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a) Title:

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

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d) Introduction and Study Objectives

The eastern spotted skunk (*Spilogale putorius*) is a small (0.5 – 2. 0 kg) carnivore that was once a common member of the carnivore community of the Midwestern United States. For reasons that remain unclear the species declined precipitously in the 1940s and has never recovered (Gompper and Hackett, 2005). The species is currently listed as state endangered or threatened in much of the Midwest (DeSanty, 2001). The species is also found in the southern and eastern United States, where its current conservation status is more difficult to discern. In Arkansas, the pattern of harvest decline is similar to that observed in Midwestern states (Gompper and Hackett, 2005; Sasse and Gompper in press), suggesting a similar population decline. However, historic harvest values for Arkansas were always lower than those of Midwestern states, and thus the apparent decline in spotted skunk populations may be, in part or in whole, an artifact of decreased harvest efforts. Thus there is a critical need to obtain additional knowledge on the population ecology and status of the eastern spotted skunk in Arkansas to allow for informed management and conservation decisions.

In Arkansas the species is apparently most common in the Ozarks and Ouachita Mountains (Sealander and Heidt, 1990; Sasse and Gompper in press), where it is both a harvested furbearer and a species of conservation concern. In Arkansas, as throughout their range, most management decisions regarding eastern spotted skunks are made based on a very limited understanding of the biology of the species. Only one robust field study of the species has ever been carried out (Crabb, 1948), and that study occurred over 60 years ago in an Iowa agricultural landscape prior to the decline of the species. We know virtually nothing about the fundamental ecology of the species in non-farm and forested landscapes. While telemetry work in southern Missouri

(McCullough 1983; McCullough and Fritzell, 1984) provides some baseline information suggesting a habitat preference for forest rather than open habitats, this work was severely limited by small sample sizes and by radiocollar loss. Thus the basis for spotted skunk management in Arkansas continues to be founded on an incomplete understanding of the species.

There is, therefore, a need to better understand the basic population ecology of eastern spotted skunks in states such as Arkansas to provide information that will allow for more informed management decisions. Here we report the results of a study of spotted skunk ecology carried out in the Ouachita Mountains, where an extant spotted skunk population was know to persist.

Specific study objectives for the project were:

1. Determine spotted skunk home range size and movement dynamics in the Ouachita Mountains.
2. Determine spotted skunk habitat use patterns in the Ouachita Mountains, including habitat use in relation to restored pine-bluestem areas on the Ouachita National Forest.
3. Survey spotted skunks inhabiting the Ouachita Mountains for evidence of exposure to disease-causing pathogens, and to identify the prevalence of ectoparasites and fecal-borne endoparasites of the species.
4. Determine spotted skunk foraging habits in the Ouachita Mountains.

e) Methods

Our initial goal was to capture 25 spotted skunks and fit them with radiotransmitters for long-term monitoring. The sample was to consist of a roughly equal number of males and females from which daytime locations would be collected every weekday (ca 20 days/month) from December 2004 through June 2006. We also attempted to obtain night-time locations every other night (ca 10 days/month). All locations were collected through use of triangulation and a detailed telemetry error study was conducted (Withey et al. 2001). The study was based out of Waldron, with day-to-day operations run by a graduate student (Mr. Damon Lesmeister) and research technicians (Mr. Aaron Nolan, Ms. Rachel Crowhurst). The sample sizes offered, in terms of both number of locations and number of animals, will be sufficient to address home range and habitat use questions given the analytical procedures described below (Seaman et al. 1999, Leban et al. 2001).

Live-trapping

Spotted skunks were captured using Tomahawk box traps (#204; 20x7x7) baited with several fish-based and fruit-based bait types and commonly used, commercially-produced trapping lures. Sides and backs of traps were covered with burlap and leaf litter and traps were checked daily. Locations of captured individuals are recorded using NAD83 datum UTM coordinates. Captured skunks were anesthetized on site with an intramuscular injection of a combination of a general anesthetic (30 mg/kg ketamine hydrochloride) and a sedative (0.3mg/kg acepromazine) to smooth induction and recovery of a Stage III, Plane II anesthesia (Kreeger, 1996). Thereafter, skunks were weighed and measured, ear tagged (#1 Monel; Hasco Tag Co.), sampled for parasites, and radiocollared with ATS Model 2900 or M1730 transmitters. Animals were then returned to the trap and allowed to fully recover prior to release. The time of anesthetization to recovery was ca 30–90 minutes.

Home Range

Only those animals with 30 locations were used given the bias associated with home range estimations based on small sample sizes. We estimated each location for a triangulation event using Lenth's maximum likelihood estimate (MLE) in GTM236 (Sartwell 2000, White and Garrott 1990). We used a combination of capture sites, den sites, and telemetry data points for locations in developing utilization distributions (UDs) for each skunk. Only those animals with ≥30 locations for at least one season were used given the potential bias associated with home range estimations based on small sample sizes (Seaman et al. 1999). The UD is a probability density that estimates the intensity of use by an animal as a specific location (Van Winkle 1975). We delineated 95% of the UD weight fixed kernel seasonal home ranges with least-squares cross validation or "plug-in" procedures to smooth the utilization distribution using Matlab (Mathworks Incorporated, Natick, MA) using the 'Kde folder'(Beardah and Baxter 1995, Worton 1995, Seaman and Powell 1996, Kernohan et al. 2001, Gitzen and Millspaugh 2003). To exclude the lower 5% of the UD volume, we used the Hawths Analysis Tools package (Beyer 2004) for ArcGIS 9.1 (Environmental Systems Research Institute, Redlands, CA). We used two-way analysis of variance (ANOVA) and linear contrasts to evaluate differences in home range size among males and females and to compare mean home range sizes between pairs of seasons (e.g., spring and summer).

