Home Range Size and Resource Use by Eastern Spotted Skunks in Virginia

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Abstract. Throughout much of the eastern U.S., many forested ecosystems have lost large amounts of core forest areas due to land-use change, isolating wildlife in forest fragments. The eastern spotted skunk (*Spilogale putorius*) is considered a species of conservation concern in Virginia, where populations are restricted to spatially disjunct forest patches in the central Appalachian Mountains. We caught and radio-tagged eastern spotted skunks in the Appalachian Mountains of Virginia to assess whether current habitat fragmentation restricts skunk movements and hence distribution, potentially leading to isolation among habitat patches. Denning home range size (approximately 3.7 km^2) in our study was smaller than those in other studies of eastern spotted skunks and excursive movements were primarily limited to core forested areas (>2 km^2). Core forested areas were used more than non-forested and forest-edge areas. We conclude core forest area fragmentation limits eastern spotted skunk movement between mountain ridges. Increased forest patch connectivity may help prevent genetic and demographic isolation, reduce the likelihood of local extinctions, and facilitate colonization of suitable unoccupied areas.

Key words: compositional analysis, exploratory excursion, fragmentation, territoriality

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Many forest ecosystems have experienced fragmentation due to land conversion for agriculture or urban development (Bogaert et al. 2015). Size, shape, and degree of isolation of forest fragments can influence the distribution, demography, and genetic diversity of species (Schneider 2001, Devictor et al. 2008). When species' occurrences are limited to patches of habitat within a matrix of unsuitable conditions, an individual's home range may be limited within the habitat patch or it may make exploratory excursions to other patches but ultimately return to its home range area (Lidicker and Stenseth 1992, Kozakiewicz 1993). Understanding an animal's ability to traverse extra-home range environments is a key component of research involving movement patterns, migration rates, and resource use and intended to inform landscape management decisions. Excursions may allow an animal to elucidate the availability of resources outside of a familiar home range before dispersing (Lidicker and Stenseth 1992). If not identified as excursive during space-use studies, these movements can contribute to overestimations of home range size and lead to erroneous interpretations of resource use (Hodder et al. 1998). Home range size and excursive movements may be shaped by both resource availability and local population density. As density increases, animals may respond by using smaller home ranges which reduces range overlap, avoiding antagonistic interactions between individuals (Kozakiewicz 1985). Conversely, range overlap may increase, intensifying competition among individuals (Wolff 1985).

The eastern spotted skunk (*Spilogale putorius*; hereinafter, spotted skunk) has a global rank of Vulnerable on the IUCN Red List of Threatened Species (Gompper and Jachowski 2016) and a state rank of Vulnerable in Virginia (Chapman 2007). In the central Appalachian Mountains of Virginia, spotted skunks occupy small, disjunct forest patches throughout their historic range (Thorne et al. 2017). Spotted skunks are sexually dimorphic in body size which contributes to variation in home range size and resource use (Lesmeister et al. 2009). Physiological differences (e.g., reproductive condition) also may explain variation in movement patterns. Pregnant or kit-rearing females require more food, are vulnerable to predation, and may be restricted to smaller daily movements (Powell 1979). Restricted movements could have demographic and genetic consequences (Templeton et al. 1990), similar to those faced by Allegheny woodrats (*Neotoma magister*) in the region (Kanine 2013).

Our study objectives were to: identify patterns in exploratory excursions by spotted skunks; estimate site- and sex-specific differences in den home range size; assess sex- and site-specific patterns

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of den home range overlap; and assess within-study site and within-den home range resource use (second- and third-order selection, respectively; Johnson 1980). We predicted: 1) male spotted skunks would make more frequent and longer distance exploratory excursions to seek additional resources (Handley and Perrin 2007); 2) due to larger body size, potential territoriality, and mate-seeking behavior, male spotted skunks would occupy larger den home ranges (Clutton-Brock 1989) which would be greater at sites with larger core forest areas (Kozakiewicz 1985); 3) as a solitary carnivore species, spotted skunks would display little home range overlap with conspecifics, though more so between male-female dyads (Powell 1979); and 4) resource use would be associated with large core forest areas at lower elevations where complex forest structure may provide foraging and escape cover (Aebischer et al. 1993).

