Am. Midl. Nat. 164:52–60

# Eastern Spotted Skunk (Spilogale putorius) Survival and Cause-specific Mortality in the Ouachita Mountains, Arkansas

DAMON B. LESMEISTER,[1] JOSHUA J. MILLSPAUGH,
MATTHEW E. GOMPPER AND TONY W. MONG

*Department of Fisheries and Wildlife Sciences, 302 Natural Resources, University of Missouri, Columbia 65211*

ABSTRACT.—Survival and cause-specific mortality of eastern spotted skunks (*Spilogale putorius*) was assessed for a radio-monitored population in the Ouachita Mountains of westcentral Arkansas, USA. We monitored 33 eastern spotted skunks over a 23 mo period. Mean annual survival was 0.354 (0.339–0.368, 95% CI), and survival estimates were similar across age and sex categories. Survival increased for males as measures of body condition index increased. This pattern was reversed for females, although interpretation of the patterns is potentially confounded by female reproductive status. Of 19 mortality events, 63% (12) were caused by avian predators, most likely great horned owls (*Bubo virginianus*), 26% (5) were caused by mammalian predators, and 11% (2) were due to unknown causes. Although eastern spotted skunks are known to avoid open areas and forested areas where the understory is less dense and the canopy more open, 11 of 12 avian-caused deaths occurred in mature shortleaf pine stands with an open canopy and herbaceous understory.

## INTRODUCTION

Eastern spotted skunk (*Spilogale putorius*) populations have declined throughout much of the central and southeastern United States. Declines began in the 1940s, and by the 1980s the species was rare throughout most of its historic range (Gompper and Hackett, 2005). Consequently, the eastern spotted skunk is now listed by many state wildlife agencies as endangered, threatened or a species of conservation concern. Given the conservation concerns about the species, it is critical that more detailed knowledge on the fundamental ecology of the species be gained to allow for more informed management. Here we report estimates of survival and causes of mortality of eastern spotted skunks.

The cause of the long-term decline in eastern spotted skunks is unknown. Proposed explanations include over-harvest, habitat change, pesticide use and disease (Choate *et al.*, 1974; Gompper and Hackett, 2005; McCullough, 1983; Schwartz and Schwartz, 2001), but given the nature of the data used to document the decline (long-term data on harvest), there is a lack of detailed information that can be brought to bear on the ultimate cause of decline. Crabb (1948) documented humans to be the major mortality factor on an agricultural landscape when the species was common; however, causes of mortality where the species persists are unknown. Therefore, information on survival in an extant population may offer insights into factors currently limiting eastern spotted skunk populations. Although factors such as survival and cause-specific mortality are difficult to assess for small forest carnivores because these animals are cryptic, occur at low densities and dead individuals are rarely found, estimating vital rates is nonetheless a critical first step for demographic assessments. Furthermore, the locations of mortality events are rarely identified, but where such information is available, it may be especially valuable as it provides insights into how habitat use correlates with habitat-specific mortality.

[1] Corresponding author present address: Cooperative Wildlife Research Laboratory, 251 Life Science II, Southern Illinois University, Carbondale 62901; Telephone: (618) 453-5495; FAX: (618) 453-6944; e-mail: dbl2882@siu.edu

Our objective was to estimate sex and age-specific annual survival rates and causes of mortality for radiocollared adult and juvenile eastern spotted skunks in a forested landscape of western Arkansas. Eastern spotted skunks in Arkansas have shown relative declines in abundance that mirror patterns observed in other states (Sasse and Gompper, 2006). However, this study took place on a population that is putatively robust with little human disturbance (*e.g.*, trapping, hunting, road-mortality), which is well documented as a dominant cause of mortality for many other small and mid-sized carnivore populations in the southeastern and Midwestern United States (Chamberlain and Leopold, 2001; Chamberlain *et al.*, 1999a, b; Gehrt, 2005; Sovada *et al.*, 1998). Further, habitat use by eastern spotted skunks in this population is well understood; animals select for young, closed canopy forest that contains a dense understory over more open or older forested habitats that have a less-dense understory (Lesmeister, 2007; Lesmeister *et al.*, 2008, 2009). Therefore, we also assessed whether mortality locations show similar patterns of occurrence, which would suggest that the likelihood of mortality is proportional to, and thus unexplained by, the use of a particular habitat type, or alternatively, whether mortality events are disproportionately likely to occur in particular habitat types, suggesting that these habitats represent areas with heightened risk of mortality.

