weighed skunks to the nearest 5g using a 2500g spring scale, measured (total body, head/body, and tail length), sexed, and aged by body size, tooth wear, and prior capture history. We fitted each eastern spotted skunk with a 12g ATS Model 1730 radio transmitter (Advanced Telemetry Systems, Isanti, MN 55040) prior to release at the capture site.

Radio Telemetry

We used ground-based triangulation radio telemetry techniques to estimate the location of collared individuals. Radio locations collected from an animal must provide an unbiased representation of the trajectory they sample and should be collected equally throughout all time periods (Aebischer et al. 1993). Thus, a 28-hour location interval was chosen because it is not a multiple of a known cycle in eastern spotted skunk behavior and provided an approximate equal number of daytime and nighttime locations, which we assumed to be independent. Triangulation was achieved by obtaining directional azimuths, using a three-element Yagi antenna and compass, from three or more known locations remote to the collared animal’s position (White and Garrott 1990, Kenward 2001). To reduce error due to movements by the animal, we collected all data for each location within seven minutes.

We conducted a detailed telemetry error study to estimate precision of directional azimuths (White and Garrott 1990, Withey et al. 2001) by collecting 134 location estimates from 476 azimuths. We determined directional error in two ways. First, we placed five transmitters 10 cm off the ground at locations unknown to the observer throughout the study area, and a total of 60 directional bearings were obtained for each transmitter from four known locations during 15 days (White and Garrott 1990, Withey et al. 2001). Second, prior to tracking 13 eastern spotted skunks to 59 different den sites, we recorded 176 azimuths from known locations. Combining the results of the two methods above, we estimated the precision of telemetry bearings to be 1.08º (± 0.48 SE).

Home Range Analysis

We estimated each location for a triangulation event using Lenth's maximum likelihood estimate (MLE) in program GTM236 (Sartwell 2000, White and Garrott 1990). To account for telemetry error, we excluded from analyses all individual locations with error ellipses larger than the mean study site stand size of 14.3 ha. Only those animals with ≥30 locations for at least one season were used to estimate utilization distributions (UDs) given the potential bias associated with home range estimations based on small sample sizes (Seaman et al. 1999). We computed fixed kernel UDs with "plug-in" procedures for smoothing using the "Kde folder" in Matlab (The Mathworks Incorporated, Natick, MA 01760; Beardah and Baxter 1995, Gitzen et al. 2006). We delineated 95% contours of the seasonal UDs using ArcGIS 9.1 (Environmental Systems Research Institute, Redlands, CA 92373), based on volume. We used two-way analysis of variance (ANOVA) and least squares means to evaluate differences in gender home range size and to compare mean home range sizes between all seasons.

Home Range Overlap

We calculated the Volume of Intersection (*VI*) Index statistic to assess eastern spotted skunk space use sharing and site fidelity (Kernohan et al. 2001, Millspaugh et al. 2004). The *VI* measures the degree of overlap between a pair of individual UDs (e.g. spring 2005 and summer 2005) by:

$$VI = \int \int \min[\hat{f}_1(x, y), \hat{f}_1(x, y)]dxdy$$

where $\hat{f}_1$ is the UD of animal 1 and $\hat{f}_2$ is the UD for animal 2. The *VI* score ranges between 0 (no overlap) and 1 (complete overlap). To evaluate animal site fidelity we calculated the *VI* score for all possible combinations of seasonal UDs within all animals. We evaluated degree of inter- and intrasexual territoriality by calculating *VI* scores for all pairs of animals tracked during the same season and year. We omitted from subsequent analyses any pair of non-adjacent individuals with *VI* scores of <0.02. We used two-way ANOVA and least squares means determine differences in animal site fidelity, inter- and intrasexual, and seasonal differences in *VI* scores.

Habitat Selection Analysis

We assessed second-order habitat selection by comparing habitat composition within the home range to the available habitat within the study area (Johnson 1980, Aebischer et al. 1993). We treated individual skunks as the experimental unit to avoid pseudoreplication (Otis and White 1999, Erickson et al. 2001). We used compositional analysis (Aebischer et al. 1993) with the Millspaugh et al. (2006) modification that assigns use values based on the UD. We defined an individual's habitat use as the proportion of UD volume by habitat type within that individual's home range (Millspaugh et al. 2006). Half of the available habitat types (middle-aged shortleaf pine, private property, other) were prevalent in low proportions in the study site, thus most radiocollared eastern spotted skunks had zero use of at least one habitat type. To reduce the probability of Type I error, we substituted 0.3% for all zero habitat use values (Bingham and Brennan 2004). Study habitat types (younger shortleaf pine, middle-aged shortleaf pine, mature shortleaf pine, hardwood, private property, other) were defined by habitat class categories that encompass the study area and then ranked using compositional analysis (Aebischer et al. 1993).

RESULTS

Home Range Size

From March 2005 to November 2006, we captured 33 eastern spotted skunks (17 M, 16 F) during 12,970 trap nights. Of these, 23 animals (12 males, 11 females) had ≥ 30 locations for ≥ 1 season with a mean of 106 (± 13 SE, range = 34-226, *n* = 2441) total locations per individual. We tracked 11 (6 M, 5 F) eastern spotted skunks during spring and summer, 16 (8M, 8 F) during the autumn, and nine (5 M, 4 F) during the winter (Table 1). In our study, eastern spotted skunk home range size was dependent on gender and season (i.e. gender-by-season interaction) ($F_{3,44} = 6.89$, $P = 0.0008$; Table 1). Male spring home ranges were >6 times larger than female spring home ranges (Table 1, Figure 2). Further, male home ranges were also ≥2 times larger than female home ranges during winter and summer, but not autumn (Table 1). With the exception of summer, we also observed greater seasonal variation in male home range size compared to female home ranges (Table 1).

Male home ranges were ≥5 times larger in spring than any other season ($F_{3,39}$ = 11.50, P = <0.0001) (Table 1, Figure 2). Conversely, we observed little difference in female home ranges by season (Table 1, Figure 2). Male home ranges increased from autumn to winter and again in spring, then decreased from spring to summer (Table 1, Figure 2). Female home ranges followed a similar, albeit a less dramatic seasonal pattern in size (Table 1, Figure 2). Of the five females tracked during the summer, all were adults and four were known to have raised young. The one nonbreeding female home range size of 52 ha was similar to the mean of all summer tracked females.

Home Range Overlap

Eastern spotted skunks displayed little space use overlap between individuals. The mean *VI* score across all pairs of animals and seasons (n = 167) was 0.02 (± 0.005 SE, Range 0.00-0.60, Table 2). We found no intra- or intersexual difference by season in space use ($F_{8,30} = 0.75$, $P = 0.6446$, Table 2). Male-male and male-female UD overlap was the greatest during the spring when male home range sizes increase (Table 1-2). With the exception of autumn, we observed no space use overlap among females (Table 2). The higher mean female intrasexual *VI* score for autumn was influenced by one pair with large overlap that may have been a mother-offspring dyad (Table 2).

We observed a moderate degree of site fidelity by eastern spotted skunks. The mean *VI* score across all pairs of seasons for every animal (n = 26) was 0.32 (± 0.029 SE, Range 0.066-0.623). Neither gender nor season affected the degree of site fidelity by eastern spotted skunks ($F_{7,18} = 1.44$, $P = 0.251$). Male site fidelity fluctuated less than did female fidelity (Figure 3). Female site fidelity was greatest during autumn through spring, and then decreased between spring and autumn (Figure 3). The variation in the degree of female site fidelity was greatest between summer and winter (Figure 3).

Habitat Selection

We observed a consistent pattern of habitat selection across all seasons by eastern spotted skunks (Figure 4). Younger (0-30 years old) shortleaf pine habitat was ranked highest in all seasons and was selected over all other habitats, except hardwoods during winter and spring (Table 3). Hardwood stands ranked second to younger shortleaf pine stands during each season (Table 3). During autumn and winter, hardwood stands were selected over all other habitat types except young shortleaf pine stands (Table 3, Figure 5). Mature (>70 years old) shortleaf pine habitat ranked third in all seasons, but was only selected in autumn when compared with private and middle aged pine stands (Table 3). "Other", private, and middle aged (31-70 years old) pine stands ranked low during all seasons; however, "Other" habitats were selected over middle aged pine stands and private land during autumn. Strong patterns of avoidance or selection of particular stand types can be inferred from the locations and associated home range boundaries of individual skunks (Figure 5).

DISCUSSION

Eastern spotted skunk home range dynamics appear to be influenced by habitat availability during the nonbreeding season and mating tactics during the breeding season, as reported for other small carnivores (Erlinge and Sandell 1986, Sandell and Liberg 1992, Gehring and Swihart 2004, King and Powell 2007). Male eastern spotted skunk home ranges were larger than female home ranges and increased significantly during the spring, as also observed by McCullough and Fritzell (1984) and Crabb (1948). Conversely, female home range size varied less throughout the year, and this variance is perhaps a function of food availability and distribution. Although male home ranges should be larger than female home ranges because of increased energetic requirements for larger body size (Sandell 1989, Gompper and Gittleman 1991, Appendix 1), we observed a disproportionate difference in male and female home range sizes. Male summer and winter ranges were 2.35 and 2.47 times larger, respectively, than female ranges. Such differences between male and female summer and winter home ranges may be due to resource scarcity and the compounded effects on males of the patchiness of selected habitat availability (Figure 2).

The pronounced change in male home range size during the breeding season can be attributed to a mating tactic. The largest home ranges were not found in winter when resources should be scarcest, but rather in spring, the breeding season for the species (Mead 1968). In solitary carnivore species males can maximize their fitness by adopting one of two alternative mating strategies: either they remain in their home ranges and try to monopolize several females, or they roam and compete for access to each female that enters estrus (Sandell 1989). The best mating tactic when females are densely and evenly distributed should be to maintain exclusive male home ranges. In such a system, little seasonal variation in male home range size should be observed (Sandell and Liberg 1992). However, females are not evenly distributed in the ONF because habitat is patchy (Figure 2). Thus, in the ONF we hypothesize that the mating system of the eastern spotted skunk is similar to many small mustelids, where males increase home range size in search of reproductive females (Erlinge and Sandell 1986, Sandell and Liberg 1992, Gehring and Swihart 2004).

Although male eastern spotted skunk spring home ranges are unusually large for their body size, male and female home ranges during the nonbreeding season are typical of what has been reported for other similar sized or closely related carnivores (Lindstedt et al. 1986, Crooks 1994, Carroll 2000, Doty 2004, Gehring and Swihart 2004, Jachowski 2007, King and Powell 2007). During the breeding season, males expand their search area because their decisive resource changes from predictably located habitat and prey items during the nonbreeding season to a more dispersed resource, reproductive females (Erlinge and Sandell 1986).

Although not as pronounced during the mating season, eastern spotted skunks appear to have some degree of territorially that influences the spatial distribution of adults throughout the year (Sandell 1989). Given the low inter- and intrasexual overlap observed and a lack of communal denning (Chapter 2), eastern spotted skunks can be legitimately characterized as a solitary carnivore. Some of our home range overlap results may be limited by small sample size (Table 2). However, we believe these data significantly improve our understanding of eastern spotted skunk spacing patterns and extent of asociality. We observed more intersexual overlap than intrasexual overlap, with the highest intersexual overlap observed during spring. The later results further support our hypothesis that males are roaming in search of mating encounters during the breeding season and male spacing is influenced by female distribution. As with many mustelids, our data suggest that eastern spotted skunks demonstrate intrasexual territoriality, especially in females (Powell 1979, King and Powell 2007). Indeed, we observed no female intrasexual overlap during spring, summer, or winter. Sandell (1989) predicted that female solitary carnivores should maintain exclusive territories when resources are relatively stable, a pattern observed here. The only female intrasexual overlap observed was during the autumn and the *VI* score was strongly influenced by a single adult-subadult pair overlap that was possibly a mother-daughter dyad.

We observed the dispersal of one male in the spring after his capture as a subadult. The animal was captured and fitted with a radio transmitter in October, 2005. The following April, the animal dispersed 6.5 km in less than 48 hours and during the following summer established a territory 9.8 km from it's winter range. The animal was not observed to return during the course of the study, thus we considered it a dispersing juvenile.