Study Area

We conducted our study within the Appalachian Mountains of Virginia in the Valley and Ridge and Blue Ridge physiographic provinces on or adjacent to the George Washington and Jefferson National Forests (Figure 1). This included Bald Mountain (BM) in Botetourt and Craig counties, Whitetop Mountain (WT) in Grayson County, and Wintergreen Resort (WG) in Nelson County. Elevation ranged from 350 to 1460 m. Forest composition varied by elevation and aspect but consisted predominately of Appalachian oak (*Quercus* spp.)–hickory (*Carya* spp.) association with cove hardwood in mesic ravines and north-facing slopes, yellow pine (*Pinus* spp.)–mountain laurel (*Kalmia latifolia*) associations on xeric ridgelines, and white pine (*P. strobus*), eastern hemlock (*Tsuga canadensis*), and rosebay rhododendron (*Rhododendron maximum*) along riparian zones. The high-elevation forest of the Mount Rogers National Recreation Area was dominated by northern hardwood and red spruce (*Picea rubens*) communities (Yarnell 1998). Annual precipitation was approximately 110 cm throughout most of the region but varied from north (less) to south (greater) and annual temperature ranged from –10.6 C in winter to 27.5 C in summer.

Methods

Sampling Methods

To assess relationships between spotted skunk movement patterns, den home range size, and resource use, we initiated a radio telemetry study using very high frequency radio collars. During the winter seasons of 2016–2017, we deployed live traps (model 103, Tomahawk Live-Trap Co., Wisconsin) in three areas of high predicted spotted skunk occupancy (Thorne et al. 2017): BM, WG, and WT. Traps were baited with a mixture of peanut butter, bacon grease, and oats. Captured spotted skunks were removed from

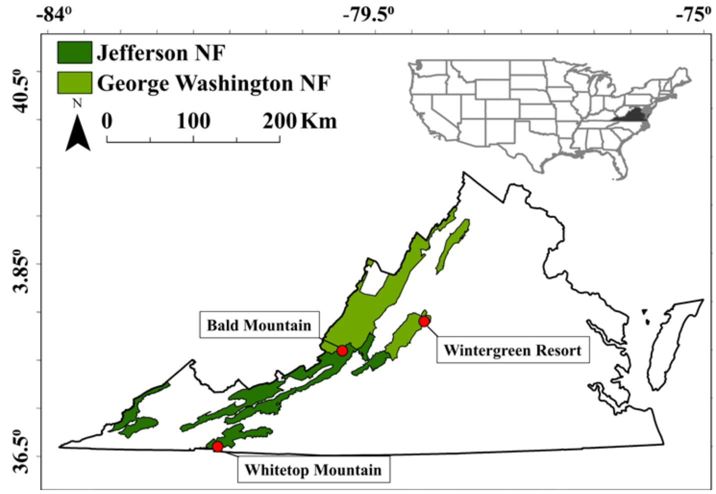

Figure 1. Eastern spotted skunk (*Spilogale putorius*) den home range study sites in Virginia, March 2016–November 2017.

the traps and physically immobilized using a cloth handling bag. We sexed and weighed all captured individuals. We assessed age class (adult and juvenile) based on weight and tooth wear (Crabb 1944) and categorized individuals as juvenile (<350 g) and adult. Only adults were initially captured during winter months (February–May) and were all >350 g. Juveniles were only captured during summer (July–August) after emerging from their natal den and were not collared as body mass was too low (<200g) to support the use of a tracking collar.

We affixed a uniquely numbered ear tag to each captured individual and deployed 16-g radio collars (model M1740, Advanced Telemetry Systems Inc., Isanti, Minnesota) to adult individuals with a mass >350 g. These collars comprised approximately 2.3–4.6% of body weight of individuals with a mass of 350–700 g. Throughout the study, we attempted to recapture all collared individuals to replace collars prior to battery failure or remove collars at the conclusion of our fieldwork. We radio-collared and tracked individuals using TRX-1000S receivers and folding three-element Yagi antennas (Wildlife Materials Inc., Carbondale, Illinois) and attempted to locate each animal every four to seven days to prevent temporal autocorrelation. We tracked through all seasons until the individual was lost, expired, or the collar failed. Trapping and handling procedures were approved by the Virginia Polytechnic Institute and State University Institutional Animal Care and Use Committee (protocol number 13-119-FIW) and permitted by Virginia Department of Wildlife Resources.