## METHODS

We monitored an eastern spotted skunk population in the Poteau Ranger District (PRD; 96,755 ha), United States Forest Service (USFS) Ouachita National Forest (ONF; 690,000 ha), Scott County, Arkansas, as part of a broader telemetry-based study examining the ecology of the species (Lesmeister, 2007; Lesmeister *et al.*, 2008, 2009). The USFS extensively manages the ONF landscape for timber harvest and endangered species (chiefly red cockaded woodpecker, *Picoides borealis*) persistence and as a result, there are well-delineated forest stands that are relatively homogeneous and vary principally in age and composition. Within the 8784 ha study site, which was bounded by the home ranges of the radiocollared study animals (Lesmeister, 2007, Lesmeister *et al.*, 2009), primary cover types included: young (0–30 y old) shortleaf pine (23% of the study site), middle-aged (31–70 y old) shortleaf pine (6%), mature (>70 y old) shortleaf pine (44%), hardwood (16%), private property (7%) and other (those habitats occurring in low proportions; 4%). Due to forest age, species composition and management approaches, these cover types differed in structure. Mature shortleaf pine forest has a more open canopy and less dense understory compared to young shortleaf pine forest (Masters, 2007; R. W. Perry, USFS, pers. comm.).

All capture and telemetry-based work occurred from Mar. 2005 to Jan. 2007 under University of Missouri Animal Care and Use Committee Protocol #4039 and Arkansas Game and Fish Commission scientific collection permit #111520042. We trapped eastern spotted skunks with Tomahawk #103 box traps (Tomahawk Live-Trap Co., Tomahawk, Wisconsin, USA) baited with various canned fish and commercial fruit-scented paste lures (Wildlife Damage Control, Charleston, West Virginia, USA). Captured animals were anesthetized with an intramuscular injection of ketamine hydrochloride (Fort Dodge Laboratories, Fort Dodge, Iowa, USA; 10 mg/kg) and xylazine (Vedco, Inc., St Joseph, Missouri, USA; 1 mg/kg), classified as adults (≥7 mo) or juvenile (<7 mo), sexed, and ear-tagged. Each eastern spotted skunk was fitted with a 12-g very high frequency collar-type radiotransmitter (ca 2–3% of adult body mass) with motion-sensitive mortality switches (8 h delay; Advanced Telemetry Systems, Inc., Isanti, Minnesota, USA).

We tracked study animals daily for the duration of the study or until mortality occurred (*see* Lesmeister, 2007). If a radiocollared eastern spotted skunk died, we used a 3-element

Yagi antenna and homing techniques to locate the animal within 24 h of death, record the location of the carcass, and examine the remains to assess cause of mortality. We classified the mortality as predation if the carcass indicted signs of trauma, and further categorized these mortalities as avian-caused if the collar was in or under a tree suitable for perching and fresh avian droppings or pellets were visible under perch site, or mammal-caused if the carcass or collar had visible canine puncture wounds. We assume that the location of the carcass represents the location of mortality, and that predators did not move carcasses between forest stands after death. Although we could not determine without doubt the exact location that the avian predator captured study animals, great horned owls (*Bubo virginianus*) are common in the region, the primary avian predator of eastern spotted skunks, and use a flight from a perch hunting technique (Kinlaw, 1995; Marti, 1974). Therefore, we are confident capture locations were near feeding perches and also consider avian mortality events to be caused by great horned owls. If the cause of death could not be determined, we categorized the mortality as unknown.