We observed consistent second order selection by eastern spotted skunks for younger shortleaf pine patches, which were the only prevalent early successional habitat in the study site. The selection was strong annually, but was especially strong during the nonbreeding seasons of summer, autumn, and winter. In general, eastern spotted skunks do not appear to select specifically for pine forest types given that populations have been found in a variety of habitats (Crabb 1948, McCullough and Fritzell 1984, Kinlaw 1990, Reed and Kennedy 2000), and we also observed selection of hardwood stands. Further, selection of shortleaf pine patches weakens as the stand age increases. The multitude of habitats utilized by this species and the age component of selected pine stands suggests that eastern spotted skunks are not selecting a habitat type per se, but rather base selection on other criteria such as forest structure.

Similar to habitat selected by of other small carnivores (Carey and Kershner 1996, Buskirk and Powell 1994, Carroll 2000, Doty and Dowler 2006, King and Powell 2007), forest with closed canopy or dense underbrush are apparently critical features of eastern spotted skunk habitat (Chapter 2). Further, we found no use of areas devoid of overhead cover, thus, the species may be intolerant of such vegetation types. The use of sites with closed canopy or dense understory may reduce the risk of predation. The primary predators of eastern spotted skunks appear to be owls and mesocarnivores (Kinlaw 1995). Indeed, during this study we observed 18 mortalities of radiocollared eastern spotted skunks. Most mortality events were avian-caused and occurred in mature shortleaf pine-bluestem habitat (D. Lesmeister, unpublished data). Compared to the dominant habitat type in the study site (mature shortleaf pine), young shortleaf pine habitat seems to be a less preferred habitat for potential eastern spotted skunk predators such as coyote (*Canis latrans*), bobcat (*Lynx rufus*), and great horned owl (*Bubo virginianus*) which prefer more open habitats over young dense forest (Litvaitis and Shaw 1980, Ganey et al. 1997, Smith et al. 1999, Chamberlain et al. 2003). Thus, the open canopy conditions of mature shortleaf pine-bluestem habitat may be favorable to eastern spotted skunk predators and thereby detrimental to eastern spotted skunks.

Although mature shortleaf pine-bluestem appears to be suboptimal eastern spotted skunk habitat, it is optimal habitat of the endangered and sympatric red-cockaded woodpecker (Kalisz and Boettcher 1991, Bukenhofer et al. 1994, Walters et al. 2002). Low densities of small and medium-sized pines, moderate densities of large pines, and herbaceous ground cover of mature shortleaf pine-bluestem habitat are goals for red-cockaded woodpecker management. Mature pines are important to red-cockaded woodpecker management for foraging and nesting habitat because fungal heart rot aids in cavity creation and is more prevalent in pine trees older than 70 years (Bukenhofer and Hedrick 1997, Walters et al. 2002). There has been interest in understanding the impacts of red-cockaded woodpecker management on other species of conservation concern

(Thill et al. 2004) such as eastern spotted skunks, yet this has not been the focus of any detailed work. Some data suggest other species have been inadvertently affected by management decisions designed to promote red-cockaded woodpecker population growth (Thill et al. 2004). However, most studies concerning non-target species have considered only commercially thinning, midstory reduction and prescribed fire primarily in mature stands without simultaneously considering other forest age classes (Wilson et al. 1995, Masters et al. 1998, Cram et al. 2002, Thill et al. 2004). There may be many other unknown impacts on other non-target species found in the same habitats (NRC 1995).

Eastern spotted skunks and red-cockaded woodpeckers are sympatric in the Ouachita Mountains and have vastly different habitat needs, so intensive management for one of these two species will likely create suboptimal habitat for the other. Management for red-cockaded woodpecker is so intensive in the ONF study site that we were unable to assess eastern spotted skunk selection or avoidance of forest stands that have been subject to several typical habitat management techniques. For instance, treatments such as wildlife stand improvement (WSI) or precommercial thinning and prescribed burning are so commonly used in the shortleaf pine – bluestem management area that few forest stands have not been regularly subject to one or both techniques. Yet, understanding how eastern spotted skunks and red-cockaded woodpeckers respond to these treatments may be an avenue for identifying habitat management strategies that simultaneously benefit both species.

MANAGEMENT IMPLICATIONS

Our data suggest that young or dense forest stands are preferred by eastern spotted skunks. Managers should be aware that stand age alone may not be driving skunk habitat selection. Rather, younger stands may simply possess structural characteristics and complexity that offer reduced risk of predation. Thus, management for this species should focus on providing early successional forest or forest which provides both complex woody vegetative understory structure as well as a closed canopy. Our results also imply that survey efforts for this species should incorporate sites with similar complex habitat structure, and that during spring the presence of males will likely be detected in a greater variety of habitats than other seasons (see also Hackett et al. 2007). Coupled with the strong selection for young forest habitat, the unusually large spatial requirements of males in spring place these individuals at risk to predators where forest management practices create large-scale increases of mature open canopy in the forest mosaic or where younger forest stands are relatively small and isolated such that males must traverse older forest stands when searching for potential mates. While mature shortleaf pine – bluestem restored stands have a woody shrub component in the understory, it is likely not dense enough to provide adequate protection from predators. Further, given that creating large areas of mature shortleaf pine-bluestem habitat is a management goal for enhancing the likelihood of red-cockaded woodpecker persistence in ONF, managers should recognize that such habitat management strategies reduce the amount of quality habitat available for eastern spotted skunks. The apparent dichotomy between woodpecker and skunk habitat enhancement strategies has the potential to mirror conflicts that have recently arisen for management of other species of conservation concern (e.g. Roemer and Wayne 2003). Thus managers should simultaneously consider the needs of both species when creating habitat management plans (NRC 1995). We recognize that pine regeneration is a critical aspect of red-cockaded woodpecker management; however our results suggest that the increase of stand rotation age from 70 to 120 years reduces the amount of young forest, and thereby optimal eastern spotted skunk habitat. However, older forest stands may be suitable for eastern spotted skunks if they contain a dense woody understory. Currently, however, techniques such as WSI and mechanical thinning reduce midstory, and prescribed fire reduces the density of woody understory species and enhance the restoration of a bluestem-dominated herbaceous ground cover. Reducing the regularity of such mid- and understory management techniques may offer an opportunity to enhance spotted skunk habitat with minimal negative effects on red-cockaded woodpeckers.

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Table 1. Fixed kernel home ranges in ha (95% of utilization distribution volume) by season and gender for eastern spotted skunks in the Ouachita Mountains, Arkansas, 2005-2006. Rows represent sample size (*n*), mean (SE), and range of home range estimates. We based analyses on two samples (years) for autumn, spring, and summer, and one sample for winter.

	Season			
	Autumn	Winter	Spring	Summer
Male				
n[a]	8	5	6	6
$\bar{x}$ (SE)	76(22)	175(62)	866(235)	142(21)
Range	19-206	37-404	222-1824	89-224
Female				
n[a]	8	4	5	5
$\bar{x}$ (SE)	65(7)	71(25)	135(30)	54(24)
Range	31-90	27-136	31-192	21-148

[a] Total number of home ranges by gender used to calculate home range size.

Table 2. Sample size (*n*), mean (SE), and range of Volume of Intersection (*VI*) scores between each pair of eastern spotted skunk utilization distributions by season and gender in the Ouachita Mountains, Arkansas, 2005-2006. We based analyses on two samples (years) for autumn, spring, and summer, and one sample for winter.

	Season				
	Autumn	Winter	Spring	Summer	All seasons[d]
Male-Male[a]					
n[b]	16	10	7	7	40
$\bar{x}$[c](SE)	0.01(0.01)	0.00(0.00)	0.03(0.02)	0.00(0.00)	0.01(0.01)
Range	0.00-0.09	0.00-0.02	0.00-0.17	0.00-0.02	0.00-0.17
Male-Female[a]					
n[b]	44	16	16	16	92
$\bar{x}$[c](SE)	0.03(0.01)	0.00(0.00)	0.04(0.02)	0.01(0.01)	0.03(0.01)
Range	0.00-0.25	0.00-0.03	0.00-0.25	0.00-0.12	0.00-0.25
Female-Female[a]					
n[b]	21	6	4	4	35
$\bar{x}$[c](SE)	0.04(0.03)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.03(0.02)
Range	0.00-0.60	0.00-0.00	0.00-0.00	0.00-0.00	0.00-0.60

[a] Gender-gender interaction where Male-Male, Male-Female, Female-Female refers to the overlap of male, male and female, and female utilization distributions.

[b] Total number of pairs of individuals with temporal and possible spatial overlap.

[c] Mean *VI* score of all possible spatial overlaps during the season.

[d] Total number of pairs (*n*), mean (SE), and range of *VI* scores for all seasons.

Table 3. Matrices and habitat ranking of eastern spotted skunk resource selection in the Ouachita Mountains, Arkansas, 2005-2006. The sign of the *t*-values is indicated with + or – signs, +++ and --- represent significant deviation from random at *P*<0.05. Lower ranks indicate higher level of selection.

Habitat type	SLP 0-30[a]	SLP 31-70[b]	SLP >70[c]	Hard-wood[d]	Private[e]	Other[f]	Rank
Autumn							
SLP 0-30	.	+++	+++	+++	+++	+++	1
Hardwood	---	+++	+++	.	+++	+++	2
SLP >70	---	+++	.	---	+++	+	3
Other	---	+++	-	---	+++	.	4
SLP 31-70	---	.	---	---	+	---	5
Private	---	-	---	---	.	---	6
Winter							
SLP 0-30	.	+++	+++	+++	+++	+++	1
Hardwood	-	+++	+++	.	+++	+++	2
SLP >70	---	+	.	---	+	+++	3
Private	---	+	-	---	.	+	4
SLP 31-70	---	.	-	---	-	+	5
Other	---	-	---	---	-	.	6

Spring							
SLP 0-30	.	+++	+++	+	+++	+++	1
Hardwood	-	+	+++	.	+	+++	2
SLP >70	---	+	.	---	+	+	3
SLP 31-70	---	.	-	-	+	+	4
Private	---	-	-	-	.	+	5
Other	---	-	-	---	-	.	6
Summer							
SLP 0-30	.	+++	+++	+	+++	+++	1
Hardwood	-	+	+++	.	+	+++	2
SLP >70	---	+	.	---	+	+	3
SLP 31-70	---	.	-	-	+	+	4
Private	---	-	-	-	.	+	5
Other	---	-	-	---	-	.	6

[a] Shortleaf pine (*Pinus echinata*) stands 0 to 30 years old.

[b] Shortleaf pine stands 31 to 70 years old.