Diurnal den locations were recorded using a hand-held GPS unit (model eTrex 20x, Garmin, Ltd., Olathe, Kansas). When field conditions prevented physical location of dens, we recorded three observer GPS coordinates and respective azimuth direction and used Program LOAS (Ecological Software Solutions, LLC, Sacramento, California) to triangulate an individual's estimated location. We estimated triangulation error by comparing the difference in distance between the actual and estimated location pairs following the methods of Lesmeister et al. (2009).

Data Analysis

We identified exploratory excursions using the Incremental Cluster Polygon method (Hodder et al. 1998). We compared number of excursions and excursion distance between sexes using Mann-Whitney U-Tests. We pooled non-excursive relocations of individuals to calculate den home range size and core-use area using 95% and 50% fixed-kernel density estimates with reference bandwidth, respectively (Worton 1989). Due to lost individuals, collar failures, and mortality, the threshold of 30–50 points per home range suggested for kernel density estimation was not achieved for all individuals (Seaman et al. 1999). Small sample sizes may lead to overestimation of home range size; however, estimates for simple home ranges, as in this study, may be less biased than complex ones (Seaman et al. 1999). Home range and habitat use information is important for spotted skunk conservation, thus we included individuals with ≥15 relocations to increase replications, understanding that estimates may be biased. We compared site- and sex-specific differences using Kruskal-Wallis tests (Kruskal 1952). We checked for correlation between number of relocations and den home range size using a Pearson's product moment correlation test. We calculated the volume of intersection (VI) to assess the degree of overlap (0 = no overlap, 1 = complete overlap) of the den home range and core area for sex-specific dyads. We then used a Kruskal-Wallis test for sex- and site-specific differences in VI of den home range and core areas.

We used compositional analysis to assess landscape characteristics and space use, or utilization distribution (UD; Millspaugh et al. 2006). Characteristics included land cover class, forest fragmentation, and elevation. We used the 2016 National Land Cover Database (NLCD) classification system (Yang et al. 2018) to categorize land cover types as hardwood forest, conifer forest, mixed hardwood-conifer forest, shrub-scrub, and non-forested (i.e., wildlife openings, oldfields, pasture and non-woody wetland areas). We derived a forest fragmentation map in ArcMap 10.2.2 (ESRI, Redlands, California) following methods of Vogt et al. (2007) to classify areas as core forest (>2 km^2 intact forest), forest-edge (boundaries around forest regions), patch forest (forest <2km^2), and perforated forest (boundaries between core forest and small forest perforations). We reclassified the 30-m National Elevation Dataset (Gesch et al. 2002) into 100-m intervals between 450 and 1050 m in elevation. However, due to limited observations at the highest and lowest elevations, we pooled observations <450 m, between 1050 and 1249, and >1249 m.

We estimated resource use at two levels according to the Johnson (1980) order of selection criteria following recommendations of Aebischer et al. (1993). We defined study areas using buffers equal to the mean radius of all home ranges at a site. We first summed the UD value of each landscape characteristic available within a den home range and divided by the total UD value of the den home range. We then used the weighted compositional analysis to assess within-home range resource use (third order selection). Next, we pooled UD values of each landscape characteristic for all individuals within a site and used the weighted compositional analysis to assess resource use (second order selection). We used the Wilk's lambda statistic to test the use of each landscape characteristic and performed a rank analysis on each resource class. All analyses were performed in R using the package 'adehabitatHR' (Calenge 2020) and R base package 'stats' (R Core Team 2014).

Results

We captured 27 spotted skunks including 18 adults (seven females, 11 males) and nine juveniles (two females, seven males). We collared and tracked all adult skunks but only collected ≥15 non-excursive relocations for 12 (seven males, five females; Table 1). Body mass of adult males ranged from 390–755 g ($\bar{x} = 566 \pm 15$ g) and adult females from 401–655 g ($\bar{x} = 470 \pm 26$ g). The 12 skunks with ≥15 relocations were tracked for an average of 296.4 ± 60.2 days and an average of 25.0 ± 2.5 relocations per individual were collected from March 2016–November 2017. Though tracking effort was generally even (1–2 tracking events per week per site), the number of relocations per individual varied across months and ranged from 1–5.8 ($\bar{x} = 2.5 \pm 2.3$). The greatest number of successful tracking attempts occurred during months immediately following live trapping and decreased to one or two from August through February. Triangulation estimate error was 0.9 ± 2.1 degree azimuth and 83.2 ± 15.1 m distance; points with an error polygon diameter greater than 115.5 m were not used. Of the 300 relocations included in the analyses, 61.3% were physically located and 38.7% were estimated from triangulation. We observed six mortality events during our study. At BM, two males were found dead during mating season (26 April 2017 and 28 Mar 2017) and three kit-rearing females were found dead (20 June 2016, 15 September 2016, and 1 August 2017). Three mortalities occurred within forest edge and two within core forest lacking understory cover. At WT, one female was found dead (11 June 2016) in forest-edge.