We used Program MARK (White and Burnham, 1999) to estimate survival rates by age and sex class using data from spring 2005–winter 2007. We used the known-fate model with the logit link function for 3 mo seasons (winter, spring, summer and fall). We left censored individuals until the season they were radio-collared and we right-censored data if the transmitter failed or if an animal disappeared from the study area and was never relocated. To maximize sample size we included animals captured within a season interval in the estimate for that season. This approach enhances sample sizes for each season, although we recognize a trade-off in that it may bias estimates of survival upward (Pac and White, 2007). We modeled survival based on the body condition index (BI), which was calculated using the residual values from a regression analysis of animal weight and length at the time of capture. Additionally, we modeled the interaction between body condition index and sex (BI $\times$ sex).

We developed 9 models to assess the relative importance of several factors in explaining spotted skunk survival rates. In the development of our models, we used biological factors (sex, age and body condition index) and time covariates that considered year, season and time from the start of the study ($t$). Our saturated model included an interaction term between $t$, sex and age ($t \times$ sex $\times$ age). We fit reduced models for each of our biological covariates, the biologically relevant time scales (year and season) and interaction terms between sex, age and year (sex $\times$ age; year $\times$ sex). We estimated male and female seasonal survival based on body condition index.

We used Akaike's Information Criterion for small sample sizes ($AIC_c$; Burnham and Anderson, 2002) to assess the relative support among candidate models. Due to model uncertainty, we used model averaging to estimate parameter coefficients of the final model and considered all models with $\Delta AIC_c \leq 2$ of the top model (Burnham and Anderson, 2002). We report the logit-transformed 95% confidence intervals for survival estimates.

## RESULTS

From Mar. 2005 to Nov. 2006, we captured 33 eastern spotted skunks (17 M, 16 F) and continued to track animals until Jan. 2007. Over the course of the study, seven (21%) of these animals were lost due to unknown causes such as dispersal or radiotransmitter failure, and seven (21%) were still alive at the conclusion of the study. We documented 19 deaths of eastern spotted skunks. We attributed 12 (63%) of those deaths to avian predators, 5 (26%) to mammalian predators and 2 (11%) to unknown causes. All mammalian-caused deaths occurred in young shortleaf pine stands (0–30 y old stands), whereas 11 of the 12 avian-caused deaths occurred in mature shortleaf pine stands (>70 y old stands).

TABLE 1.—Number of monitored eastern spotted skunks and number of mortality events, subdivided by season in the Ouachita Mountains, Arkansas, 2005–2007

| Year | Season | Number at risk | Avian mortalities | Mammalian mortalities | Other mortalities | Total mortalities |
|---|---|---|---|---|---|---|
| 2005 | Winter | 5 | 0 | 1 | 0 | 1 |
| 2005 | Spring | 6 | 2 | 0 | 0 | 2 |
| 2005 | Summer | 5 | 0 | 0 | 0 | 0 |
| 2005 | Fall | 15 | 2 | 2 | 0 | 4 |
| 2006 | Winter | 15 | 3 | 1 | 0 | 4 |
| 2006 | Spring | 8 | 1 | 0 | 0 | 1 |
| 2006 | Summer | 11 | 1 | 1 | 1 | 3 |
| 2006 | Fall | 14 | 2 | 0 | 1 | 3 |
| 2007 | Winter | 5 | 1 | 0 | 0 | 1 |

Mean annual survival for all individuals was 0.354 (0.339–0.368, 95% CI) and mean survival after capture was 169 (SD ± 153.91, range 5–496) days. Seven (37%) of the mortality events occurred in fall (4 were avian-caused in the mature shortleaf pine stands), 3 (16%) in the summer, 3 (16%) in the spring and 6 (32%) in the winter (Table 1). Correcting for the number of monitored eastern spotted skunks in each season, the 6 winter mortalities, 3 spring mortalities, 3 summer mortalities and 7 fall mortalities represented 30%, 21%, 19% and 24%, respectively, of monitored animals that were at risk during each season. Seasonal and annual survival estimates were also similar across sex, age class and years (Table 2). Survival increased for males but decreased for females as body condition index increased (Fig. 1).