Habitat Use

We used compositional analysis to evaluate second- and third-order (Johnson 1980) selection of habitat types (Aebischer et al. 1993) by skunks. In this procedure, habitat use is defined by the proportion of area by habitat type throughout the total home range area. The radio locations are used to estimate the bounds on the total range area. Thus, sample size is the number of animals and the number of locations is important only to the extent enough locations must be collected to accurately estimate total range area (Aebischer et al. 1993). The proportional area of each habitat type used sums to 1 (i.e., unit sum constraint). By using a log–ratio transformation $y_i = \ln(x_i/x_j)$ (i=1,…, D, $i \neq j$) where x_i is the proportion of the individual's home range in habitat i, x_j is the proportion of one habitat type, and D equals habitat types, the y_i are linearly independent (Aitchison 1986). This transformation was conducted for both used and available data. Availability was similarly defined as the proportional occurrence of habitat types, but at a larger scale (e.g., study area). Aebischer et al. (1993) suggested a two–stage analysis procedure; home range selection within the study area (Johnson's [1980] second order) and resource selection within the home range (Johnson's [1980] third order). Next, differences in the log transformed availability data were subtracted from the log transformed use data for each animal (i.e., $d_i = \ln(x_{ui}/x_{uj}) - \ln(x_{ai}/x_{aj})$ where d is a matrix used to test the hypothesis that use equals availability). An overall test for selection was performed using a multivariate analysis of variance. In the case where use equals availability, d = 0. However, if d $\neq$ 0, t–tests (Aebischer et al. 1993) or randomization tests (Manly 1991) were used to determine whether selection differs by habitat pairs (Erickson et al. 2001).

Using the telemetry data points, we delineated 95% fixed kernel (Worton 1989, Seaman and Powell 1996, Kernohan et al. 2001) seasonal home ranges and 50% ranges using Ranges V Software (Kenward and Hodder 1996). We used Least Squares Cross-Validation or "plug-in" procedures to smooth the utilization distribution (Kernohan et al. 2001, Gitzen and Millspaugh 2003). Study habitat types were defined by habitat class categories (e.g., restored pine-bluestem areas) that encompass the study area. For the second-order analysis, we compared the habitat composition of the study area to the habitat composition within an individual skunk's seasonal home range. For the third-order analysis, we compared the habitat composition within a skunk's home range to the habitat composition of its activity area within the home range, which we defined as the 50% home range area. We determined habitat composition by calculating the proportion of the study area, 95% home ranges, and 50% home ranges by each habitat type. Habitats were then ranked according to preference of use (Aebischer et al. 1993).

Den Site Selection

Radiocollared skunks were tracked to their den sites approximately once per week. These sites were flagged and then revisited when no longer used (so as not to disturb the animal) for microhabitat data collection. For each used den site, a nearby, available, unused site was also located and paired with the used site for comparison. We identified and characterized a total of 127 inhabited dens from 13 individuals to use in data analysis (Table 1).

Table 1. Number of den sites characterized for radiocollared skunks. For each den site, data was also collected on an available, but unused site.

Skunk ID#	# of dens characterized
002	15
004	16
005	16
007	15
008	2
009	1
011	3
017	12
018	11
020	3
021	12
022	11
023	10

For each used and available den site a grid was determined (Figure 1) and the following measurements were obtained: <u>Den type</u> was classified as burrow, rocky outcrop, hollow log, hollow tree, or wood rat nest. The location, entrance orientation, and size was also documented. <u>Forest type</u> was determined by estimating percentage of the pine and hardwood component. Age of the stand was documented using USFS records. Basal area was determined using a 10 BAF wedge prism. Species and number determined for each live tree, and then measured for DBH and height. Snags falling into basal area were also measured for DBH and height. Water presence and type within den site transect grid were documented. Slope within den site transect grid and aspect of the slope were documented. Fire evidence within den site transect grid was documented and year of fire determined from USFS records. Canopy cover percentage measurements were taken at nine nodes (A_1, A_2, A_3, B_1, B_2, B_3, C_1, C_2, C_3) using a densitometer. Ground cover percentage was estimated for a 1 m^2 plot at nine nodes. The percentage of forbs and grasses was estimated and the presence of big blue stem is documented. Duff layer thickness was measured. Species and number of live trees and other herbaceous material >1.5 m tall was documented. Course and fine woody debris (course ≥10 cm; fine 10>x≥1 cm) was counted and diameters were measured (course: A_1-B_1-C_1, A_2-B_2-C_2, A_3-B_3-C_3, B_1-B_2-B_3; fine: B_1-B_2-B_3 only). Rock numbers and size class were documented from one of the four quadrates (Q_1, Q_2, Q_3, Q_4; randomly selected). The size classifications are small (0.5>x≥0.1 m), medium (1>x≥0.5 m), large (1.5>x≥1 m), and x-large (≥1.5 m). Live trees and snags ≥1.5 m tall and not already accounted for in basal area (from one quadrate) were quantified, and vine/brier number was estimated.

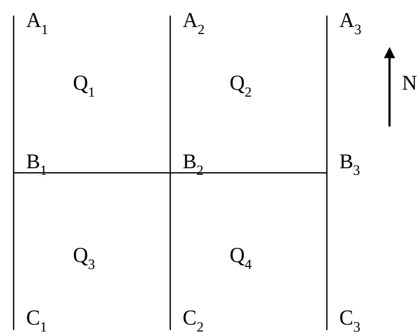


Figure 1: Den site line transect grid (25m X 25m) with den site location at node B_2.

Based on known carnivore ecology and field observations, we developed *a priori* hypotheses regarding the correlation of various habitat factors influencing den site selection by spotted skunks. First, we hypothesized that predator avoidance, thermal regulation, prey availability, or edge effects might be influencing den site selection. For each hypothesis we developed a set of *a priori* models. We used several covariates to develop the set of *a priori* candidate models representing multiple hypotheses of covariate effects on den site selection. For each hypothesis a sub-global model was developed. The four hypotheses, associated covariates, and candidate models are summarized in Table 2. We used information-theoretic model selection (Burnham and Anderson 1998) using multinomial discrete choice (PROC MDC) procedure in SAS where individual den sites were the sampling unit. We ranked models based on their AIC_c values and weights in a 90% confidence set.