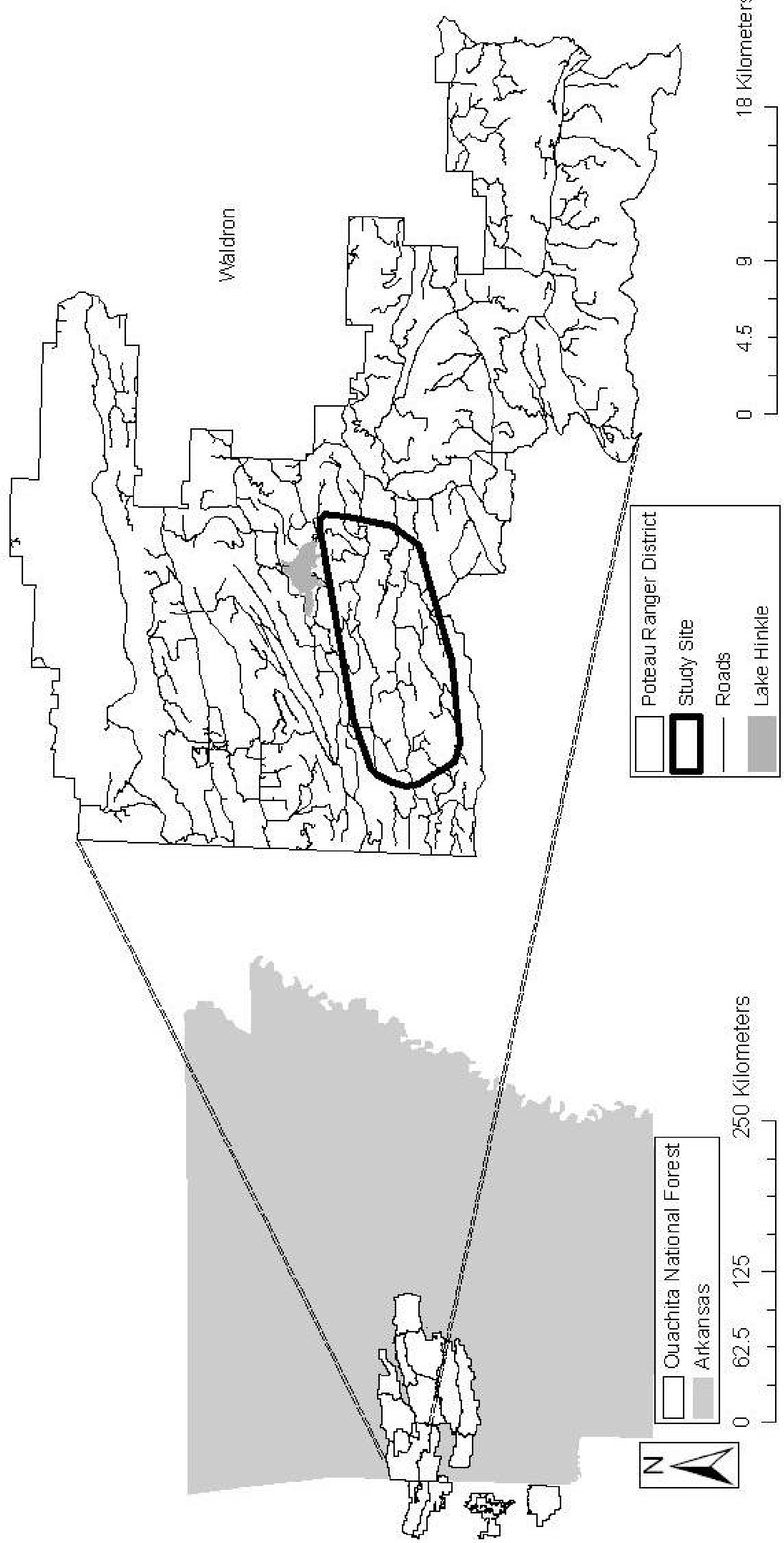
[c] Shortleaf pine stands over 70 years old.

[d] Hardwood stands (*Quercus* spp. and *Carya* spp.).

[e] Private property, which is primarily young forest or open pasture land

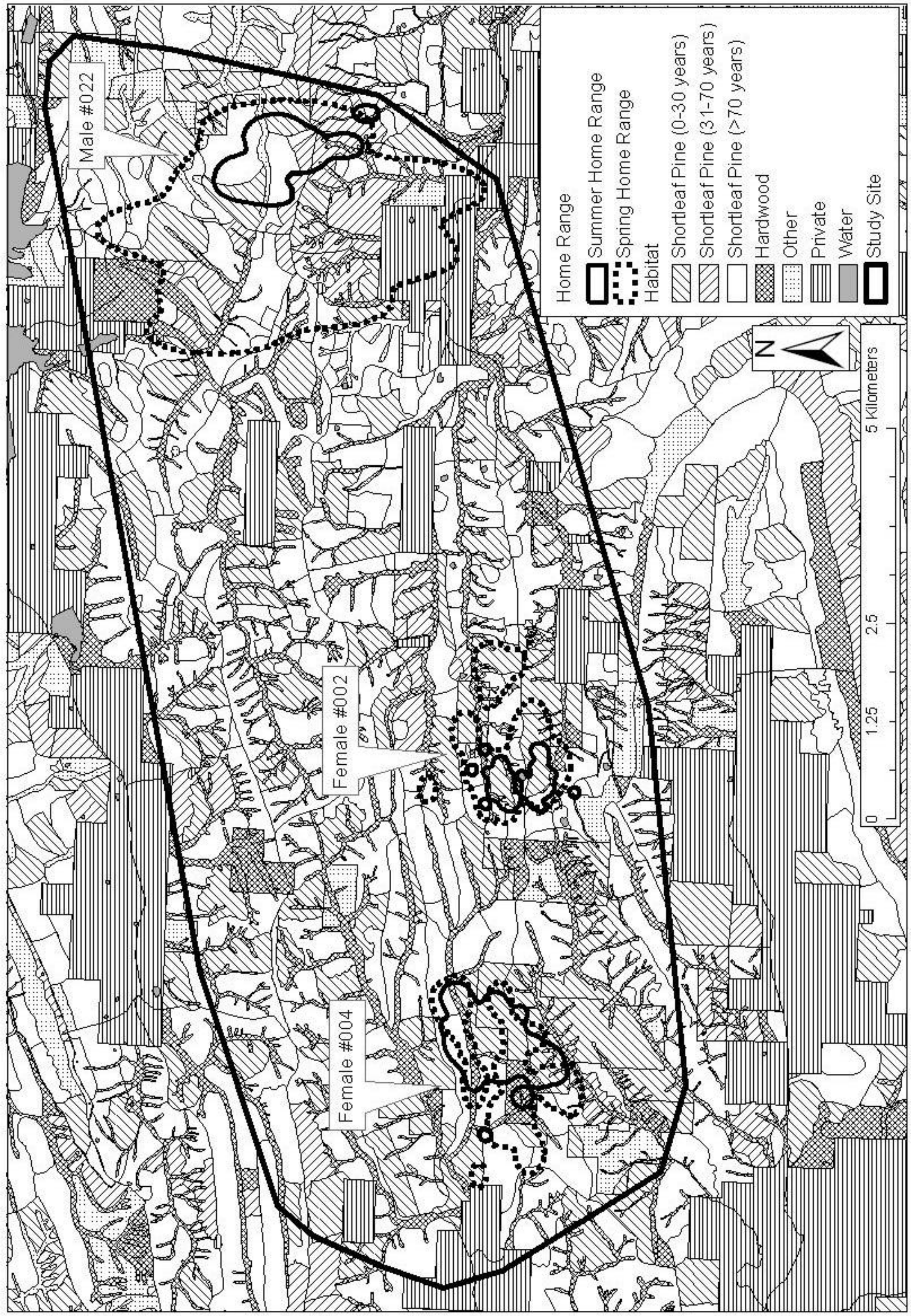
[f] "Other" habitat, includes mixed pine (*Pinus* spp) – hardwood and loblolly pine (*Pinus taeda*) stands.

Figure 1. A map of eastern spotted skunk study site (expanded) in west-central Arkansas, Poteau Ranger District (expanded), Ouachita National Forest, 2005-2006. Boundary of the 8784 ha study site is the minimum convex polygon around the collection of study animal home ranges.



Waldron
18 Kilometers
0
4.5
9
Poteau Ranger District
Study Site
Roads
Lake Hinkle
Ouachita National Forest
Arkansas
0
62.5
125
250 Kilometers
N

Figure 2. Eastern spotted skunk study site (8784 ha), Ouachita National Forest, Arkansas, 2005-2006. Boundary of the study site is the minimum convex polygon around the collection of study animal home ranges. Overlaid on forest stand management layer are two female and one male spring and summer home ranges. Habitat types: shortleaf pine (*Pinus echinata*) stands 0-30 years old, shortleaf pine stands 31-70 years old, shortleaf pine stands over 70 years old, hardwood stands (*Quercus* spp. and *Carya* spp.), "other" (mixed pine (*Pinus* spp) – hardwood and loblolly pine (*Pinus taeda*) stands, and private property.


Male #022
Female #002
Female #004
Home Range
Summer Home Range
Spring Home Range
Habitat
Shortleaf Pine (0-30 years)
Shortleaf Pine (31-70 years)
Shortleaf Pine (>70 years)
Hardwood
Other
Private
Water
Study Site
N
0
1.25
2.5
5 Kilometers

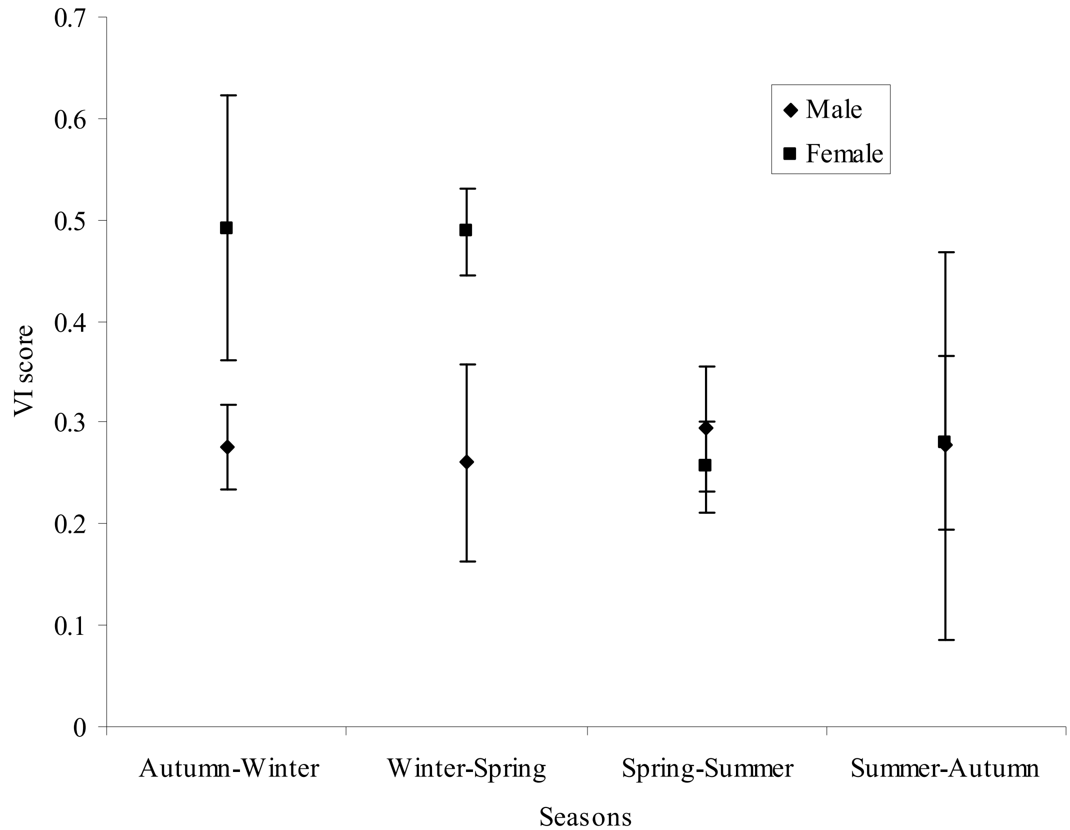
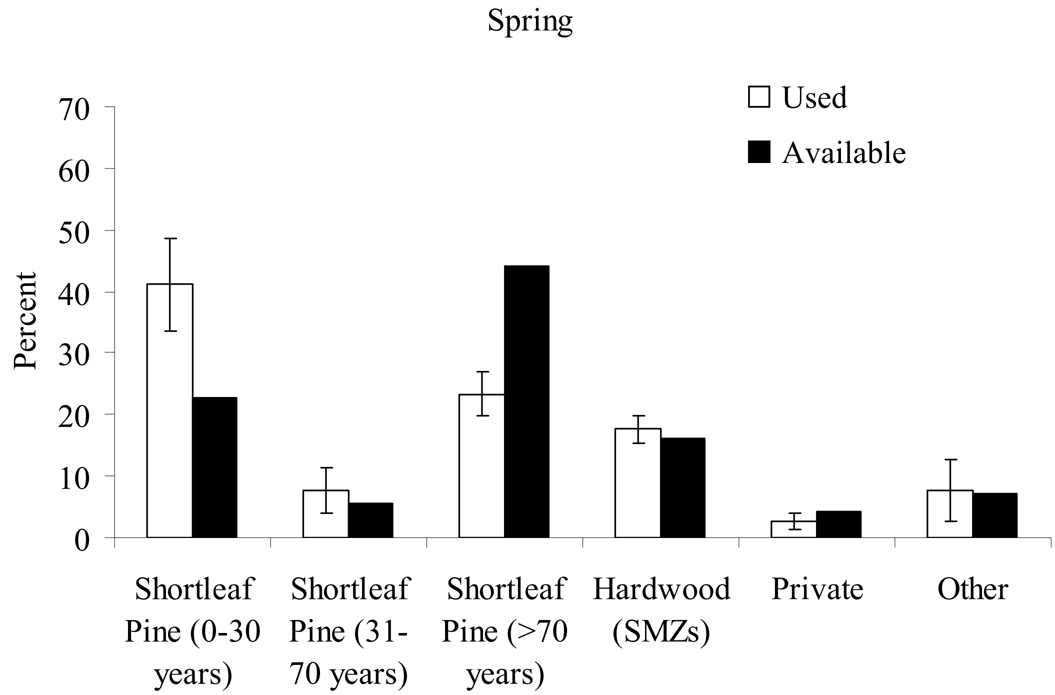
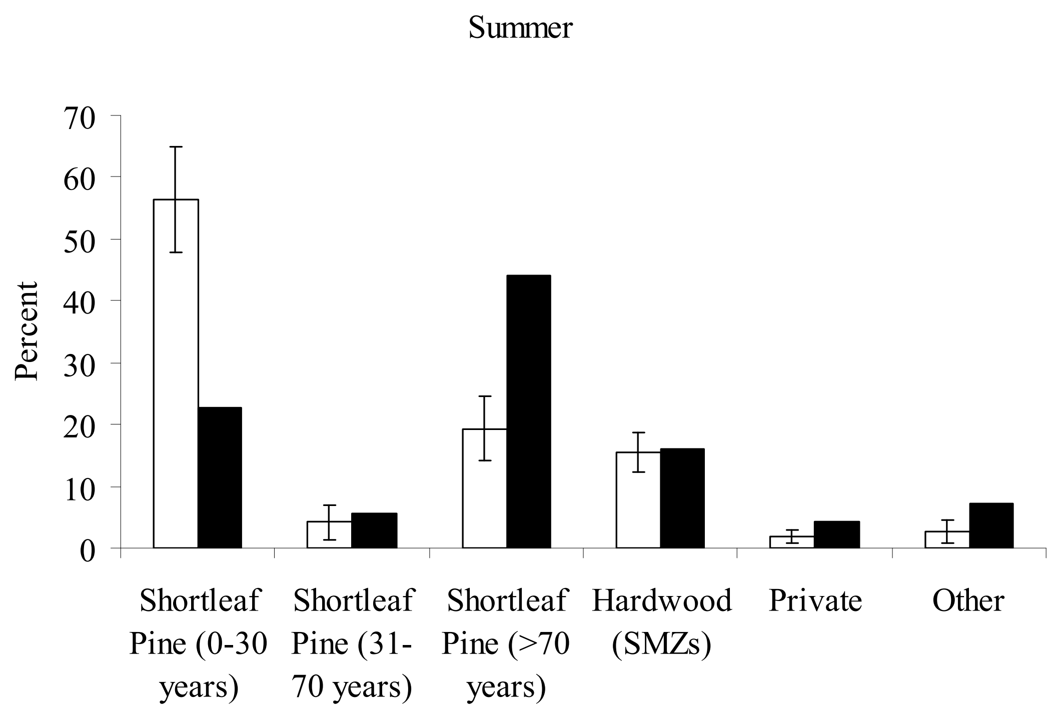