We observed five exploratory excursions by three males: one during mating season and four during early summer. Additionally, we observed six exploratory excursions by three females. All three females made at least one excursion during early pregnancy (April) and one female made two excursions post-partum (June and July). All excursions were observed at BM. Number of excursions varied ranged from 1–3 ($\bar{x} = 2.3 \pm 0.7$) and 1–4 ($\bar{x} = 2.0 \pm 1.0$) for males and females, respectively, and did not differ significantly between sexes ($W = 4.0$, $P = 1.0$). Excursion distance differed significantly between sexes and ranged from 0.4 km to 2.1 km ($\bar{x} = 1.1 \pm 0.3$ km) for males and 0.1 km to 0.75 km ($\bar{x} = 0.4 \pm 0.11$ km) for females. One excursion occurred within 200 m of forest-edge, and one occurred within forest-edge. All others occurred within core forest areas.

The number of relocations was not correlated with den home range size ($t_{10} = -1.58$, $P = 0.17$) or core area size ($t_{10} = -1.68$, $P = 0.12$). Mean den home range (95% KDE) size was 3.04 ± 0.63 km^2 for males and 3.96 ± 0.95 km^2 for females (Table 2). We found no difference in mean den home range size between sexes ($\chi^2 = 0.006$, $P = 0.94$) or among sites ($\chi^2 = 4.03$, $P = 0.13$). Similarly, core use area (50% KDE) did not differ between sexes ($\chi^2 = 0.007$, $P = 0.94$) or among study sites ($\chi^2 = 3.76$, $P = 0.15$; Table 2).

The VI of den home ranges was not influenced by sex dyad ($\chi^2 = 3.68$, df = 2, $P = 0.16$), and nearly differed by study site at the $\alpha = 0.05$ level ($\chi^2 = 5.72$, df = 2, $P = 0.06$, Figure 2). The VI was greatest at WT ($\bar{x} = 0.58$, SE = 0.07), followed by BM ($\bar{x} = 0.38$, SE = 0.03) and WG (no overlap). Mean core use area was not influenced by sex dyad (χ^2 =2.96, df = 2, $P = 0.23$), but differed among sites ($\chi^2 = 6.60$, df = 2, $P = 0.04$). The largest mean core area VI occurred at WT ($\bar{x} = 0.24$, SE = 0.05) followed by BM ($\bar{x} = 0.10$, SE = 0.02) and WG (no overlap).

Total area of each site was: BM = 28.9 km^2, WT = 25.5 km^2, and WG = 13.4 km^2. Use of cover types available within sites differed from random ($\lambda = 0.03$, $P = 0.001$), with greater use of mixed-hardwood-evergreen, followed by evergreen then hardwood (Table 3). Use of cover types within home ranges also differed from random ($\lambda = 0.07$, $P = 0.002$, Table 3). Spotted skunks used mixed-deciduous-evergreen most and avoided non-forested areas. Use of forest fragmentation type differed from random at both the second order ($\lambda = 0.02$, $P = 0.001$) and third order ($\lambda = 0.02$, $P = 0.001$, Table 4). Within-study site use of elevation differed significantly from random ($\lambda = 0.004$, $P = 0.003$, Table 5). Low elevations (between 549 and 650 m) and high elevations (above 1250 m) were used most, whereas mid-elevations were avoided. Third-order selection of elevation did not differ from random ($\lambda = 0.15$, $a = 0.05$, $P = 0.10$, Table 5).

Table 1. Number of relocations, unique den locations, triangulated locations, and reused dens for individual male (M) and female (F) eastern spotted skunks (*Spilogale putorius*) at three study sites in the central and southern Appalachian Mountains, Virginia, March 2016–November 2017.