Model selection results identified five competing models within 2 AIC units of the top model (Table 3), indicating a great deal of model uncertainty. These models collectively contained the covariates sex, age, year and body condition index and had weights of evidence ($w_i$) of 0.24–0.17 ($\Sigma w_i = 0.92$). The sex × body condition index model was also among the competing models. However, neither season nor time since the start of the study were significant predictors of survival.

## DISCUSSION

Our data revealed several distinct insights into eastern spotted skunk survival and mortality. First, given that 58% of study animals died over the course of the study, our data suggest relatively low annual survival rates for eastern spotted skunks. Our annual survival estimates are lower than those of larger forest dwelling carnivores such as bobcat (*Lynx rufus*), coyote (*Canis latrans*) and striped skunks (*Mephitis mephitis*; Chamberlain and Leopold, 2001; Chamberlain *et al.*, 1999; Fuller *et al.*, 1995; Gehrt, 2005; Van Deelen and Gosselink, 2006). However, we observed similar survival rates as stoats (*Mustela ermine*) and common weasels (*M. nivalis*) in Europe (King and Powell, 2007), and swift foxes (*Vulpes velox*) in western Kansas (Sovada *et al.*, 1998). Further, predation was also the primary cause of mortality for eastern spotted skunks. The species potentially has high reproductive rates (Crabb, 1944; Mead, 1968), which may compensate for low survival. For most carnivores, human caused mortality is typically important, even for populations inhabiting protected areas (Woodruffe and Ginsberg, 1998), but does not appear a limiting factor for eastern spotted skunks in western Arkansas.

Second, most known-cause mortalities occurred in suboptimal eastern spotted skunk habitat and there was a clear difference in the cause of mortality between young and mature

TABLE 2.—Seasonal ($\hat{S}$) and annual survival rates ($\hat{S}_y$) of 33 (17M, 16F) radio-collared eastern spotted skunks in the Ouachita Mountains, Arkansas, 2005–2007

| Age | Sex | Year | n | $\hat{S}$ | $\hat{S}$ 95% CI | $\hat{S}_y$ | $\hat{S}_y$ 95% CI |
|---|---|---|---|---|---|---|---|
| Juvenile | Female | 2005 | 1 | 0.749 | 0.525–0.889 | 0.314 | 0.264–0.364 |
| | | 2006 | 1 | 0.747 | 0.530–0.885 | 0.311 | 0.264–0.358 |
| Juvenile | Male | 2005 | 3 | 0.789 | 0.614–0.897 | 0.387 | 0.347–0.426 |
| | | 2006 | 4 | 0.788 | 0.624–0.893 | 0.385 | 0.350–0.421 |
| Adult | Female | 2005 | 9 | 0.746 | 0.574–0.865 | 0.310 | 0.279–0.341 |
| | | 2006 | 5 | 0.744 | 0.580–0.860 | 0.307 | 0.279–0.335 |
| Adult | Male | 2005 | 5 | 0.784 | 0.633–0.884 | 0.378 | 0.348–0.408 |
| | | 2006 | 5 | 0.783 | 0.643–0.879 | 0.377 | 0.350–0.403 |

shortleaf pine habitats. Although mature shortleaf pine stands dominate the landscape of the study area, eastern spotted skunks consistently selected young shortleaf pine and hardwood stands, and avoided the use of older shortleaf pine stands (Lesmeister *et al.*, 2009). Given the selection of young shortleaf pine and hardwood stands, we expected that most mortality would occur in young shortleaf pine and hardwood habitats. However, 65% of known-cause mortalities occurred in mature shortleaf pine stands. Furthermore, these