Table 2. A priori models concerning spotted skunk resource selection. Measured parameters are abbreviated as follows: *Std_age* = Stand age based on USFS records; *BA* = Basal area measured at the time of den site characterization; *Vine* = Estimated number of vines in randomly selected quadrant; *Grnd* = Mean percentage of ground cover estimated at each node of den site; *Ent* = Den 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), which is most frequently used management type. Other types for comparison: mgt_00 (all other types), mgt_31 (Loblolly Pine), mgt_53 (White Oak – Red Oak – Hickory)]; *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 den site; *Snag* = Number of snags counted in randomly selected quadrant; *Rd_dist* = distance to nearest road calculated in ArcGIS; *Std_edge* = distance to nearest stand edge calculated in ArcGI; *Std_size* = Size of stand, taken from USFS records; *Cnpy* = Mean canopy cover for all nine nodes; *Slope* = Degree (˚) slope measured at den site; *Ent_sine* = Sine of the orientation of the den entrance, using an orientation of 45˚ as the reference point; *H20* = Distance to nearest water calculated in ArcGIS.

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	$Prey_{mgt\_00 +}$	$\beta_0 + \beta_1(mgt\_00) +$	$\beta_1 < 0, \beta_2 < 0,$

management type and rough year class, combined with positive effects of rock, course woody debris, and snag number	mgt_31 + mgt_53 + rgh_3_6 + rgh_7_10 + rgh_11 + rock + CWD + snag	β_2(mgt_31) + β_3(mgt_53) + β_4(rgh_3_6) + β_5(rgh_7_10) + β_6(rgh_11) + β_7(rock) + β_8(CWD) + β_9(snag)	$\beta_3 < 0$, $\beta_4 < 0$, $\beta_5 < 0$, $\beta_6 < 0$, $\beta_7 > 0$, $\beta_8 > 0$ $\beta_{10} > 0$ $\beta_{11} > 0$
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) + β_2(CWD) + β_3(rgh_3_6) + β_4(rgh_7_10) + β_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) + β_2(CWD)	$\beta_1 > 0$, $\beta_2 > 0$
9. Negative effects of management type and rough year	$Prey_{mgt\_00}$ + mgt_31 + mgt_53 + rgh_3 + rgh_3_6 + rgh_11	$\beta_0 + \beta_1$(mgt_01) + β_2(mgt_12) + β_3(mgt_31) + β_4(mgt_53) + β_5(rgh_yr)	$\beta_1 < 0$, $\beta_2 < 0$, $\beta_3 < 0$, $\beta_4 < 0$, $\beta_5 < 0$
10. Positive effects of rock number	$Prey_{rock}$	$\beta_0 + \beta_1$(rock)	$\beta_1 > 0$
<u>Edge Effects (Edge)</u>			
11. Positive effects of distance to road and stand edge	$Edge_{rd\_dist}$ + std_edge	$\beta_0 + \beta_1$(rd_dist) + β_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) + β_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) + β_2(rd_dist), β_2(std_edge)	$\beta_1 > 0$, $\beta_2 > 0$, $\beta_3 > 0$
<u>Thermal (Ther)</u>			
15. Positive effects of canopy cover and slope, combined with negative effects of distance from water and sine of den entrance	$Ther_{cnpy}$ + slope + h2o +ent_sine	$\beta_0 + \beta_1$(cnpy) + β_2(slope) + β_3(h2o) + β_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) + β_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 den 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	$Ther_{h2o}$	$\beta_0 + \beta_1(h2o)$	$\beta_1 < 0$

Parasite and Disease Survey

The disease ecology of eastern spotted skunks is poorly understood, and no robust surveys of the parasites and diseases of the species have been published. We collected feces from beneath traps and at den sites of known individuals and immediately preserved the samples in 10% formalin acetate for analysis in the laboratory. Ectoparasites were sampled by standardized collection with a flea comb in ten strokes along an animal's back from the base of the neck to the base of the tail, supplemented by timed visual examinations (similar to Clayton & Drown 2001). For ectoparasites, samples collected will ultimately be identified by examination under a dissecting microscope. Diagnostic work will be carried out in the PI's laboratory and at the MU Veterinary Diagnostic Laboratory, or when necessary at other diagnostic laboratories. Fecal samples will be analyzed via fecal flotation and sedimentation.

Positive and negative associations between parasites will be used to examine species interactions in parasite infracommunities (Lotz & Font 1991; Poulin 2001). Measures of component community structure include species richness, prevalence, and standard measures (Magurran 1988) of diversity and evenness such as kernel-based visualizations, Berger-Parker Dominence Index, Simpson's Index, and Shannon-Wiener Index modified for prevalence data (Wright and Gompper 2005). Randomized species accumulation curves, statistical estimators of species richness, and statistical estimates of the number of species shared between pairs of samples are calculated using EstimateS (Colwell 2000; Gompper et al. 2003). Analyses will also be substructured for demographic classes to identify sex and age-specific variance.

Feeding ecology

To determine dietary patterns of eastern spotted skunks we obtained feces from trapped animals and from dens of known (radiocollared) individuals. Samples containing bait were excluded from further analysis. Scats were air-dried and stored for later analysis or were preserved in 10% formalin acetate to facilitate simultaneous assessment of fecal-borne parasites. For examination, samples will be soaked in water until components are separated without breaking, and then analyzed moist and unsifted. Prey determination was performed by microscopic examination of remains and identified to the lowest possible taxonomic level by comparing to reference collections. Ultimately we will express the representation of each food type in the diet as percentage occurrence (number of samples containing each prey type times 100 divided by number of samples) and as relative percentage occurrence (number of occurrences of each prey type times 100 divided by total occurrences of all prey types in all samples). This is a measure of the relative importance of a given food type in the diet of the species (Loveridge & Macdonald, 2003). Dietary overlap between seasons will be discerned using relative frequency occurrence, and calculated as $O = \Sigma p_i q_i / (\Sigma p_i^2 \Sigma q_i^2)^{1/2}$ where O is the dietary overlap between seasons, p_i is the relative frequency of food item *i* in one season and q_i is the relative frequency of food item *i* in the other season (Pianka, 1975). Values range from 0 (no overlap) to 1 (total overlap).