Figure 3. Eastern spotted skunk site fidelity between temporally adjacent seasons in the Ouachita Mountains, Arkansas, 2005-2006. Presented are the measured seasonal volume of intersection (*VI*) scores (± SE). Data are subdivided by season and gender. Sample sizes are: autumn-winter, 4 M, 2 F; winter-spring, 3 M, 3 F; spring-summer 5 M, 4 F;, summer-autumn, 2 M, 3 F.


Spring
Used
Available
70
60
50
40
30
20
10
0
Percent
Shortleaf Pine (0-30 years)
Shortleaf Pine (31-70 years)
Shortleaf Pine (>70 years)
Hardwood (SMZs)
Private
Other


Summer
70
60
50
40
30
20
10
0
Percent
Shortleaf Pine (0-30 years)
Shortleaf Pine (31-70 years)
Shortleaf Pine (>70 years)
Hardwood (SMZs)
Private
Other

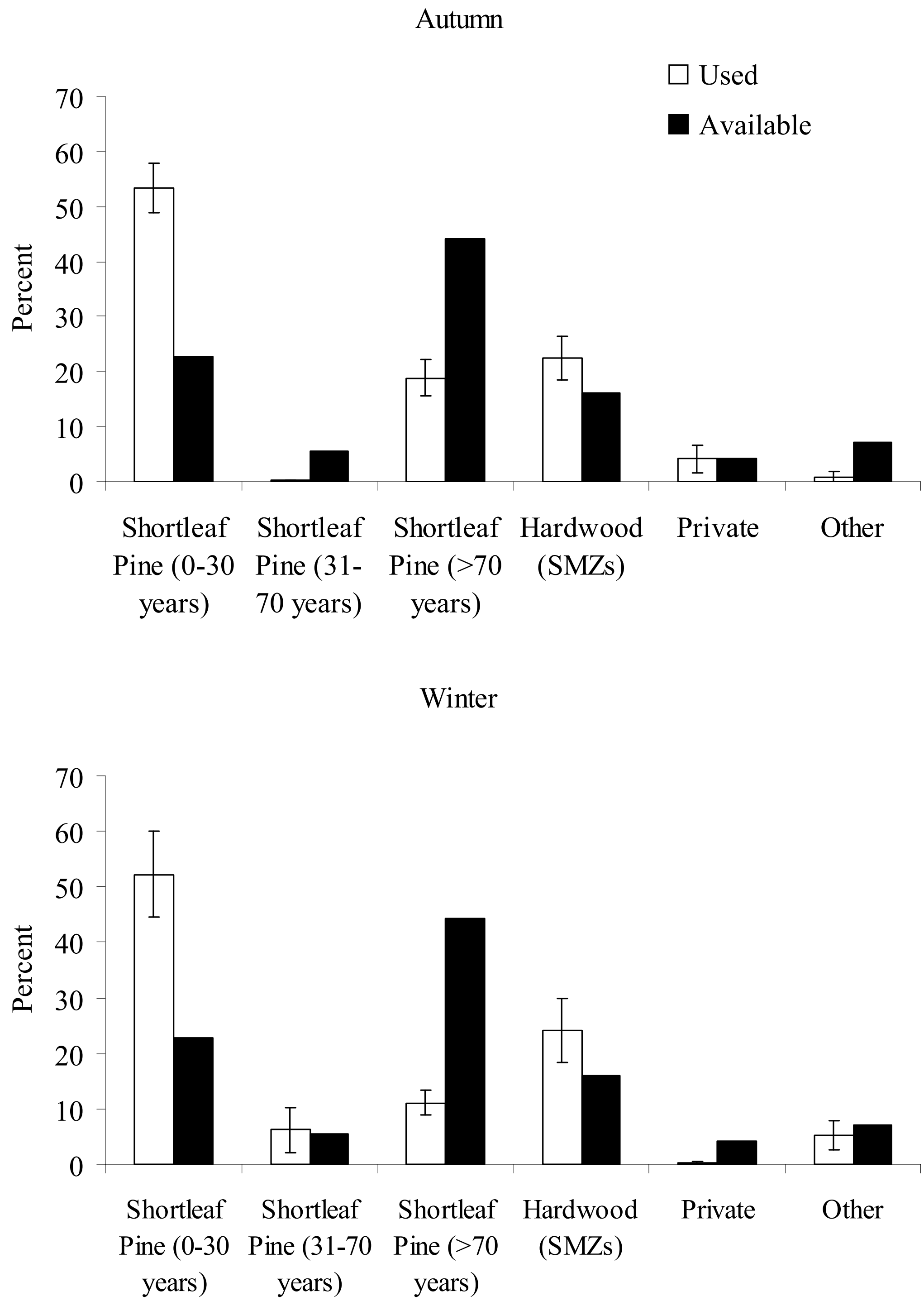


Figure 4. Eastern spotted skunk seasonal percent use (± SE) of habitat types compared to percent available within the study site, Ouachita Mountains, Arkansas, 2005-2006.

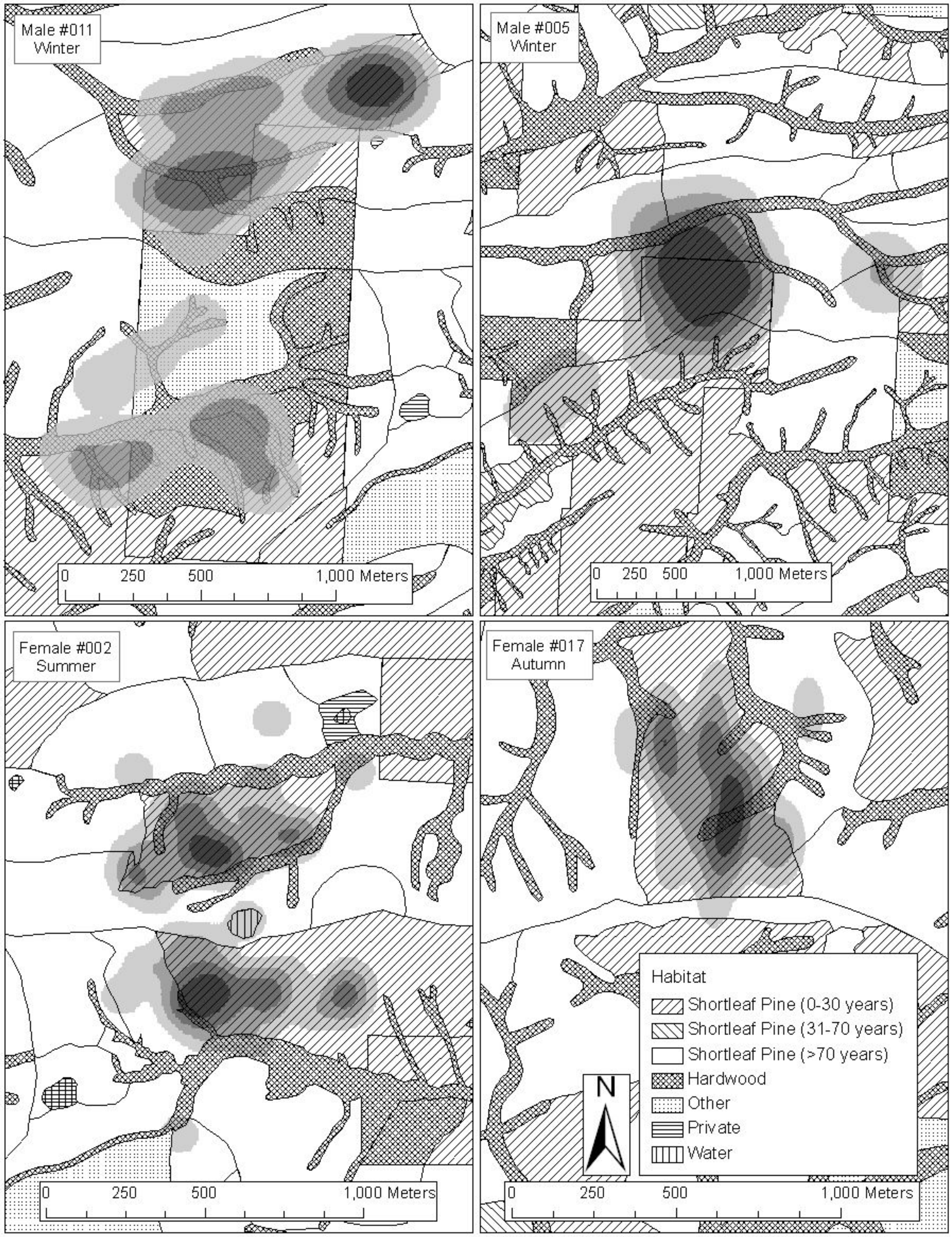


Figure 5. 95% utilization distributions (darker areas are higher use) for eastern spotted skunks superimposed over habitat management maps in the Ouachita Mountains, Arkansas. Females were tracked in 2005, males in winter 2005-2006.