Site	Skunk ID	Relocations	Unique dens	Triangulated	Reused
Bald Mountain	F009	46	34	10	2
	F012	16	7	8	1
	F018	19	9	10	0
	F029	34	22	12	0
	M008	25	19	6	0
	M010	29	20	18	1
	M011	21	11	10	0
Whitetop Mountain	F015	26	16	0	0
	M007	24	9	14	1
	M016	28	14	13	1
Wintergreen Mountain	M013	15	7	7	1
	M014	17	8	8	1

Table 2. Mean (SE) den home range (95% fixed kernel density estimator [KDE 95%]) and core-use area (50% fixed KDE) estimates of seven male and five female eastern spotted skunks (*Spilogale putorius*) in the central and southern Appalachian Mountains, Virginia, March 2016–November 2017.

	KDE 50%		KDE 95%	
Group	Mean (km^2)	SE	Mean (km^2)	SE
All sites				
Males ($n = 7$)	1.01	0.27	3.04	0.63
Females ($n = 5$)	0.87	0.15	3.96	0.96
Bald Mountain				
Males ($n = 3$)	1.11	0.33	3.78	0.13
Females ($n = 4$)	0.98	0.06	4.23	1.19
Whitetop Mountain				
Males ($n = 2$)	1.19	0.18	5.06	0.62
Females ($n = 1$)	0.62	–	2.87	–
Wintergreen Mountain				
Males ($n = 2$)	0.36	0.22	1.29	0.72

Table 3. Weighted composition analysis of within study-site den home range (second-order) and within home range relocation (third-order) use and ranking of land cover types by eastern spotted skunks (Spilogale putorius) in Virginia, March 2016–November 2017. Log-ratios indicate more (+) or less (-) use of cover type in row than in column. Significant divergence from random (P < 0.05) in bold. Lower ranks indicate higher level of use.

Cover type	Non-forested	Shrub-scrub	Evergreen	Mixed	Deciduous	Rank
Second order						
Non-forested		−2.43	**−5.57**	**−6.25**	**−3.47**	5
Shrub-scrub	2.43		**−3.14**	**−3.82**	−1.04	4
Evergreen	**5.57**	**3.14**		−0.68	**2.10**	2
Mixed	**6.25**	**3.82**	**0.68**		**2.78**	1
Deciduous	**3.47**	1.04	−2.10	−2.78		3
Third order						
Non-forested		−2.80	−5.92	−6.23	−7.31	5
Shrub-scrub	**2.80**		−3.61	−4.64	−4.28	4
Evergreen	**5.92**	**3.61**		−1.03	−0.67	2
Mixed	**6.23**	**4.64**	1.03		0.36	1
Deciduous	**7.31**	**4.28**	0.67	−0.36		3

Table 4. Weighted composition analysis of within study-site den home range (second-order) and within den home range relocation (third-order) use and ranking of forest fragmentation by eastern spotted skunks (*Spilogale putorius*) in Virginia, USA, March 2016–November 2017. Log-ratios indicate more (+) or less (-) use of forest fragmentation type in row than in column. Significant divergence from random (*P* < 0.05) in bold. Lower ranks indicate higher level of use.

Fragment type	NonForest	Patch	Edge	Perforated	SmallCore	LargeCore	Rank
Second order							
NonForest		−0.19	**−3.09**	−1.69	**−3.99**	**−3.39**	6
Patch	0.19		**−2.90**	**−1.50**	**−3.81**	**−3.21**	5
Edge	**3.09**	**2.90**		1.40	**−0.91**	−0.31	3
Perforated	1.69	**1.50**	−1.40		**−2.30**	**−1.70**	4
SmallCore	**3.99**	**3.81**	**0.91**	**2.30**		0.60	1
LargeCore	**3.39**	**3.21**	0.31	**1.70**	−0.61		2
Third order							
NonForest		−0.29	−0.43	−0.36	**−0.94**	**−0.46**	6
Patch	0.29		−0.14	−0.07	**−0.65**	−0.17	5
Edge	0.43	0.14		0.07	**−0.51**	−0.04	3
Perforated	0.36	0.07	−0.07		−0.58	−0.11	4
SmallCore	**0.94**	**0.65**	**0.51**	0.58		**0.47**	1
LargeCore	**0.46**	0.17	0.04	0.11	**−0.47**		2

Table 5. Weighted composition analysis of within study-site den range (second-order) and within den home range relocation (third-order) use and ranking of elevation by eastern spotted skunks (*Spilogale putorius*) in Virginia, March 2016–November 2017. Log-ratios indicate more (+) or less (-) use of elevation row than in column. Significant divergence from random (*P* < 0.05) in bold font. Lower ranks indicate higher level of use.