f) Results

Trapping effort, captures, and collared animals

Data discussed here covers the period of 13 March 2005-17 January 2007, with monthly trapping efforts occurring March 2005-March 2006 and September 2006-October 2006 (Table 3) due to reduced capture success in late April-September (see below). Initial trapping efforts used 25 traps in a grid or trap-line formation, which over the course of the remaining trapping effort was increased up to 100 traps in an attempt to increase capture rates. Trap-lines were generally run for 1-3 wks/month, resulting in capture efforts of 269-2082 trap-nights per month, and a total capture effort of ca. 13,000 trap-nights. A total of 30 different spotted skunks were captured on 110 occasions. A marked decline in capture success occurred in May-September 2005 despite increased capture efforts (Hackett et al. 2007). The cause of this decline is unclear, but may relate to altered movement patterns following the mating season (see below) or to changes in feeding habits. A similar decline in capture success has been observed in southeastern Missouri (Hackett et al. 2007). This pattern of extreme seasonality in capture success of spotted skunks has also been observed for striped skunks (Bailey 1971), a pattern that we also witnessed in the Ouachita Mountains.

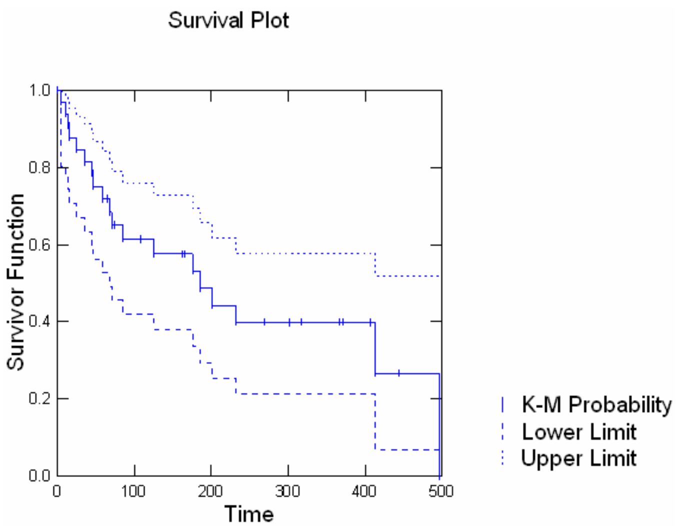
Table 3. Spotted-skunk capture effort and success (March 2005-March 2006 and September 2006-October 2006).

Month	Trap-line length	Trap-line nights	Trap-nights	Total captures	New captures
March 2005	25-50	12	350	10	5
April 2005	50-53	15	765	11	2
May 2005	50	9	450	2	0
June 2005	50-100	14	950	0	0
July 2005	100	5	500	0	0
August 2005	47-100	24	2082	2	1
September 2005	45-100	18	1200	2	1
October 2005	60-100	8	677	16	7
November 2005	24-92	7	506	15	1
December 2005	50-100	23	1952	16	2
January 2006	33-100	12	951	12	2
February 2006	20-100	12	710	10	0
March 2006	35-82	20	1311	5	2
September 2006	20-44	8	269	0	0
October 2006	15-63	7	297	9	7
Total		194	12970	110	30

Mortality

The 30 adults were radiocollared (Table 4). Of these, 16 were killed by predators (five Carnivora, 11 raptors), one from unknown cause, and one study-related death due to radiocollar entanglement. Excluding the study-related mortality, mean survival from time of capture was 245 days, with annual survival from time of capture to be ca. 40% (Figure 2). While there was no evidence that collars facilitated capture by predators (weight of the collars was well within the range that these animals should be able to bear without being hindered), the timing of several mortality events soon after collaring early in the study was worrisome. Therefore we redesigned a reduced-sized collar (ATS model M1730) that had a more flexible antenna, and replaced collars on those animals that had the earlier collar style. These animals nonetheless also had high rates of mortality due to predators (Table 4).

Figure 2. Kaplan-Meier survival plot indicating survival (days) from time of initial capture.



Two collared females (004 and 008) have reproduced in 2005 and four collared females (004, 017, 018, and 020) reproduced in 2006. As indicated by remote cameras at the natal site, the female #020 had at least two pups. She was killed by a predator in July 2006, when the pups were estimated to be ca. 40 days old and too young to forage successfully alone. Therefore traps were set at the natal site in an attempt to capture young, resulting in the capture of 3 pups. The pups were reared for 3 weeks, radiocollared and released at the natal site. One juvenile (024) was killed by a predator, another (026) disappeared, and one (025) was released in January 2007 (Table 4).

Table 4. Chronology of spotted skunk captures (March 2005-January 2007). Bold indicates initial capture event.