CHAPTER 2

SUMMER RESTING AND DEN SITE SELECTION BY EASTERN SPOTTED SKUNKS IN THE OUACHITA MOUNTAINS, ARKANSAS

ABSTRACT

Sites used for denning and resting are important ecological and life history components for carnivores. We investigated summer resting and den site selection by a radiocollared population of eastern spotted skunks (*Spilogale putorius*) in the Ouachita Mountains of western Arkansas. We identified and characterized microhabitat and landscape characteristics of 127 (*n* = 115 resting and *n* = 12 den) sites used by 13 eastern spotted skunks. Sites were located in burrows (48%) excavated by other mammal species, in decayed or burned root systems (22%), in rocky outcrops (14%), in eastern woodrat (*Neotoma floridana*) nests (9%), or in ground level tree or log cavities (7%). Reuse of sites was common for both males and females, but communal resting was rare. We contrasted both used dens and resting sites to putatively suitable but unused nearby sites and used an information-theoretic approach and discrete choice analysis to contrast support for several hypotheses potentially underlying resting and den site selection. We found support for thermal regulation and predator avoidance as influencing den site selection. We also conducted a second stage analysis to create a best-fit model for resting and den site selection. Sites were selected based on increased vegetative cover, with canopy closure being the most important factor influencing resting and den site selection. Higher rock and vine densities, younger pine forest stands, older hardwood stands, steeper slope, and smaller site entrance also positively influenced resting and den site selection. These findings suggest that eastern spotted skunks select structurally complex

sites, likely to enhance protection from predators, and may be vulnerable to habitat alterations that reduce this structural complexity.

INTRODUCTION

Sites used for denning and resting are important ecological and life history components for carnivores because they provide protection and potentially limit the distribution and abundance of populations (Doncaster and Woodroffe 1993, Endres and Smith 1993, Larivière and Messier 1998, Frafjord 2003). We define dens as those sites used for parturition and resting sites as the location of an animal's daily resting bout. Choosing a resting site may be among the most important choices made by forest carnivores, particularly during the nonbreeding season because they should provide thermal cover and protection from predators. Further, the availability of suitable sites for natal and maternal dens is essential for recruitment of forest carnivores, and thereby could have important implications for conservation (Buskirk and Ruggiero 1994). Forest growth, disturbance, and resource extraction all directly relate to the number and type of resting and den sites available as habitat (Zielinski et al. 2004).

Here we examine the microhabitat characters of resting and den sites selected by a population of radiocollared eastern spotted skunks (*Spilogale putorius*) in the Ouachita Mountains, where the species in putatively most common in Arkansas (Sealander and Heidt 1990, Sasse and Gompper 2006). Although currently localized in distribution, the eastern spotted skunk was historically abundant throughout the central and southeastern United States (Kinlaw 1995, Gompper and Hackett 2005). The species was once common in the Great Plains, but precipitous population declines have occurred since the 1940s (Gompper and Hackett 2005). Causes of the decline have not been identified, although a variety of explanations have been put forth, including habitat alteration (Choate et al. 1974, McCullough 1983, Gompper and Hackett 2005). The species is currently listed as endangered, threatened, or a species of conservation concern throughout much of its geographic range (Gompper and Hackett 2005). A paucity of studies have been conducted to elucidate ecological requirements of the eastern spotted skunk, and the need for fundamental ecological information to facilitate informed management has been repeatedly expressed (McCullough and Fritzell 1984, Kinlaw 1990, Gompper and Hackett 2005, Hackett et al. 2007).

Resting and denning ecology of the eastern spotted skunk is virtually unknown; those reports on resting have been primarily descriptive, focusing on the substrate for which the site was located rather than site selection processes. Two studies of resting sites (Crabb 1948, Polder 1968) were conducted when the species was common and on northern agriculture landscapes where they no longer persist. A third study (McCullough and Fritzell 1984) examined resting site use of just four males in the forested Missouri Ozarks. Crabb (1948) identified three general requirements for eastern spotted skunk dens and resting sites: 1) exclusion of light; 2) protection against weather; and 3) protection against predators. Polder (1968) reported use of a wide variety of resting sites with selection for the burrows of Franklin's ground squirrels (*Spermophilus franklinii*) and plains pocket gophers (*Geomys bursarius*). McCullough and Fritzell (1984) reported hollow logs and rocky outcroppings as primary resting sites. None of these studies, however, quantitatively addressed selection of resting or den sites. Studies of western spotted skunk (*S. gracilis*) denning ecology suggest selection for ground sites with vegetative cover (Crooks 1994, Carroll 2000, Doty and Dowler 2006).

To compare support for a variety of hypotheses that could underlie site selection in this population, we identified used resting and den sites and contrasted these to nearby unused but putatively available sites. We were particularly interested in the potential selection of age classes or management type of forest stands. Large portions of the Ouachita Mountains are intensively managed for timber extraction as well as endangered species persistence (USDA 1996, Thill et al. 2004), and thus we attempted to address how these management techniques influence the locations of resting sites and dens for eastern spotted skunk populations.

STUDY SITE

This study was conducted in the 96,755 ha Poteau Ranger District (PRD), which is part of the 690,000 ha Ouachita National Forest (ONF) in Scott County, Arkansas (15 376663E 3852595N; Figure 1). The Ouachita Mountain physiographic region is located in west-central Arkansas and southeastern Oklahoma. Mountain ridges were formed from sedimentary rock formations compressed into great folds. Linear ridges reach maximum elevations of about 790 m and trend east-west. The climate is one of warm winters, hot, dry summers, an average temperature of 17° C, and average annual precipitation of 105 cm. South and west aspects and dry sandstone ridges of the Ouachita Mountains are covered with as much as 40% shortleaf pine (*Pinus echinata*) and 73% of the study site is managed as shortleaf pine stands. Hardwoods (*Quercus* spp. and *Carya* spp.) dominate the rich alluvial soil bottom lands of the valleys and north aspects of the mountains (Bailey 1980).

The study site has been intensively managed to meet a shortleaf pine – bluestem (*Andropogon* spp and *Schizachyrium* spp) restoration objective (USDA 1996). To provide habitat for a recovered population of federally endangered red-cockaded woodpeckers (*Picoides borealis*), this management program creates an open canopy and herbaceous vegetation in the understory (Lochmiller et al. 1994, Bukenhofer and Hedrick 1997, Masters et al. 1998). Ecosystem restoration and maintenance is accomplished by reducing tree basal areas through commercial and non-commercial thinning of shortleaf pine stands and increasing the use of prescribed fire (Bukenhofer et al. 1994, Bukenhofer and Hedrick 1997), and by increased shortleaf pine stand rotation age, which in turn increases the number of fungal heart rot (*Phellinus pinii*) infected shortleaf pine trees available for cavity construction by red-cockaded woodpecker (USDA 1996, Bukenhofer and Hedrick 1997). Forest management in the PRD also aims to retain streamside management zones (SMZs) within the intensively managed shortleaf pine stand mosaic. SMZs are managed natural hardwood forest stands retained along intermittent and perennial streams (Miller et al. 2004) and account for 87% of the hardwood management stands in the study site.

METHODS

Capture and Handling

We conducted a telemetry-based study from March 2005 through January 2007. Detailed capture and handling methodology is given in Chapter 1. We captured most eastern spotted skunks between late autumn and early spring when the species is more easily trapped (Hackett et al. 2007), and fitted each individual with a 12 g ATS Model 1730 (Advanced Telemetry Systems, Isanti, MN 55040) radio transmitter prior to release at the capture site. We followed animal care procedures outlined in University of

Missouri Animal Care and Use Protocol #4039 and carried out field work under Arkansas Game and Fish Commission permit #111520042.

Radio Telemetry and Site Characterization

To determine summer resting sites and dens, we tracked radiocollared eastern spotted skunks to their den or resting sites using a handheld receiver and three-element Yagi antennae approximately once per week in daytime hours during the months of May through August 2005 and 2006. Repeated site use and localized movement of females indicated that a maternal den had been located. We attempted to identify equal numbers of sites for each individual by not characterizing a second site for an individual until sites used by all study animals being tracked during the study period had already been characterized. For each used site, a nearby, available, but unused and putatively appropriate site was also located and paired with the used site for comparison. We selected the available unused site by searching, ≥ 50 and ≤ 300 m from the used site, along a randomly selected azimuth for a burrow, hollow log, hollow tree, rocky outcrop, or woodrat nest that could possibly be used as a den or resting site by eastern spotted skunks. A site was judged as reasonable by having an entrance size of at least 10 X 10 cm, a cavity large enough for spotted skunks and meeting the three requirements described by Crabb (1948). Upon location of a putatively available site, we measured habitat characteristics as for the used site.

Within one week of the den or resting site being vacated, we used a combination of variable radius plot and transect methods to collect microhabitat data. For each used and available unused site, we established a 25 m X 25 m true north grid with nine nodes. We centered the grid at the site entrance and established four 25 m node-to-node transects, with two centered at, and in cardinal directions from, the entrance, and two extending between the outer east and west nodes. Using the nine nodes, we identified four quadrants. We classified the substrate for each site (Burrows = animal-dug sites in soil substrates; Root system = burned or decayed root systems; Rocky outcrop = cavities among rocky outcrops; Hollow log/tree = cavity of hollow logs or trees; Woodrat nest = eastern woodrat, *Neotoma floridana*, nests). We documented entrance orientation, entrance size, basal area, and slope within the site transect grid. At each node we used a densiometer to calculate percent canopy cover and estimated percent ground cover for a 1 m^2 plot. We averaged canopy and ground cover for the site. Course woody debris (≥10 cm diameter) was counted along transects. One of the four quadrants was randomly selected and the following data collected: rocks (≥10 cm) were counted and documented, snags (≥1.5 m tall) were quantified, and the number of vines and briers were estimated.

We collected additional landscape-scale data using U.S. Forest Service records and GIS analysis. From USFS records, we identified the size of the stand for each site, the ages of the stands since last timber harvest, the time since the last burn, and the forest management type for the stand (shortleaf pine, hardwood, "other"), in which the site was located. Stands categorized as "other" were loblolly pine stands and private property. We used the ArcGIS 9.1 (Environmental Systems Research Institute, Redlands, CA 92373) near feature to determine distance to the nearest road, stand edge, and water.

A Priori Model Development

We used an information-theoretic approach to develop *a priori* hypotheses regarding the den and resting site selection by eastern spotted skunks (Burnham and Anderson 2002). Based on the carnivore ecology literature and preliminary field observations, we formulated four hypotheses that may explain eastern spotted skunk den and resting site selection: predator avoidance, thermal regulation, prey availability, and edge effects. Using the empirical data collected for each site (Table 1), we developed a set of *a priori* models for each hypothesis (Table 2).

We proposed five *a priori* models for predator avoidance as the primary pressure determining site selection, and predicted positive effects of increased vine numbers and basal area; negative effects of increased stand age and entrance size; and a pseudothreshold structure for percent ground cover. To determine support for prey availability as the primary determinant of site selection we developed five *a priori* models, which included stand management, rough year, and number of rocks, woody debris, and snags. We predicted that increasing abundance of rock, woody debris, and snags would have positive effects on site selection. Incorporating the covariates distance to road, stand edge, and stand size, we developed an additional four *a priori* models that represent the hypothesis that site selection is primarily determined by edge effects. Each covariate increase was predicted to have a positive effect. Finally, we developed five *a priori* models that represent the hypothesis that site selection is primarily determined by thermal regulation needs. The covariates used to determine support for this hypothesis were percent canopy cover, slope, distance to water, and orientation of site entrance. We predicted a positive influence of canopy cover and slope, but a negative influence of increased distance from water and site entrances oriented away from 45º (Table 2).