Elevation (m)	<450	450–549	550–649	650–749	750–849	850–949	950–1049	1050–1249	>1249	Rank
Second order										
<450		**−3.31**	**−2.32**	0.30	1.51	1.99	**3.52**	0.12	**−2.18**	4
450–549	**3.31**		**0.98**	**3.60**	**4.82**	**5.30**	**6.82**	**3.43**	**1.13**	1
550–649	**2.32**	**−0.98**		**2.62**	**3.83**	**4.31**	**5.84**	**2.44**	0.14	2
650–749	−0.30	**−3.60**	**−2.62**		1.21	1.69	**3.22**	−0.18	**−2.48**	6
750–849	−1.51	**−4.82**	**−3.83**	−1.21		0.48	**2.01**	−1.39	**−3.69**	7
850–949	−1.99	**−5.30**	**−4.31**	−1.69	−0.48		**1.53**	−1.87	**−4.17**	8
950–1049	**−3.52**	**−6.82**	**−5.84**	**−3.22**	**−2.01**	−1.53		**−3.40**	**−5.70**	9
1050–1249	−0.12	**−3.43**	**−2.44**	0.18	1.39	1.87	**3.40**		**−2.30**	5
>1249	**2.18**	**−1.13**	−0.14	**2.48**	**3.69**	**4.17**	**5.70**	**2.30**		3
Third order										
<450		−0.22	0.08	0.56	0.27	0.24	0.19	−0.82	−0.07	4
450–549	0.22		0.30	**0.78**	**0.48**	**0.46**	**0.41**	−0.61	**0.15**	2
550–649	−0.08	−0.30		**0.47**	0.18	0.15	0.11	−0.91	0.15	5
650–749	−0.56	**−0.78**	**−0.47**		−0.29	−0.32	−0.36	**−1.38**	−0.63	9
750–849	−0.27	**−0.48**	−0.18	0.29		−0.03	−0.07	**−1.09**	**−0.34**	8
850–949	−0.24	**−0.46**	−0.15	0.32	0.03		−0.04	**−1.06**	−0.31	7
950–1049	−0.19	**−0.41**	−0.11	0.36	0.07	−0.04		−1.02	−0.27	6
1050–1249	0.82	0.61	0.91	**1.38**	**1.09**	**1.06**	1.02		0.75	1
>1249	0.07	**−0.15**	0.15	0.63	**0.34**	0.31	0.27	−0.75		3