ID	Date	(R) Ear tag	(L) Ear tag	Collar Frequency	Sex	Notes
001	3/13/2005	901	902	150.016	♂	**Killed by predator 3/05**
002	3/13/2005	903	904	150.036	♀	**Released 12/05**
003	3/13/2005	906	905	150.136	♀	**Killed by predator 3/05**
004	3/13/2005	925	908	150.054	♀	**Died 7/06**
005	3/13/2005	910	909	150.075	♂	**Killed by predator 4/06**
002	3/14/2005	Recapture		150.036		
002	3/16/2005	Recapture		150.096		Collar replaced
002	3/18/2005	Recapture		150.096		
002	3/19/2005	Recapture		150.096		
004	3/27/2005	Recapture		150.054		
006	4/9/2005	924	945	150.016	♂	**Killed by predator 4/05**
005	4/10/2005	950(new)	Recapture	150.075		Ear tag replaced
006	4/10/2005	Recapture		150.016		
006	4/11/2005	Recapture		150.016		
007	4/12/2005	922	949	150.036	♂	**Killed by predator 11/05**
007	4/12/2005	Recapture		150.036		
007	4/13/2005	Recapture		150.036		
004	4/26/2005	Recapture		150.054		
004	4/27/2005	Recapture		150.054		
004	4/28/2005	Recapture		150.054		
004	4/29/2005	Recapture		150.054		
004	5/1/2005	Recapture		150.054		
004	5/16/2005	Recapture		150.054		
002	6/24/2005	920 (new)	977(new)	150.614		Collar replaced
004	6/24/2005	Recapture		150.695		Collar replaced
005	6/24/2005	919(new)	978(new)	150.515		Collar replaced
008	8/21/2005	948	946	150.538	♀	**Killed by predator 3/06**
008	8/23/2005	Recapture		150.538		
008	8/28/2005	Recapture		150.538		
008	9/23/2005	Recapture		150.538		
009	9/23/2005	974	942	150.676	♂	**Disappeared 3/06**
008	9/24/2005	Recapture		150.538		
008	10/7/2005	Recapture		150.538		
008	10/8/2005	Recapture		150.538		
010	10/8/2005	911	968	150.656	♀	**Killed by predator 12/05**
008	10/9/2005	Recapture		150.538		
011	10/9/2005	954	936	150.734	♂	**Released 8/06**
008	10/10/2005	Recapture		150.538		
010	10/10/2005	Recapture		150.656		
012	10/11/2005	953	962	150.795	♂	**Disappeared 12/05**
007	10/11/2005	Recapture		150.795	♂	
011	10/12/2005	Recapture		150.734		
007	10/12/2005	Recapture		150.715		

008	10/13/2005	Recapture		150.538		
012	10/13/2005	Recapture		150.795		
007	10/13/2005	Recapture		150.715		
013	10/13/2005	929	941	150.555	♂	**Killed by predator 2/06**
014	10/13/2005	930	965	150.575	♀	**Killed by predator 12/05**
010	10/14/2005	Recapture		150.656		
015	10/14/2005	984	993	150.595	♀	**Killed by predator 11/05**
013	10/14/2005	Recapture		150.555		
014	10/14/2005	Recapture		150.575		
010	10/15/2005	Recapture		150.656		
014	10/15/2005	Recapture		150.575		
014	10/16/2005	Recapture		150.575		
013	10/18/2005	Recapture		150.555		
016	10/23/2005	960	996	150.637	♀	**Killed by predator 12/05**
014	10/23/2005	Recapture		150.575		
013	10/24/2005	Recapture		150.555		
013	10/25/2005	Recapture		150.555		
010	10/25/2005	Recapture		150.656	♀	
012	10/25/2005	Recapture		150.795	♂	
011	11/4/2005	Recapture		150.734		
013	11/4/2005	Recapture		150.555		
017	11/4/2005	928	944	150.755	♀	**Released 1/07**
014	11/4/2005	Recapture		150.575		
014	11/5/2005	Recapture		150.575		
011	11/5/2005	Recapture		150.734		
005	11/5/2005	Recapture		150.776	♂	
014	11/6/2005	Recapture		150.575		
011	11/6/2005	Recapture		150.734		
011	11/7/2005	Recapture		150.734		
011	11/9/2005	Recapture		150.734		
011	11/29/2005	Recapture		150.734		
011	12/3/2005	Recapture		150.734		
011	12/4/2005	Recapture		150.734		
011	12/5/2005	Recapture		150.734		
011	12/6/2005	Recapture		150.734		
011	12/7/2005	Recapture		150.734		
011	12/8/2005	Recapture		150.734		
008	12/8/2005	Recapture		150.844	♀	
011	12/9/2005	Recapture		150.734		
011	12/10/2005	Recapture		150.734		
011	12/11/2005	Recapture		150.734		
011	12/12/2005	Recapture		150.734		
011	12/13/2005	Recapture		150.734		
011	12/14/2005	Recapture		150.734		
018	12/14/2005	935	912	150.804	♀	**Released 1/07**
011	12/16/2005	Recapture		150.734		
018	12/16/2005	Recapture		150.804		
011	12/17/2005	Recapture		150.734		
002	12/19/2005	987	969	150.614	♀	
019	12/30/2005	918	926	150.964	♀	**Killed by predator 1/06**
013	12/31/2005	Recapture		150.555	♂	

020	1/4/2006	967	998	150.822	♀	**Killed by predator 7/06**
019	1/4/2006	Recapture		150.964		
019	1/5/2006	Recapture		150.964		
019	1/6/2006	Recapture		150.964		
019	1/7/2006	Recapture		150.964		
011	1/7/2006	Recapture		150.984	♂	
019	1/8/2006	Recapture		150.964		
002	1/8/2006	Recapture				Collar removed
021	1/8/2006	932	957	150.863	♂	**Released 1/07**
013	1/9/2006	Recapture		150.904	♂	
018	1/15/2006	935	912	150.804	♀	
005	1/25/2006	Recapture		150.776	♂	
005	1/27/2006	Recapture		150.776		
005	1/28/2006	Recapture		150.776		
005	1/30/2006	Recapture		150.776		
017	1/31/2006	Recapture		150.924	♀	
004	2/8/2006	Recapture		150.695		
004	2/9/2006	Recapture		150.695		
005	2/17/2006	Recapture		150.776		
004	2/18/2006	Recapture		150.695		
005	2/19/2006	Recapture		150.776		
005	2/21/2006	Recapture		150.776		
004	2/22/2006	Recapture		150.695		
004	2/23/2006	Recapture		150.695		
005	2/23/2006	Recapture		150.776		
004	2/27/2006	Recapture		150.695		
018	3/6/2006	935	912	150.943	♀	Collar replaced
021	3/11/2006	932	957	150.094	♂	Collar replaced
022	3/24/2006	955	983	150.614	♂	**Released 12/06**
022	3/25/2006	Recapture		150.614		
022	3/27/2006	Recapture		150.614		
022	3/29/2006	Recapture		150.614		
023	3/31/2006	933	973	150.572	♂	**Died 9/06**
011	4/2/2006	torn out, not replaced		151.052	♂	Collar replaced
017	4/13/2006	torn out, not replaced		150.883	♀	Collar replaced
018	5/25/2006	Recapture		150.632	♀	Collar replaced
004	6/15/2006	torn out, not replaced		151.073	♀	Collar replaced
021	6/15/2006	932	957	150.154	♂	Collar replaced
023	6/27/2006	933	973	150.064	♂	Collar replaced
020	6/28/2006	torn out, not replaced		150.092	♀	Collar replaced
011	6/30/2006	torn out, not replaced		150.011	♂	Collar replaced
022	7/2/2006	torn out, not replaced		150.133	♂	Collar replaced
017	7/6/2006	torn out, not replaced		150.034	♀	Collar replaced
024	7/30/2006	951	963	151.092	♂	**Juvenile, Killed by predator 8/06**
025	7/30/2006	956	931	150.904	♂	**Juvenile, Released 1/07**
026	7/30/2006	917	985	151.012	♀	**Juvenile, Disappeared 10/06**
018	8/10/2006	torn out, not replaced		151.043	♀	Collar replaced
011	8/22/2006	torn out, not replaced			♂	Collar removed
026	8/24/2006	917	torn out	150.653	♀	Collar adjusted