Statistical Analyses

We used discrete choice analysis to fit site selection models because of the paired used/available design (Cooper and Millspaugh 1999, 2001). The main benefit of discrete choice analysis is that the researcher can define resource availability separately for each site (Cooper and Millspaugh 1999). Discrete choice models have the general form:

$$P_J(A) = \frac{\exp(\mathbf{B}'\mathbf{X}_{AJ})}{\sum \exp\left(\mathbf{B}'\mathbf{X}_{iJ}\right)},$$

where the probability of individual j choosing resource *A* rather than any other of the *i* resources available, $\mathbf{X}_{ij}$ is a vector of the attributes of resource *i* as perceived by individual *j*, **B** is a vector of estimable parameters that determine each attribute's contribution to utility. We fit the discrete choice models using PROC MDC procedure in SAS 9.1 (SAS Institute Inc, Cary, NC 27513). We used Akaike's Information Criterion corrected for small sample sizes (AIC_c) values and Akaike weights (w_i) to predict the most parsimonious model (Burnham and Anderson 2002). The w_i for each model represents the probability of a model being the best approximating model of those evaluated. We addressed model selection uncertainty by calculating model-averaged estimates of the coefficients and their associated 95% confidence interval for models in the 90% confidence set (Burnham and Anderson 2002) as:

$$\hat{\bar{\theta}} = \sum_{i=1}^{R} w_i \, \hat{\theta}_i$$

where $\hat{\bar{\theta}}$ is the model averaged estimate of the coefficient, w_i is the Akaike weight computed from AIC_c values for R candidate models containing the specific predictor variable, and $\hat{\theta}_i$ the estimator of the coefficient for a specific variable in model *i*. We calculated unconditional standard errors for model averaged coefficients (Burnham and Anderson 2002) using:

$$SE(\hat{\bar{\theta}}) = \sqrt{\hat{\text{var}}(\hat{\bar{\theta}})},$$

where

$$\hat{\text{var}}(\hat{\bar{\theta}}) = \left[\sum_{i=1}^{R} w_i \sqrt{\hat{\text{var}}(\hat{\theta}_i) + (\hat{\theta}_i - \hat{\bar{\theta}})^2} \right]^2 .$$

We estimated the relative importance of covariates from averaged models by summing the Akaike weights across all models in the 90% confidence set where the covariate occurred (Burnham and Anderson 2002). We calculated odds ratios and associated confidence interval for all parameter estimates in the 90% confidence set (Hosmer and Lemeshow 2000). The odds ratio is the probability increase of a site being selected for resting or denning for every unit increase in the predictor variable at one site compared to another. We also compared relative support for the various groupings of models, predator avoidance, prey availability, thermal regulation, and edge effects.

Because some variables could potentially influence site selection within the context of several hypotheses, we also conducted a second stage analysis to create a best-fit model for eastern spotted skunk den and resting site selection. We began with a full main-effects model which included all covariates used in stage one modeling and three interaction terms (stand age * vine, stand age * management type, basal area * vine). We tested the influence of each covariate by individually removing them and recording changes to AICc. Using changes in AIC_c, we removed the least supported variable (e.g., the one that reduced AICc the most when it was removed). We removed covariates until the AIC_c value was minimized. We retained in the final model any main effect involved in a significant interaction (McCullagh and Nelder 1989).

We used the Mann-Whitney U test to determine differences between male and female resting site reuse and individual variables. To detect differences between characteristics of den and resting sites and the amount of reuse, we also used the Mann-Whitney U test.

RESULTS

Between March 2005 and March 2006 we captured and radiocollared 23 eastern spotted skunks (11 males and 12 females, Appendix 1), of which 13 (7 males and 6 females) were tracked and had sites characterized during the months of May through August 2005 and 2006. We identified and characterized a total of 127 (n = 68 male, n = 59 female, n = 115 resting sites, n = 12 dens) inhabited sites (Figure 2) and an additional 127 paired unused but putatively available sites. The mean number of sites characterized per individual tracked during the summer was 9.69 (± 1.53 SE) with 7.92 (± 0.78 SE) days between site locations. Most used sites (n = 61, 48%) were found in burrows. Twenty eight sites (22%) were located in the root system of burned or decayed root systems and 18 (14%) occurred in rocky outcrops. Eleven sites (9%) were located inside eastern woodrat nests and nine (7%) occurred in the cavity of hollow logs or trees at ground level.

Resting Sites

We identified and characterized 68 male and 47 female eastern spotted skunk resting sites, and observed study animals using resting sites for a mean of 1.51 (± 0.10 SE) days. Males and females did not differ in the amount of resting site reuse (U = 2889.5, P = 0.2258). Four (± 0.01 SE) percent of characterized resting sites were reused by an eastern spotted skunk after the animal used a resting site elsewhere. A larger percentage of male resting sites (33.82) were located in hardwood stands (most are SMZs) compared to female sites (14.89). Male resting sites were located in stands 63%

older and two times larger than the stands where female resting sites were found (Table 3). Female resting site entrance size was smaller than those of males (Table 3). Communal resting was only observed on one occasion when an adult male and female were observed together in April 2006 during the breeding period. Additionally, resting site use by different animals on separate occasions was also rare. We observed only one such event, where a resting site used in mid June 2006 by an adult male was used by another adult male in late July 2006.

Den Sites

Of the 127 sites characterized, 12 were den sites used by five females. One female was monitored for two seasons with two maternal den sites per season. The other four females each had two dens identified and characterized. We did not observe communal denning, thus no evidence of cooperative young-rearing behavior. Den sites were used for a mean of 16.25 (± 2.48 SE) consecutive days, which is greater than the reuse of resting sites (U = 1445.0, $P < 0.001$). The strong den site fidelity exhibited by the individual likely indicated the presence of offspring in the den. No variable differed between dens and resting sites (U = 609.0 – 959.5, $P > 0.05$ for all tests). Therefore, dens and resting sites were combined for subsequent analyses.

Site Characterization

Eastern spotted skunks selected sites in shortleaf pine managed stands 69% of the time ($n = 88$); the study area maintains about 73% of the forest in shortleaf pine managed stands (Figure 2). However, study animals used sites in hardwood stands to at greater extent (28%) than the 16% of the forest in hardwoods (Figure 2). Used sites were found in areas where the mean growing seasons since last burn was 4.4 (± 0.3 SE) years. Used sites were located in younger stands, and had more than two times as many vines than nearby available sites (Table 4, Figure 2). Compared to available sites, used sites also had greater percent canopy cover, 66% more rocks, and 73% smaller entrances (Table 4).

Discrete choice analyses support the thermal regulation and predator avoidance hypotheses (Table 5). The most supported model was the thermal regulation sub-global model $Ther_{cnpy + slope + h2o + ent\_sine}$ (Table 5). Model uncertainty existed, however, with two other models falling into the 90% confidence set. The next competing models were the predator avoidance sub-global model $Pred_{vine + BA + grnd + grnd^2 + std\_age + ent}$, and the thermal regulation candidate model $Ther_{cnpy + h2o}$ (Table 5). The edge effects and prey availability models received little support as strong predictors of eastern spotted skunk site selection.

The most influential covariates in top *a priori* models were percent canopy cover, slope, distance to water, estimated number of vines, stand age, and entrance size (Table 6). Estimated coefficients, odds ratios, and importance values suggest the percentage of canopy cover was the most influential thermal regulation candidate model predictor of site selection (Table 6). Canopy closure positively influences site selection; each percent increase in canopy cover at one site compared to another increased the odds of selection by 1.04 times (Table 6). Distance from water had a negative influence on site selection. For each meter further from water a site is compared to another there was a decrease in the odds of selecting by 0.99 times.

The second stage analysis resulted in a more supported model than *a priori* models (AIC_c = 108.74). The eight parameters in the best-fit model were rock, entrance size, slope, canopy cover, vine, stand age, management type, and the interaction between stand age and management type. Increases in the parameters rock, slope, canopy, and vine positively influenced the likelihood of a site being selected (Table 7). Used sites were in younger stands and were more often in shortleaf pine managed stands than other stands (Table 7). However, we found an important interaction between stand age and management type, where radiocollared animals selected hardwood and other stands over shortleaf pine stands as stand age increases (Table 7). The odds of selecting a hardwood stand over a shortleaf pine stand increased by 1.038 times for each year increase in stand age (Table 7).

DISCUSSION

Eastern spotted skunks appear to be opportunistic in their resting site selection, using multiple available sites within their home ranges and various substrate types in different ecological situations. This flexibility in site selection is further supported by the variability in resting site use reported elsewhere (Crabb 1948, Polder 1968, McCullough and Fritzell 1984), and is similar to the variability reported for site selection by western spotted skunks (Crooks 1994, Carroll 2000, Doty and Dowler 2006). Although, all den and resting sites met the exclusion of light, weather, and predator protection requirements, we observed, as did Polder (1968), greater use of burrows for resting than did other researchers (Crabb 1948, McCullough and Frizell 1984). Additionally, we observed only burrows used for denning, which may indicate more restricted requirements for dens than resting sites given that burrows provide a microenvironment that is dry, insulated, and inaccessible to predators. We observed less use of hollow logs than did McCullough and Frizell (1984) and no use of man-made structures reported by Crabb (1948), as man-made structures are rare in the study site. Crooks (1994) reported that island spotted skunks (*S. g. amphiala*) excavated all burrows used as dens and resting sites. Thus, spotted skunks are able to create burrows when necessary. However, eastern spotted skunks in the Ouachita Mountains appear to occupy burrows excavated by other mammal species. We found no evidence of eastern spotted skunks excavating burrows, suggested by entrance dimension data and the paucity of fresh diggings at dens or resting sites.

Our observation of little reuse by either sex of individual resting sites is similar to that reported for other closely related carnivores (Larivière and Messier 1997, Norbury et al. 1998, Zielinski et al. 2004). The finding suggests that eastern spotted skunks do not restrict use to a few central locations but instead prefer multiple resting structures distributed throughout their home ranges. Combining these findings with those of Chapter 1, eastern spotted skunks appear to forage over portions of their home range, opportunistically resting close to foraging areas that provide protection from predators. The low reuse rate of individual structures may also be influenced by the need to minimize transit time and distance between forage sites and preferred resting locations.

Our data on resting site and den site use by eastern spotted skunks support the hypothesis that the species is a solitary carnivore in western Arkansas (see also Chapter 1). Communal resting was rare, and communal denning and cooperative young-rearing behavior was not observed. Although there may have been resting site sharing between radiocollared eastern spotted skunks and non-radiocollared eastern spotted skunks, only one observation was made of multiple study animal occupancy of a single site. The event was observed between a male and female during the breeding season and lasted only one day. Communal resting observed when the species was more common may have been influenced by population density (Crabb 1948). The number of different sites used by individuals and the lack of communal resting suggests that resting and den sites are not limiting distribution or abundance of eastern spotted skunks in the Ouachita Mountains. Similar conclusions were also reported for western spotted skunks in Texas and California (Crooks 1994, Carroll 2000, Doty and Dowler 2006).

As reported for other forest carnivores, our models of resting and den site selection indicate that combinations of vegetation and topographic features contribute to resting and den site selection (Zielinski et al. 2004, King and Powell 2007). Canopy closure, slope, number of vines, stand age, and entrance size were influential parameters in both the hypothesis testing models and the second stage best-fit model. We also found an important interaction between stand age and management type, where shortleaf pine stands were selected if the stand was young and hardwood stands were selected if the stands were old. The significance of this interaction is likely due to the importance of forest structure that provides protection from predators, a finding also reported at a larger scale based on home range structure (Chapter 1).

Forest structure appears to be important to eastern spotted skunk ecology, and populations may be limited to areas with dense cover. The factor with the strongest influence on eastern spotted skunk den and rest site selection appears to be increased amount of vegetative cover, which was also reported for western spotted skunks (Kinlaw 1990, Carroll 2000, Doty and Dowler 2006). No den or resting sites were found in open areas in those studies or this study. Areas selected for resting and denning have greater canopy closure than nearby sites. Given that these nearby sites had 76% closed canopy, the species likely places a premium on continuous overhead cover, as reported for some mustelids (Buskirk and Ruggiero 1994, Zielinski et al. 2004, King and Powell 2007).