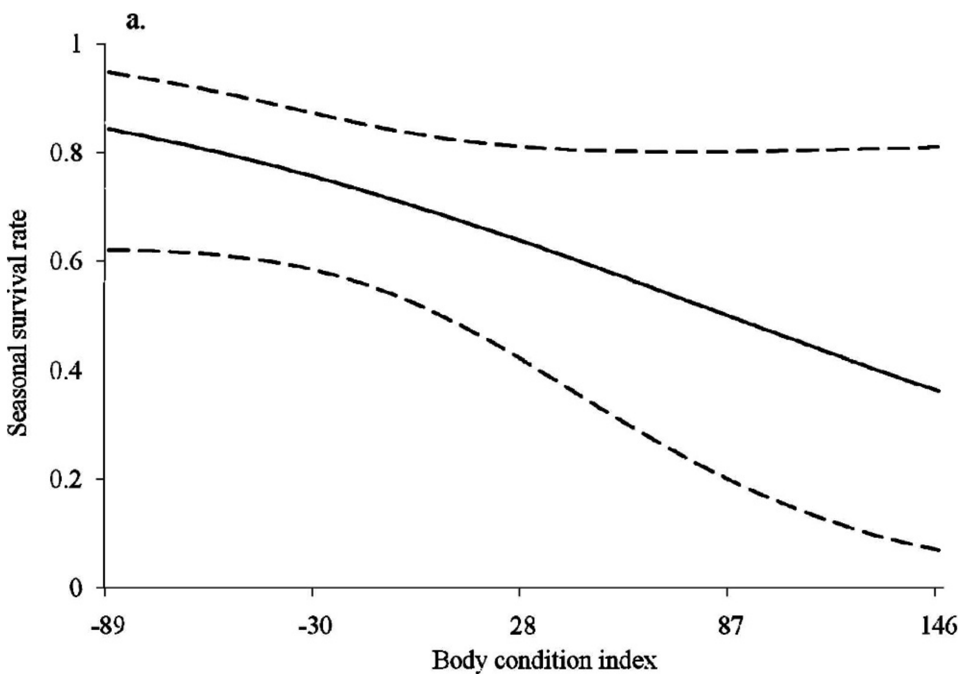


FIG. 1.—Seasonal survival (survival from one season to the next) of radio-collared female (a) and male (b) spotted skunks in the Ouachita Mountains, Arkansas, USA, based on body condition index. The solid line represents the predicted survival estimate and the dashed lines represent the 95% confidence intervals

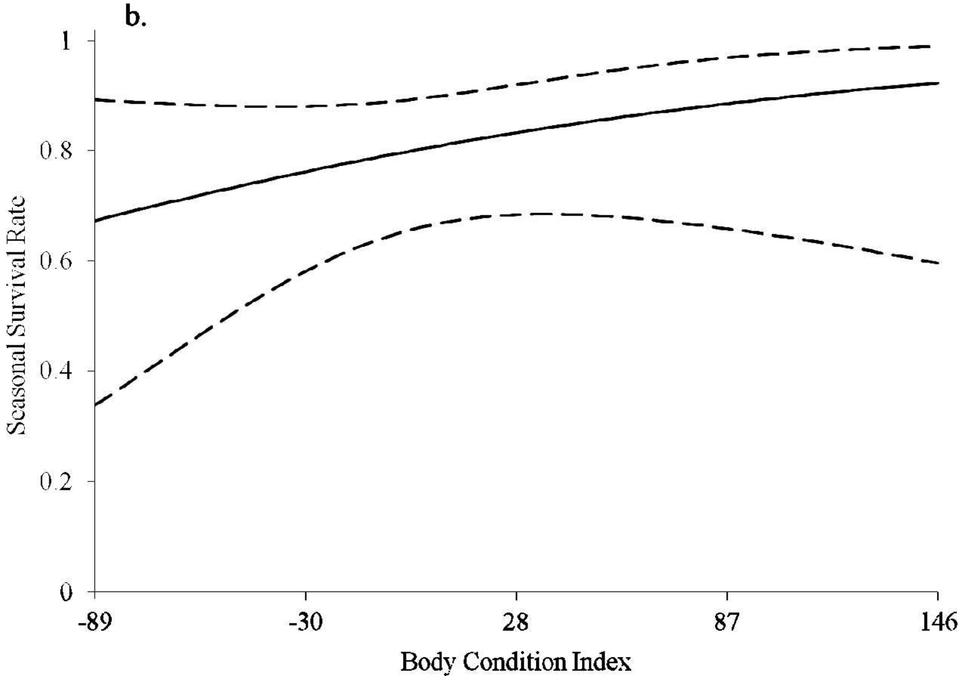


FIG. 1.—Continued

TABLE 3.—Model selection results for survival analysis of radio-collared eastern spotted skunks in the Ouachita Mountains, Arkansas, USA, 2005–2007