025	8/24/2006	956	torn out	150.714	♂	Collar adjusted
022	9/20/2006	torn out, not replaced		150.074	♂	Collar replaced
017	9/20/2006	torn out, not replaced		151.023	♀	Collar replaced
021	10/3/2006	torn out, not replaced		150.054	♂	
027	10/2/2006	995	994	151.103	♂	**Released 1/07**
028	10/2/2006	979	938	151.084	♂	**Disappeared 10/06**
029	10/2/2006	913	943	150.733	♀	**Disappeared 11/06**
030	10/3/2006	648	646	150.534	♀	**Killed by predator 12/06**
031	10/3/2006	639	620	150.773	♂	**Killed by predator 11/06**
027	10/4/2006	Recapture		151.103	♂	
029	10/6/2006	Recapture		150.733	♀	
032	10/18/2006	636	625	150.595	♀	**Killed by predator 11/06**
033	10/19/2006	650	627	150.353	♂	**Released 1/07**
018	11/4/2006	torn out, not replaced		150.613	♀	
025	11/25/2006	956	torn out, not replaced	150.754	♂	
025	12/4/2006	956	torn out, not replaced	150.754	♂	
022	12/18/2006	torn out, not replaced		150.553	♂	Released
018	1/7/07	torn out, not replaced		151.043	♀	Released
017	1/8/07	torn out, not replaced		151.023	♀	Released
021	1/9/07	torn out, not replaced		150.054	♂	Released
033	1/16/07	650	627	150.353		Released
027	1/17/07	995	994	151.103		Released

Spotted skunks from the Ouachita Mountains were relatively small. Mean body weight of 13 males was 540 g (range = 390-705). Mean weight of 14 adult females was 436 g (range = 340-585). Mean measures of total, head-body and tail length (cm) for the males were 48.0, 30.0, and 18.1, respectively. For females, mean measures were 44.9, 27.8, and 17.2, respectively.

Den site selection

Results of the multinomial discrete choice analysis indicate support for the thermal regulation and predator avoidance hypotheses (Table 5). Among the candidate models to assess skunk den site selection, the thermal regulation sub-global model ($Ther_{cnpy + slope + h2o + ent\_sine}$) had the lowest AIC_c value and its AIC_c weight was nearly two times higher than the next highest rank model. This model explained 46% of the variation between used and available unused den sites. The next competing models were the predator avoidance sub-global model ($Pred_{vine + BA + grnd + grnd^2 + std\_age + ent}$) and a thermal regulation candidate model ($Ther_{cnpy + h2o}$), explaining 25% and 24% of the variation, respectively. Of the nine covariates in the 90% confidence set models only canopy cover, slope, distance to water, vine, stand age, and entrance size were significant ($P > 0.05$).

Table 5. Ranking of a priori hypothesized models relating habitat covariates to eastern spotted skunk den site selection in the Ouachita National Forest.

Sub global Model	model	Hypothesis	K‡	AICc	ΔAICc$_i$	w$_i$
Thermal	$Ther_{cnpy + slope + h2o + ent\_sine}$	15	5	151.446	0	0.464
Predator Avoidance	$Pred_{vine + BA + grnd + grnd^2 + std\_age + ent}$	4	7	152.695	1.248	0.248
Thermal	$Ther_{cnpy + h2o}$	16	3	152.777	1.331	0.238

Home Range Analyses and Observations on Reproduction

We used 95% fixed kernel home ranges with least-squares cross validation (Worton 1995, Seaman and Powell 1996, Kernohan et al. 2001) to delineate ranges for each skunk. We used calendar seasons for the analyses, which were completed in Matlab (Beardah and Baxter, 1995), and using Hawths tools in ArcGIS.

During the period March 2005 to November 2006, 12970 trap nights were recorded resulting the capture and radio-collaring of 33 skunks (17 males, 16 females) , including 3 juveniles (see below), with a mean of 106 (sd 63) total locations per animal. Of these, 23 skunks, (12 males, 11 females) were tracked for periods long enough to estimate home range size and resource selection for at least one season. Eleven skunks were tracked during spring and summer, 16 during the fall, and nine during the winter (Table 6).

A strong seasonal gender difference in home range size occurred (df = 3, P = <0.0001) (Table 6). Males had larger home ranges than females (P = 0.001). The 95% fixed kernel contour area for adult males were 541%, 135%, 15%, and 146% larger than females for spring, summer, fall, and winter, respectively (Table 5). The only seasonal variation occurred during the spring, when compared to summer (P = 0.0005), fall (P = <0.0001) and winter (P = 0.0026). There were no differences between home ranges within or between sexes of other seasons; within sexes and (P > 0.1).