Relative to other measured parameters, canopy closure was the most influential main effect to eastern spotted skunk resting site and den selection, and likely enhances predator avoidance in addition to thermal regulation. The importance of canopy closure underlies why mature stands that are used for denning and resting are hardwood stands, which have more canopy closure than mature shortleaf pine stands. Further, management type had negative impact on model performance when not part of an interaction term with stand age. However, when interacting with one another, they were the most influential predictor of site selection.

Increased vines densities and the availability of young shortleaf pine stands contribute to the vegetative cover selected by eastern spotted skunks, and likely serve a similar predator avoidance function as shrubs and prickly pear cactus do for western spotted skunks (Carroll 2000, Doty and Dowler 2006). Radiocollared animals selected den and rest sites with more than double the number of vines (Table 4) and selected young shortleaf pine stands compared to nearby available sites for home range use (Chapter 1). Given their agility, body size and shape, eastern spotted skunks can easily maneuver through patches of vines and the dense vegetation of young forest, while those stands provide enhanced protection from predators. Primary predators such as coyotes (*Canis latrans*), bobcat (*Lynx rufus*), and great horned owls (*Bubo virginianus*; Kinlaw 1995, D. Lesmeister, unpublished data) prefer more open habitats over forest with a dense vegetation (Litvaitis and Shaw 1980, Bukenhofer et al. 1994, Ganey et al. 1997, Smith et al. 1999, Chamberlain et al. 2003). Thus, the open canopy and herbaceous understory conditions of mature shortleaf pine-bluestem habitat may be favorable to eastern spotted skunk predators and thereby detrimental to eastern spotted skunks. D.

Lesmeister (unpublished data) observed great horned owls to be the primary predator of study animals and most (92%) avian predation events occurred in mature, fully restored pine-bluestem habitat that is characterized by a more open canopy and herbaceous understory.

If predation limits eastern spotted skunk use of more open habitats and plays a role in den and rest site selection, the association of eastern spotted skunks with areas of dense forest cover would appear to make the species heavily susceptible to changes in forest ecosystems that reduce protective habitat. Because stand age and management type had a prominent influence on resting site and den selection in top models, managers can increase suitable habitat for eastern spotted skunks by favoring the production of young shortleaf pine forest and retention of SMZs.

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Table 1. Codes and descriptions of measured parameters used in models comparing selected eastern spotted skunk den and resting sites to nearby unused and putatively available sites in the Ouachita National Forest, Arkansas, 2005-2006.

Variable	Description
Std_age	Stand age in years based on USFS records
BA	Basal area measured in ft^2 from site entrance
Vine	Estimated number of vines in randomly selected quadrant
Grnd	Mean percentage of ground cover estimated at each node of characterized site
Ent	Site entrance size measured in cm^2
Rock	Number of rocks ≥ 10cm diameter counted in randomly selected quadrant
Mgt_##	Management type of stand taken from USFS records [Reference is management type mgt_32 (Shortleaf Pine). Other types for comparison: mgt_00 (all other types), mgt_53 (Hardwood)]
Rgh_##	Classification of the number of growing seasons between fire and use taken from USFS records [Reference is rgh_3 (rough year of three or less). Other rough year classifications for comparison: rgh_3_6 (rough year greater than three and less than seven), rgh_7_10 (rough year greater than six and less than eleven), and rgh_11 (rough year greater than ten)]
CWD	Number of course woody debris ≥ 10 diameter counted in the four transects of site
Snag	Number of snags counted in randomly selected quadrant
Rd_dist	Distance in meters to nearest road calculated in ArcGIS

Std_edge	Distance in meters to nearest stand edge calculated in ArcGIS
Std_size	Size of stand in hectares calculated in ArcGIS
Cnpy	Mean percent canopy cover for all nine nodes
Slope	Degree (˚) slope measured at characterized site
Ent_sine	Sine of the orientation of the site entrance, using an orientation of 45˚ as the reference point
H_2O	Distance in meters to nearest water calculated in ArcGIS
Age_00	Interaction term between stand age and all other management types
Age_53	Interaction term between stand age and hardwood management stands

Table 2. Description and expected direction of a *priori* models used to evaluate microhabitat effects on eastern spotted skunk den and resting site selection in the Ouachita Mountains, Arkansas (period May - August 2005 and May - August 2006). See Table 1 for measured parameter codes and descriptions.

Hypothesis	Model	Model structure	Expected result
Predator avoidance (Pred)			
1. Negative effects of increased stand age and low basal area	$Pred_{std\_age + BA}$	$\beta_0 + \beta_1(std\_age) + \beta_2(BA)$	$\beta_1 < 0$, $\beta_2 > 0$
2. Positive effects of increase vine numbers and basal area and negative effects of stand age	$Pred_{vine + BA + std\_age}$	$\beta_0 + \beta_1(vine) + \beta_2(BA) + \beta_3(std\_age)$	$\beta_1 > 0$, $\beta_2 > 0$, $\beta_3 < 0$
3. Positive effects of vine numbers	$Pred_{vine}$	$\beta_0 + \beta_1(vine)$	$\beta_1 > 0$
4. Positive effects of vine numbers, basal area and ground cover, combined with negative effects of stand age and entrance size	$Pred_{vine + BA + grnd + grnd^2 + std\_age + ent}$	$\beta_0 + \beta_1(vine) + \beta_2(BA) + \beta_3(grnd) + \beta_4(grnd)^2 + \beta_5(std\_age) + \beta_6(ent)$	$\beta_1 > 0$, $\beta_2 > 0$, $\beta_3 > 0$, $\beta_4 < 0$, $\beta_5 < 0$, $\beta_6 < 0$
5. Positive effects of vine numbers and negative effects of increased stand age	$Pred_{vine + std\_age}$	$\beta_0 + \beta_1(vine) + \beta_2(std\_age)$	$\beta_1 > 0$, $\beta_2 < 0$
Prey availability (Prey)			
6. Negative effects of management	$Prey_{mgt\_00}$	$\beta_0 + \beta_1(mgt\_00) +$	$\beta_1 < 0$, β_2

	type and rough year class, combined with positive effects of rock, course woody debris, and snag number	$_{+ mgt\_53 + rgh\_3\_6 + rgh\_7\_10 + rgh\_11 + rock + CWD + snag}$	$\beta_2(mgt\_53) + \beta_3(rgh\_3\_6) + \beta_4(rgh\_7\_10) + \beta_5(rgh\_11) + \beta_6(rock) + \beta_7(CWD) + \beta_8(snag)$	$< 0, \beta_3 < 0, \beta_4 < 0, \beta_5 < 0, \beta_6 > 0, \beta_7 > 0, \beta_8 > 0$
7.	Positive effects of rock and course woody debris number, combined with negative effects of rough year	$Prey_{rock + CWD + rgh\_3\_6 + rgh\_7\_10 + rgh\_11}$	$\beta_0 + \beta_1(rock) + \beta_2(CWD) + \beta_3(rgh\_3\_6) + \beta_4(rgh\_7\_10) + \beta_5(rgh\_11)$	$\beta_1 > 0, \beta_2 > 0, \beta_3 < 0, \beta_4 < 0, \beta_5 < 0$
8.	Positive effects of rock and course woody debris number	$Prey_{rock + CWD}$	$\beta_0 + \beta_1(rock) + \beta_2(CWD)$	$\beta_1 > 0, \beta_2 > 0$
9.	Negative effects of management type and rough year	$Prey_{mgt\_00 + mgt\_53 + rgh\_3\_6 + rgh\_7\_10 + rgh\_11}$	$\beta_0 + \beta_1(mgt\_00) + \beta_2(mgt\_53) + \beta_3(rgh\_3\_6) + \beta_4(rgh\_7\_10) + \beta_5(rgh\_11)$	$\beta_1 < 0, \beta_2 < 0, \beta_3 < 0, \beta_4 < 0, \beta_5 < 0$
10.	Positive effects of rock number	$Prey_{rock}$	$\beta_0 + \beta_1(rock)$	$\beta_1 > 0$
Edge effects (Edge)				
11.	Positive effects of distance to road and stand edge	$Edge_{rd\_dist + std\_edge}$	$\beta_0 + \beta_1(rd\_dist) + \beta_2(std\_edge)$	$\beta_1 > 0, \beta_2 > 0$

12. Positive effects of stand size and distance to stand edge	$Edge_{std\_size + std\_edge}$	$\beta_0 + \beta_1(std\_size) + \beta_2(std\_edge)$	$\beta_1 > 0, \beta_2 > 0$
13. Positive effects of stand size	$Edge_{std\_size}$	$\beta_0 + \beta_1(std\_size)$	$\beta_1 > 0$
14. Positive effects of stand size, distance to road, and distance to stand edge	$Edge_{std\_size + rd\_dist + std\_edge}$	$\beta_0 + \beta_1(std\_size) + \beta_2(rd\_dist), \beta_2(std\_edge)$	$\beta_1 > 0, \beta_2 > 0, \beta_3 > 0$
Thermal regulation (Ther)			
15. Positive effects of canopy cover and slope, combined with negative effects of distance from water and sine of site entrance	$Ther_{cnpy + slope + h2o +ent\_sine}$	$\beta_0 + \beta_1(cnpy) + \beta_2(slope) + \beta_3(h2o) + \beta_4(ent\_sine)$	$\beta_1 > 0, \beta_2 > 0, \beta_3 < 0, \beta_4 < 0$
16. Positive effects of canopy cover and negative effects of distance from water	$Ther_{cnpy + h2o}$	$\beta_0 + \beta_1(cnpy) + \beta_2(h2o)$	$\beta_1 > 0, \beta_2 < 0$
17. Positive effects of slope	$Ther_{slope}$	$\beta_0 + \beta_1(slope)$	$\beta_1 > 0$
18. Positive effects of slope, combined with negative effects of the sine of the site entrance	$Ther_{slope + ent\_sine}$	$\beta_0 + \beta_1(slope) + \beta_2(ent\_sine)$	$\beta_1 > 0, \beta_2 < 0$
19. Negative effects of distance from water	$Ther_{h2o}$	$\beta_0 + \beta_1(h2o)$	$\beta_1 < 0$

Table 3. Mean ($\bar{x}$), standard error (SE), Mann-Whitney U test statistic, and p value for selected male (*n* = 68) versus female (*n* = 47) eastern spotted skunk resting site variable parameters in the Ouachita Mountains, Arkansas (period May - August 2005 and May - August 2006). See Table 1 for measured parameter codes and descriptions.

Variable	Male		Female		U Value	Pr > |U|
	$\bar{x}$	SE	$\bar{x}$	SE		
Std_age (years)	54.25	3.68	34.40	4.34	2184.5	0.0026
BA (ft^2)	107.21	5.87	104.47	6.03	2691.0	0.8442
Vine	131.03	32.12	83.70	17.84	2692.0	0.8481
Grnd (%)	46.96	2.26	47.17	3.27	2714.5	0.9501
Ent (cm^2)	175.94	16.38	130.74	15.70	2317.5	0.0220
Rock	50.50	9.25	45.66	7.71	2830.0	0.5570
CWD	6.31	0.73	4.68	0.60	2506.0	0.2125
Snag	2.26	0.38	4.38	1.03	2955.5	0.1869
Rd_dist (m)	417.76	41.82	376.72	36.20	2710.0	0.9299
Std_edge (m)	40.01	5.14	39.09	5.89	2735.0	0.9615
Std_size (ha)	63.28	10.17	31.55	2.17	2120.0	0.0008
Cnpy (%)	84.26	1.21	79.64	1.74	2331.0	0.0266
Slope (˚)	5.97	0.69	7.57	0.70	3089.5	0.0403
Ent_sine (˚)	1.08	0.09	1.08	0.10	2728.5	0.9909
H_2O (m)	142.50	16.64	217.55	20.42	3278.0	0.0022

Table 4. Mean ($\bar{x}$) and standard error (SE) for used (n = 127) versus available site (n = 127) continuous variable parameters used in discrete choice analysis of eastern spotted skunk den and resting site selection in the Ouachita Mountains, Arkansas (period May - August 2005 and May - August 2006). See Table 1 for measured parameter codes and descriptions.