| Model | $k$[a] | $AIC_c$[b] | $\Delta AIC_c$ | $w_i$[c] | Deviance[d] |
|---|---|---|---|---|---|
| S(sex) | 2 | 92.808 | 0.000 | 0.236 | 88.658 |
| S(age) | 2 | 93.404 | 0.596 | 0.175 | 89.254 |
| S(BI[e]) | 2 | 93.422 | 0.614 | 0.173 | 89.272 |
| S(year) | 2 | 93.449 | 0.641 | 0.171 | 89.299 |
| S(sex × BI) | 4 | 93.492 | 0.684 | 0.167 | 84.979 |
| [S(sex × age)] | 4 | 97.097 | 4.289 | 0.028 | 88.584 |
| [S(year × sex)] | 4 | 97.109 | 4.301 | 0.027 | 88.596 |
| [S(season)] | 4 | 97.550 | 4.742 | 0.022 | 89.037 |
| [S($t$[f] × age × sex)] | 36 | 199.308 | 106.500 | 0.000 | 69.395 |

[a] Number of parameters

[b] $AIC_c$ = Akaike Information Criterion for small samples

[c] Akaike weight

[d] Difference in −2log(Likelihood) of the current model and −2log(Likelihood) of the saturated model

[e] Body condition index

[f] Time from start of study

mortality events were almost entirely due to avian predators; 92% of avian-caused mortalities occurred in mature shortleaf pine stands.

The disproportionately lower use of mature open canopy forest habitats of the Ouachita Mountains, as well as the disproportionately large number of mortalities that occurred in these older stands, suggests that older stands represent dangerous areas for eastern spotted skunks. Although mature shortleaf pine appears to be suboptimal habitat, it is the dominant habitat in the study area. Study animals were forced to traverse these stands as they traveled between selected habitats, thereby enhancing their susceptibility to avian predators. Thogmartin and Schaeffer (2000) observed great horned owl predation of wild turkey (*Meleagris gallopavo*) in large stands of mature shortleaf pine in ONF, whereas, canid-caused mortalities were in small young shortleaf pine stands. Kinlaw (1995) suggested that great horned owls were the primary predators of eastern spotted skunks on a Florida barrier island, and Errington *et al.* (1940) commonly found eastern spotted skunk remains in great horned owl pellets. We previously hypothesized that the strong selection of young shortleaf pine and hardwood stands may be due to the closed canopy and dense understory structure of those habitats (Lesmeister *et al.*, 2008, 2009) providing protection from avian predators, which appear to the be the primary predator of eastern spotted skunks in the Ouachita Mountains. We observed fewer mortalities in young shortleaf pine stands and all those were mammalian-caused. The association between cause of death and habitat was likely due to the hunting habits of eastern spotted skunk predators. Great horned owls are likely more specialized to hunt in open mature stands (Ganey *et al.*, 1997; Grossman *et al.*, 2008), whereas coyotes and bobcats select a variety of habitats, and thus will use young and dense closed canopy forest (Chamberlain *et al.*, 2000, 2003; Kolowski and Woolf, 2002; Schrecengost *et al.*, 2009).

We observed little variability between age, sex and year, which lead to model uncertainty and limited the inferences we could draw from AIC results. Further, small sample size limited the number of covariates to include in models and four of those six covariates were included in competing models. Although season was not among competing models, we observed more mortalities in the fall than other seasons, which may be attributed to reduced leaf cover, exposing eastern spotted skunks to overhead predators.