Table 6. 95% of UD volume fixed kernel home range size (ha) by season and sex. n = number of home ranges calculated, $\bar{x}$ = mean home range size (ha), SE = standard error.

	Spring			Summer			Fall			Winter		
Sex	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE
M	6	866	235	6	127	31	8	75	22	5	175	62
F	5	135	30	5	54	24	8	65	7	4	71	25

Female 004 gave birth in late May 2005 and used only a few den sites from May 22 – late June 2005. On June 7 2005 the den was disturbed by a digging animal (possibly an armadillo) and the female switched den sites, abandoning one of the cubs. This cub was estimated as 10-14 day old (based on developmental stages; Crabb 1944) when abandoned. Female 002 may also have reproduced in 2005, although support for this is equivocal. When captured on 24 June 2005, female 002 was lactating. However during the entire summer this female did not use any single den for more than a few days (the other two females known to have litters used the same den for ca 2 weeks). Breeding female 008 was captured in late August and to date has also used only a small number of dens. At the time of capture the female had already given birth. The telemetry data on this individual are too preliminary for home range analyses, but the observation of an abandoned cub with closed eyes near the den site on 22 August 2005 indicates the potential for an extended birthing season. This cub was estimated to be ca 40 days of age. Thus, minimally the birthing season of Ouachita skunks extends from late May through mid July.

Females 004, 017, 018 and 020 gave birth late May 2006 and each used just a few den sites during that period through mid July. The female 020 was killed by a predator on July 7 2006, therefore the three juveniles were captured at the den site and kept captive until they were developed enough to forage and carry radio transmitters successfully. Following their release on July 31 2006 one was killed by a predator, one was monitored frough October 2006 at which point it disappeared, and third was monitored through January 2007.

Habitat Use

Summarizing the seasonal results of habitat use for all skunks, we found strong patterns of habitat selection by spotted skunks. During each season, there is a much higher percent use of young shortleaf pine (0-30 year old) managed stands available (Figure 3); indicating strong selection for those stands. Young shortleaf pine stands are ranked first in resource selection ranking for each season. Significant selection of shortleaf pine compared to all other available habitats occurred during summer and fall (Tables 6-9). During winter and spring, young shortleaf pine stands are ranked first, but significant selection of young shortleaf pine compared to hardwood stands did not occur (Tables 6-9).

Hardwood stands (SMZs) were consistently ranked second to young shortleaf pine stands during each season. Percent use was either equal to or greater than percent available (Figure 3). Mature shortleaf pine stands occur in the highest percent in the mosaic of available habitat on the study site (Figure 3). Mature shortleaf pine (>70 years old) stands are consistently ranked third, indicating weak selection. The ranking may be an artifact of the large percent availability, not selection for. A typical fall 95% UD for a female skunk is shown in Figure 4 and demonstrates the skunk's use is mostly of young shortleaf pine stands with the highest use area occurring at SMZs. The stand is surrounded by hardwood and mature shortleaf pine, yet very little use occurs in the mature stands, which appears to be either strong selection for the young stand or avoidance of mature stands. The remaining available habitat types (shortleaf pine 31-70 years old, private, other) were consistently ranked in the bottom three rankings, but were not consistent in specific rank for each season.

Figure 3. Seasonal percent use of habitat types compared to available. Open bars, with standard error indicated, represent percent use during the season, whereas filled bars represent percent available.

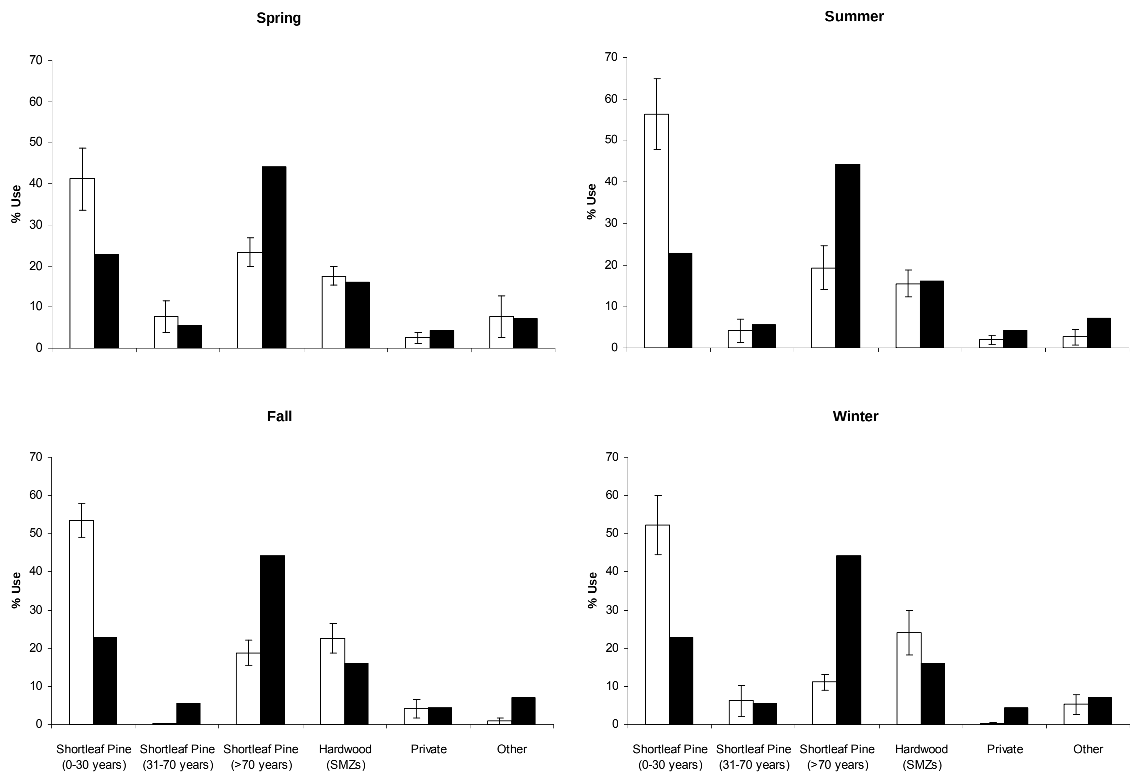


Table 6. Matrix of spring spotted skunk resource selection. +++ indicates significant deviation from random at $P<0.05$.