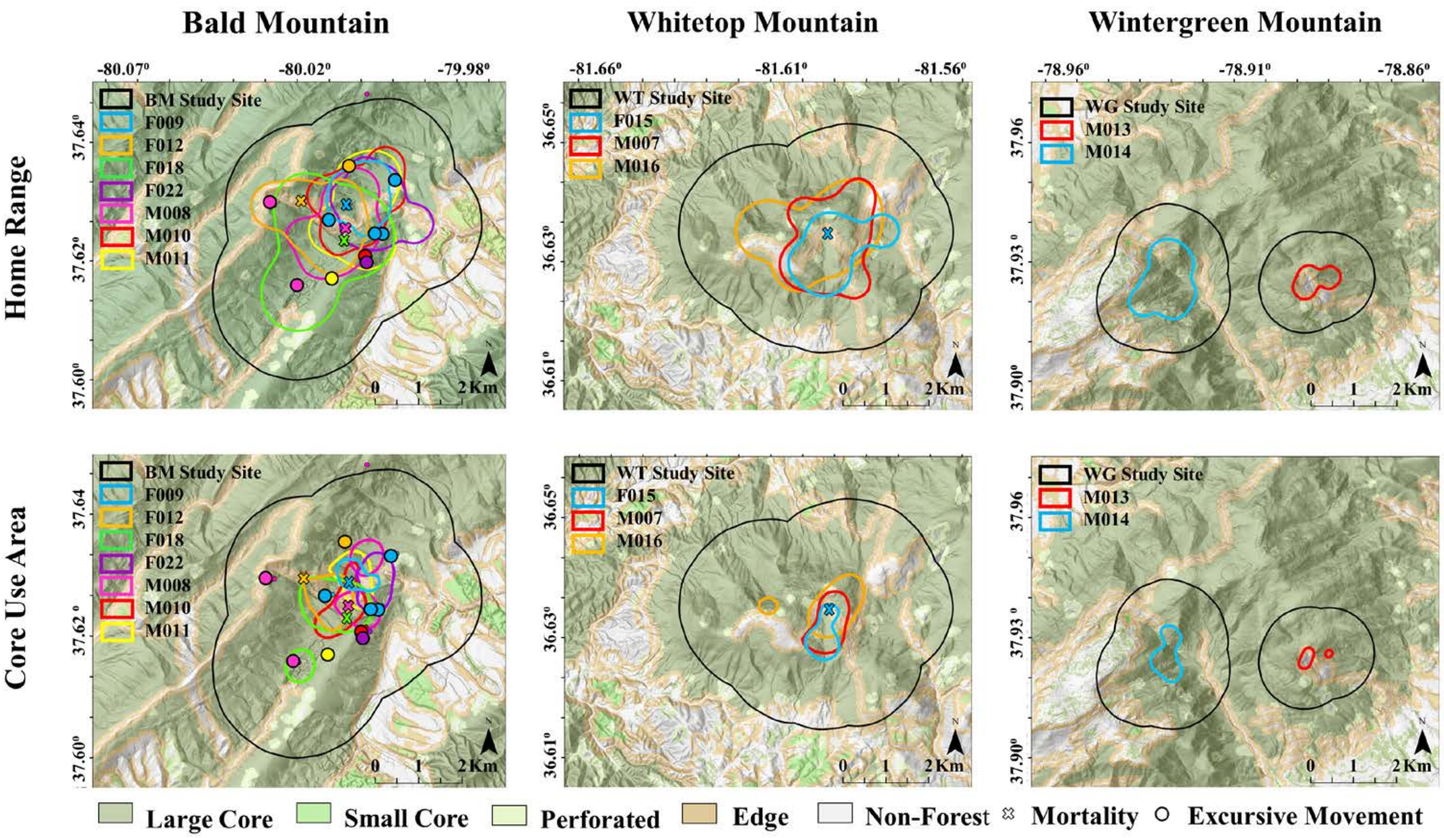

Figure 2. Eastern spotted skunk (*Spilogale putorius*) den home range (95% kernel density estimate [KDE]) and core use area (50% KDE) at three study sites in Virginia, March 2016–November 2017.

Discussion

Our first prediction that male spotted skunks would make more frequent excursions than females was not supported; however, we observed patterns of seasonality that differed between sexes. Male excursive movements occurred during mating season whereas female excursions occurred during pregnancy or kit-rearing. It is unclear why we only detected excursions at BM, however this site had the greatest number of spotted skunks. Also, we tracked individuals to diurnal den sites, thus, we potentially missed nocturnal excursive movements at BM and other sites.

Animals exploit known resources within their home ranges, while traversing novel landscapes risks higher energetic expenses with no guarantee of resource availability or increased fitness. At BM, male spotted skunks may have been avoiding intraspecific competition, seeking mating opportunities, or avoiding inbreeding. Excursive movements during the breeding season may act as a form of breeding (temporary) dispersal, as has been observed for other small carnivores (Cavallini 1996, Deuel et al. 2017). In contrast, pregnant and nursing females may be seeking food resources due to a greater energy demand (Rödel et al. 2016).

Animals often show behavioral plasticity related to dynamic environmental conditions (Komers 1997). During our study, a prescribed burn occurred at BM. We did not observe large movements by any of the skunks following the burn and tracked two individuals within the burned area immediately after the fire. Thus, the excursive movements observed in our study likely represented behavioral plasticity related to intrinsic condition (i.e., reproductive status).

Successful monitoring protocols and habitat restoration for conditional specialist species (Thorne and Ford 2022) requires consideration of seasonally appropriate cover types. For example, female spotted skunks prefer underground dens with ample cover when kit rearing (Thorne and Ford 2022). Female mortality was high in summer months when their excursive movements were greatest, supporting that escape cover is important. Conversely, tree cavities in brushy areas are used during mating season (Thorne and Ford 2022) when male excursive movements were most common. Both cover types support spotted skunk population growth and thus are important to consider when managing habitat. Few excursive relocations were detected within forest-edge areas and no relocations were detected outside of forested areas. This suggests spotted skunks in our study region may be limited to core forest patches, with non-forested areas serving as barriers to movement.