We found differences in eastern spotted skunk survival based on body condition index and sex. Survival increased for males as body condition index increased. However, survival decreased for females as body condition index increased. This latter finding should be treated with caution, however, as the assessment of body condition index based on body weight and length ratios may be confounded by reproductive status. On the other hand, for males the finding implies that individuals in better body condition survive longer. Because survival appears primarily driven by predation, and especially predation by owls, this result suggests that healthier males may be less likely to use older or more open forests patches where predation risk is apparently higher.

*Acknowledgments.*—Funding for this research came from the Arkansas Game and Fish Commission, the U.S. Forest Service, and the University of Missouri. R. Crowhurst, A. Nolan, B. Sasse and W. Montague provided extensive field and logistic assistance. Two anonymous reviewers provided helpful comments that improved the manuscript.

## LITERATURE CITED

BURNHAM, K. P. AND D. R. ANDERSON. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Second edition. Springer-Verlag, New York, New York, USA.

BUSKIRK, S. W. AND R. A. POWELL. 1994. Habitat ecology of fishers and American martens, p. 283–296. *In:* S. W. Buskirk, A. S. Harestad and M. G. Raphael (eds.). Martins, sables and fishers: biology and conservation. Cornell University Press, Ithaca, New York, USA.

CHAMBERLAIN, M. J. AND B. D. LEOPOLD. 2001. Survival and cause-specific mortality of adult coyotes (*Canis latrans*) in central Mississippi. *Am. Midl. Nat.*, **145**:414–418.

———, ———, L. W. BURGER, JR., B. W. PLOWMAN AND L. M. CONNER. 1999a. Survival and cause-specific mortality of adult bobcats in central Mississippi. *J. Wildl. Manag.*, **63**:613–620.

———, ——— AND L. M. CONNER. 2003. Space use, movements and habitat selection of adult bobcats (*Lynx rufus*) in central Mississippi. *Am. Midl. Nat.*, **149**:395–405.

———, C. D. LOVELL AND B. D. LEOPOLD. 2000. Spatial-use patterns, movements, and interactions among adult coyotes in central Mississippi. *Can. J. Zool.*, **78**:2087–2095.

———, K. M. HODGES, B. D. LEOPOLD AND T. S. WILSON. 1999b. Survival and cause-specific mortality of adult raccoons in central Mississippi. *J. Wildl. Manag.*, **63**:880–888.

CHOATE, J. R., E. D. FLEHARTY AND R. J. LITTLE. 1974. Status of the spotted skunk, *Spilogale putorius*, in Kansas. *Trans. Kans. Acad. Sci.*, **76**:226–233.

CRABB, W. D. 1944. Growth, development and seasonal weights of spotted skunks. *J. Mammal.*, **25**:213–221.

———. 1948. The ecology and management of the prairie spotted skunk in Iowa. *Ecol. Monog.*, **18**:201–232.

CREEL, S., G. SPRONG AND N. CREEL. 2001. Interspecific competition and the population biology of extinction-prone carnivores, p. 35–60. *In:* J. L. Gittleman, S. M. Funk, D. Macdonald and R. Wayne (eds.). Carnivore conservation. Cambridge University Press, Cambridge, United Kingdom.

FULLER, T. K., S. L. BERENDZEN, T. A. DECKER AND J. E. CARDOZA. 1995. Survival and cause-specific mortality rates of adult bobcats (*Lynx rufus*). *Am. Midl. Nat.*, **134**:404–408.

GANEY, J. L., W. M. BLOCK, J. S. JENNESS AND R. A. WILSON. 1997. Comparative habitat use of sympatric Mexican spotted and great horned owls. *J. Wildl. Res.*, **2**:115–123.

GEHRT, S. D. 2005. Seasonal survival and cause-specific mortality of urban and rural striped skunks in the absence of rabies. *J. Mammal.*, **86**:1164–1170.