Habitat	shortleaf pine 0-30	shortleaf pine 31-70	shortleaf pine >70	Hardwood	Private	Other	Rank
shortleaf pine 0-30		+++	+++	+	+++	+++	1
shortleaf pine 31-70	---		-	-	+	+	4
shortleaf pine >70	---	+		---	+	+	3
Hardwood	-	+	+++		+	+++	2
Private	---	-	-	-		+	5
Other	---	-	-	---	-		6

Table 7. Matrix of summer spotted skunk resource selection. +++ indicates significant deviation from random at $P<0.05$.

Habitat	shortleaf pine 0-30	shortleaf pine 31-70	shortleaf pine >70	Hardwood	Private	Other	Rank
shortleaf pine 0-30		+++	+++	+++	+++	+++	1
shortleaf pine 31-70	---		-	-	+	-	5
shortleaf pine >70	---	+		_	+	+	3
Hardwood	---	+	+		+++	+	2
Private	---	-	-	---		-	6
Other	---	+	-	-	+		4

Table 8. Matrix of fall spotted skunk resource selection. +++ indicates significant deviation from random at $P<0.05$.

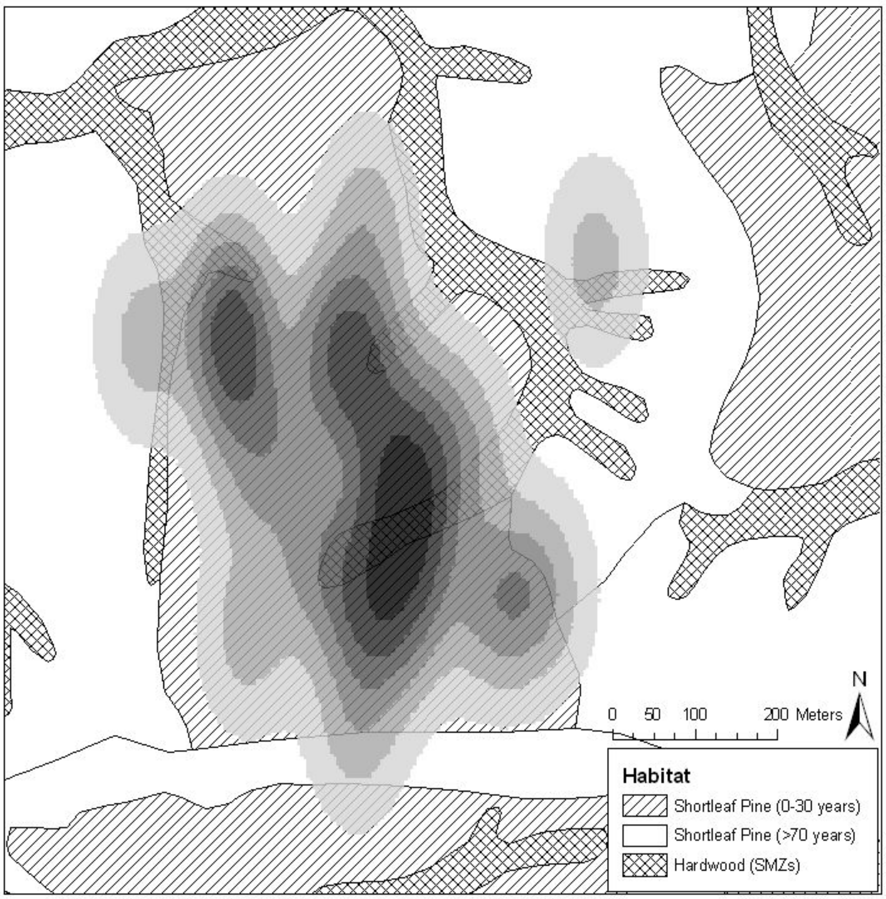
Habitat	shortleaf pine 0-30	shortleaf pine 31-70	shortleaf pine >70	Hardwood	Private	Other	Rank
shortleaf pine 0-30		+++	+++	+++	+++	+++	1
shortleaf pine 31-70	---		---	---	+	---	5
shortleaf pine >70	---	+++		---	+++	+	3
Hardwood	---	+++	+++		+++	+++	2
Private	---	-	---	---		---	6
Other	---	+++	-	---	+++		4

Table 9. Matrix of winter spotted skunk resource selection. +++ indicates significant deviation from random at $P<0.05$.

Habitat	shortleaf pine 0-30	shortleaf pine 31-70	shortleaf pine >70	Hardwood	Private	Other	Rank
shortleaf pine 0-30		+++	+++	+	+++	+++	1
shortleaf pine 31-70	---		-	---	-	+	5

shortleaf pine >70	---	+		---	+	+++	3
Hardwood	-	+++	+++		+++	+++	2
Private	---	+	-	---		+	4
Other	---	-	---	---	-		6

Figure 3. Utilization distribution for a female skunk during fall. The UD has been interpolated to a raster file and overlaid on GIS habitat layer. The darker areas of the UD are areas with higher use.



Feeding and parasite analyses
Scat analyses will be used to assess endoparasite burdens and diet. Currently we have ca 90 fecal samples being qualitatively analyzed for endoparasites. Preliminary observation of scat contents suggest a diet dominated by invertebrates for the collection periods of March-September 2005 and 2006. For ectoparasites, ticks and fleas have been collected from captured individuals. These ectoparasites will be keyed to species in late 2007.

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