Variable	Used		Available	
	$\bar{x}$	SE	$\bar{x}$	SE
Std_age (years)	45.66	2.81	58.35	2.81
BA (ft^2)	106.30	3.92	108.11	4.68
Vine	113.61	18.85	51.65	10.07
Grnd (%)	47.38	1.80	48.35	1.87
Ent (cm^2)	163.11	12.29	222.11	13.14
Rock	47.67	5.85	31.53	8.41
CWD	5.61	0.51	6.00	0.50
Snag	3.23	0.51	3.42	0.79
Rd_dist (m)	389.63	26.56	362.43	24.51
Std_edge (m)	39.65	3.62	46.30	4.89
Std_size (ha)	48.69	5.71	42.22	5.71
Cnpy (%)	82.74	0.98	76.34	1.31
Slope (˚)	6.53	0.48	5.76	0.35
Ent_sine (˚)	1.11	0.06	1.10	0.06
H_2O (m)	171.10	12.48	195.35	11.61

Table 5. Ranking of *a priori* hypothesized models in the 90% confidence set relating habitat covariates to eastern spotted skunk den and resting site selection in the Ouachita Mountains, Arkansas (period May - August 2005 and May - August 2006). Columns include the number of variables (*K*), Akaike's Information Criterion adjusted for small sample sizes (AIC_c), distance from lowest AIC_c (ΔAIC_c), and Akaike's model weight (w_i). See Table 1 for measured parameter codes and descriptions.

Hypothesis	Model	*K*	AIC_c	ΔAIC_c	w_i
15. Thermal *	$Ther_{cnpy + slope + h2o + ent\_sine}$	5	151.446	0	0.464
4. Predator Avoidance *	$Pred_{vine + BA + grnd + grnd^2 + std\_age + ent}$	7	152.695	1.248	0.248
16. Thermal	$Ther_{cnpy + h2o}$	3	152.777	1.331	0.238

* Sub-global model.

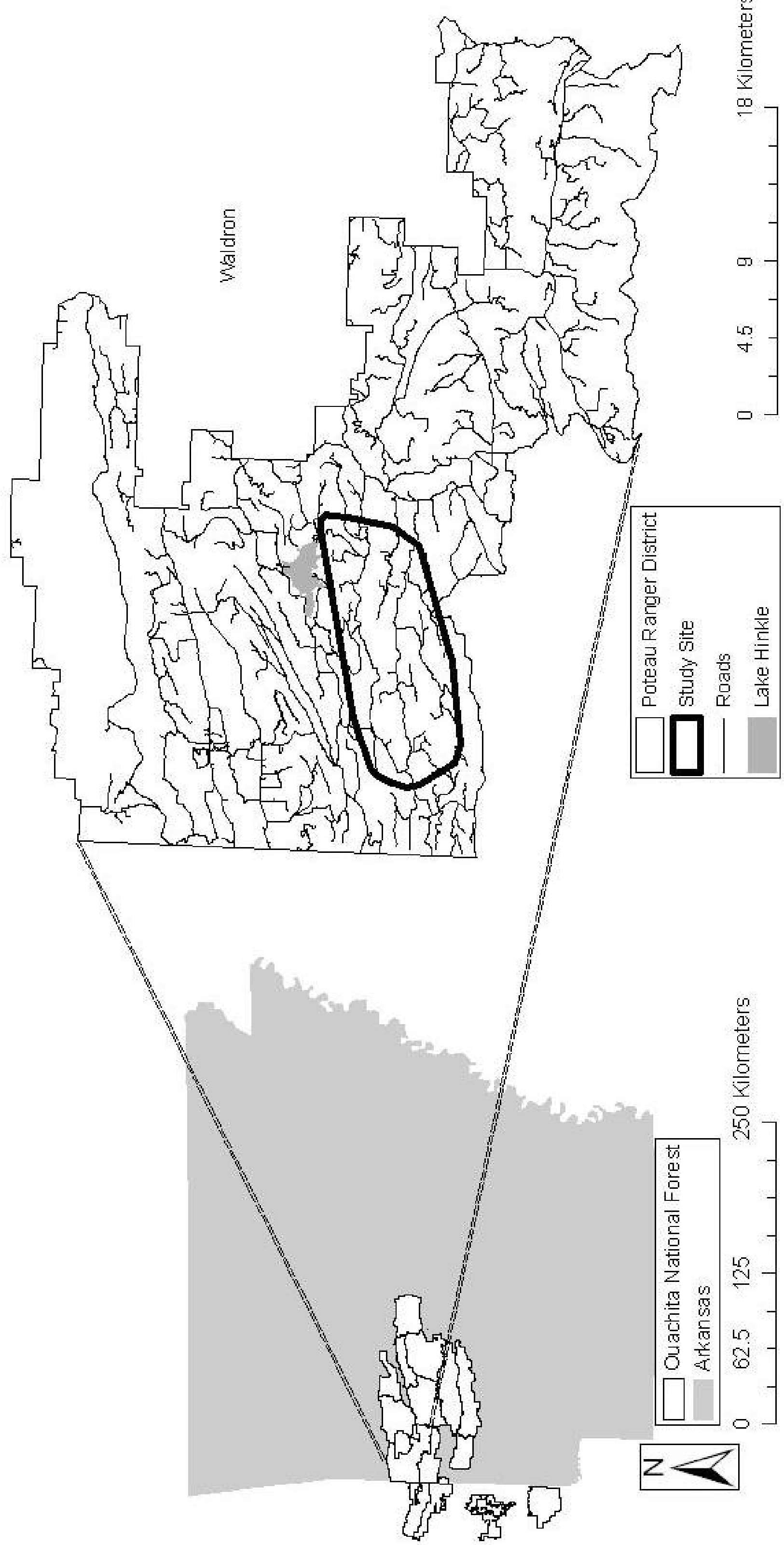
Table 6. Most influential *a priori* model-averaged parameter estimates, unconditional standard errors (SE), odds ratios, odds ratio 95% confidence intervals, and importance values explaining eastern spotted skunk den and resting site selection in the Ouachita Mountains, Arkansas (period May - August 2005 and May - August 2006). See Table 1 for descriptions of variable codes.

Parameter	Estimate	SE	Odds Ratio	Lower CI	Upper CI	Importance
Cnpy	0.062	0.016	1.04	1.01	1.07	0.70
H_2O	-0.008	0.003	0.99	0.98	1.00	0.70
Slope	0.092	0.038	1.04	0.97	1.11	0.46
Vine	0.005	0.002	1.00	1.00	1.00	0.30
Std_age	-0.022	0.008	0.99	0.97	1.01	0.30
Ent	-0.004	0.001	1.00	1.00	1.00	0.25

Table 7. Parameter estimates, unconditional standard errors (SE), odds ratios, and odds ratio 95% confidence intervals for eastern spotted skunk den and resting site selection best-fit model in the Ouachita Mountains, Arkansas (period May - August 2005 and May - August 2006). See Table 1 for descriptions of variable codes.

Parameter	Estimate	SE	Odds Ratio	Lower CI	Upper CI
Rock	0.004	0.003	1.004	1.003	1.005
Ent	-0.003	0.002	0.997	0.992	1.003
Slope	0.145	0.085	1.156	1.131	1.182
Cnpy	0.063	0.026	1.065	1.052	1.077
Vine	0.009	0.002	1.009	1.004	1.013
Std_age	-0.047	0.014	0.954	0.879	1.029
Age_00	0.171	1.562	1.010	0.888	1.132
Age_53	0.095	0.102	1.038	1.019	1.056
Mgt_00	-8.761				
Mgt_53	-4.093	8.171			

Figure 1. Map of the eastern spotted skunk study site in west-central Arkansas, Poteau Ranger District (expanded), Ouachita National Forest, 2005-2006. Boundary of the 8784 ha study site is the minimum convex polygon around the collection of study animal home ranges (Chapter 1).



Waldron
0
4.5
9
18 Kilometers
Poteau Ranger District
Study Site
Roads
Lake Hinkle
Ouachita National Forest
Arkansas
0
62.5
125
250 Kilometers
N

Figure 2. Study site with available habitats (Chapter 1) and location of eastern spotted skunk dens and resting sites used in analyses, Ouachita Mountains, Arkansas, 2005-2006. Resting sites and dens are collectively labeled as “den site” in legend.


Legend
Study Site
Water
Shortleaf Pine (0-30 years)
Shortleaf Pine (31-70 years)
Shortleaf Pine (>70 years)
Hardwood
Other
Private
Den Site
N
0
1.25
2.5
5 Kilometers

Appendix 1. Capture history and morphological measures for 33 captured eastern spotted skunks in the Ouachita Mountains, Arkansas, 2005-2006.

Number[a]	Date[b]	Weight[d]	Total length[e]	Head/body length[f]	Tail length[g]
Adult female[c]					
002	3/13/2005	490	47	27	20
002	6/24/2005	450	47	27	20
003	3/13/2005	450	45	28	17
004	3/13/2005	390	45	27	18
004	6/24/2005	390	45	27	18
008	8/21/2005	390	43	27	16
014	10/13/2005	525	45	29	16
015	10/14/2005	535	45	29	16
016	10/23/2005	585	45	30	15
017	11/4/2005	465	48	30	18
017	1/31/2006	530	48	30	18
017	4/13/2006	430	48	30	18
017	7/6/2006	455	48	30	18
017	9/20/2006	505	48	30	18
018	12/14/2005	340	41	24	17
018	1/15/2006	390	41	24	17
018	3/6/2006	350	41	24	17
018	5/25/2006	405	41	24	17

018	8/10/2006	340	41	24	17
018	11/4/2006	445	41	24	17
019	12/30/2005	450	47	28	19
020	1/4/2006	450	46	30	16
020	6/28/2006	450	46	30	16
029	10/2/2006	375	43	29	14
030	10/3/2006	370	43	29	14
032	10/18/2006	370	44	28	16
Juvenile/subadult female[c]					
010	10/8/2005	190	29	17	12
010	10/25/2005	275	34	22	12
026	7/30/2006	245	35	23	12
026	8/24/2006	305	41	26	15
Adult male[c]					
001	3/13/2005	550	50	31	18
005	3/13/2005	580	50	32	18
005	6/24/2005	500	50	32	18
005	11/5/2005	670	50	32	18
005	1/25/2006	530	50	32	18
006	4/9/2005	480	44	27	17
007	4/12/2005	505	51	33	18
007	10/11/2005	660	51	33	18
009	9/23/2005	390	46	28	18

021	1/8/2006	525	47	29	18
021	3/11/2006	540	47	29	18
021	6/15/2006	455	47	29	18
021	10/3/2006	555	47	29	18
022	3/24/2006	535	50	31	19
022	7/2/2006	520	50	31	19
022	9/20/2006	580	50	31	19
022	12/18/2006	705	50	31	19
023	3/31/2006	680	50	31	19
023	6/27/2006	495	50	31	19
025	11/25/2006	565	49	30	19
028	10/2/2006	465	47	30	17
033	10/19/2006	565	47	30	17
Juvenile/subadult male[c]					
011	10/9/2005	410	44	27	17
011	1/7/2006	595	47	29	18
011	4/2/2006	530	47	29	18
011	6/30/2006	490	47	29	18
011	8/22/2006	545	48	30	18
012	10/11/2005	220	31	18	13
012	10/25/2005	300	34	22	12
013	10/13/2005	500	46	28	18
024	7/30/2006	250	35	23	12

025	7/30/2006	250	36	23	13
025	8/24/2006	300	41	26	15
027	10/2/2006	355	42	26	16
031	10/3/2006	385	44	29	15

[a] Study animal identification number.

[b] Date of capture.

[c] Gender and estimated age class of animal at capture based on tooth wear, pelage, and capture history.

[d] Mass of animal at capture estimated to the nearest 5 g.

[e] Length of animal from tip of nose to tip of tail.

[f] Length of head and body from tip of nose to base of tail.

[g] Length of tail from base to tip.