GOMPPER, M. E. AND H. M. HACKETT. 2005. The long-term, range-wide decline of a once common carnivore: the eastern spotted skunk (*Spilogale putorius*). *Anim. Cons.*, **8**:195–201.

GROSSMAN, S. R., S. J. HANNON AND A. SÁNCHEZ-AZOFEIFA. 2008. Responses of great horned owls (*Bubo virginianus*), barred owls (*Strix varia*), and northern saw-whet owls (*Aegolius acadicus*) to forest cover and configuration in an agricultural landscape in Alberta, Canada. *Can. J. Zool.*, **86**:1165–1172.

KING, C. M. AND R. A. POWELL. 2007. The natural history of weasels and stoats: ecology, behavior, and management. Oxford University Press, New York, New York, USA.

KINLAW, A. E. 1995. *Spilogale putorius. Mammal. Spec.*, **511**:1–7.

KOLOWSKI, J. M. AND A. WOOLF. 2002. Microhabitat use by bobcats in southern Illinois. *J. Wildl. Manag.*, **66**:822–832.

LESMEISTER, D. B. 2007. Space use and resource selection by eastern spotted skunks in the Ouachita Mountains, Arkansas. MS Thesis, University of Missouri, Columbia, USA.

———, M. E. GOMPPER AND J. J. MILLSPAUGH. 2008. Summer resting and den site selection by eastern spotted skunks (*Spilogale putorius*) in Arkansas. *J. Mammal.*, **89**:1512–1520.

———, ——— AND J. J. MILLSPAUGH. 2009. Habitat selection and home range dynamics of eastern spotted skunks in the Ouachita Mountains, Arkansas, USA. *J. Wildl. Manag.*, **73**:18–25.

MARTI, C. D. 1974. Feeding ecology of four sympatric owls. *Condor*, **76**:45–61.

MCCULLOUGH, C. R. 1983. Population status and habitat requirements of the eastern spotted skunk on the Ozark Plateau. MS thesis, University of Missouri, Columbia, USA.

MEAD, R. A. 1968. Reproduction in eastern forms of the spotted skunk (genus *Spilogale*). *J. Zool.*, **156**:119–136.

PAC, D. F. AND G. C. WHITE. 2007. Survival and cause-specific mortality of male mule deer under different hunting regulations in the Bridger Mountains, Montana. *J. Wildl. Manag.*, **71**:816–827.

SCHWARTZ, C. W. AND E. R. SCHWARTZ. 2001. The wild mammals of Missouri. University of Missouri Press, Columbia, Missouri, USA.

SASSE, D. B. AND M. E. GOMPPER. 2006. Geographic distribution and harvest dynamics of the eastern spotted skunk in Arkansas. *J. Arkan. Acad. Sci.*, **60**:119–124.

SCHRECENGOST, J. D., J. C. KILGO, H. S. RAY AND K. V. MILLER. 2009. Home range, habitat use and survival of coyotes in western South Carolina. *Am. Midl. Nat.*, **162**:346–355.

SOVADA, M. A., J. B. BRIGHT, J. R. GILLIS AND C. C. ROY. 1998. Causes and rates of mortality of swift foxes in western Kansas. *J. Wildl. Manag.*, **62**:1300–1306.

THOGMARTIN, W. E. AND B. A. SCHAEFFER. 2000. Landscape attributes associated with mortality events of wild turkeys in Arkansas. *Wildl. Soc. Bull.*, **28**:865–874.

VAN DEELEN, T. R. AND T. E. GOSSELINK. 2006. Coyote survival in a row-crop agricultural landscape. *Can. J. Zool.*, **84**:1630–1636.

WHITE, G. C. AND K. P. BURNHAM. 1999. Program MARK: survival estimation from populations of marked animals. *Bird Study*, **46**(Supplement):120–139.

WOODRUFFE, R. AND J. R. GINSBERG. 1998. Edge effects and the extinction of populations inside protected areas. *Science*, **280**:2126–2128.

SUBMITTED 13 JULY 2009 ACCEPTED 19 OCTOBER 2009