Our second prediction was not supported as male and female den home range size did not differ. In other studies, male spotted skunk home ranges were significantly larger than female home ranges (Lesmeister et al. 2013, Hassler et al. 2021). Although female den home range sizes in our study were similar to those found by Lesmeister et al. (2013) and Hassler et al. (2021), male ranges in our study were smaller. However, we did not include nocturnal and excursive movements which could explain differences between our estimates and other studies.

We also predicted den range overlap would be low, similar to other spotted skunk species (Jones et al. 2013). However, our estimates were more consistent with those of other species within Mephitidae, suggesting a similar solitary behavior with flexible territorial strategies. For example, striped skunks often come into contact and share dens with conspecifics suggesting overlap may not result in antagonism (Theimer et al. 2016). We did observe greater overlap at sites with smaller core forest areas, suggesting overlap could be affected by habitat quality. Though this difference was not statistically significant at the $\alpha = 0.05$ level, there is likely biological significance, a larger sample size may elucidate the relationship between core forest availability and home range overlap among conspecifics. We suggest future research assess how home range overlap and resource competition impacts spotted skunk vital rates. Additionally, social behavior studies may help determine if home range overlap and habitat quality precipitates hospitable or antagonistic interactions. Our high recapture rates of marked individuals at all three sites suggest nearly all animals were captured within site-years and our estimates of den home range distributions and overlap are representative of the population.

Our fourth prediction was supported as spotted skunks used cover types non-randomly. Mixed-hardwood-conifer was used more often than conifer or hardwood-dominated. Regionally, mixed forests often are associated with heavy understory cover, such as herbaceous ground cover and woody midstory shrub or tree cover, and may provide cover from predation and a variety of den resources (Menzel et al. 2002, 2004), an ideal combination for spotted skunks. Hardwood trees, particularly oaks, provide tree cavities used by spotted skunks in as den sites throughout their range (Lesmeister et al. 2008, Sprayberry and Edelman 2018, Eng and Jachowski 2019, Thorne et al. 2022). Moreover, evergreen species, such as conifer trees and ericaceous shrubs, provide year-round cover from avian predators in areas of more limited understory or ground cover (Lesmeister et al. 2010). We strongly suspect all mortalities documented in this study were due to avian predators, likely barred owls (*Strix varia*) or great horned owls (*Bubo virginianus*), as these species are known spotted skunk predators (Lesmeister et al. 2010, Hassler et al. 2021).

Consistent with other research in the region, elevations below 650 m and above 1050 m were used more than mid-range elevations (Thorne et al. 2017, Eng and Jachowski 2019). Lower elevations typically are associated with cove hardwood forests which are biologically and structurally diverse (Ford et al. 2002, Turner et al. 2003). Alternatively, high elevation old-growth evergreen cover or emergent rocky outcrops also provide ample escape cover from predation (Lesmeister et al. 2008, Thorne et al. 2017, Sprayberry and Edelman 2018, Eng and Jachowski 2019). Conservation and restoration of both forest types would benefit additional sensitive wildlife species, notably cerulean warblers (*Setophaga cerulea*) and northern flying squirrels (*Glaucomys sabrinus*) (Ford et al. 2002, Nareff et al. 2019). Many of the mid-elevation forests in our study region are mid-rotational forest without the complexity associated with early successional or older-growth forests ages (Yarnell 1998).

As we observed no use of non-forested areas and restricted den home range size and increased den home range overlap at sites with smaller core forest areas, we surmise forest patch size limits spotted skunk movement. Legacy reduction in core forest areas may impede spotted skunk extra-home range movement, dispersal among populations, and recolonization of unoccupied areas. Consequences of movement barriers, such as vulnerability to demographic stochasticity, loss of genetic variation, and disease outbreak have been observed in recent studies of eastern spotted skunks (Thorne 2020, Butler et al. 2021, Harris et al. 2021). The persistence of spotted skunks may depend on both habitat conservation and restoration through actions such as prescribed fire or forest harvesting. Additionally, assessments of spotted skunk population dynamics and genetic diversity could better inform current baselines, monitor future trends, and assist management planning that could increase connectivity among occupied and available forest patches.

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