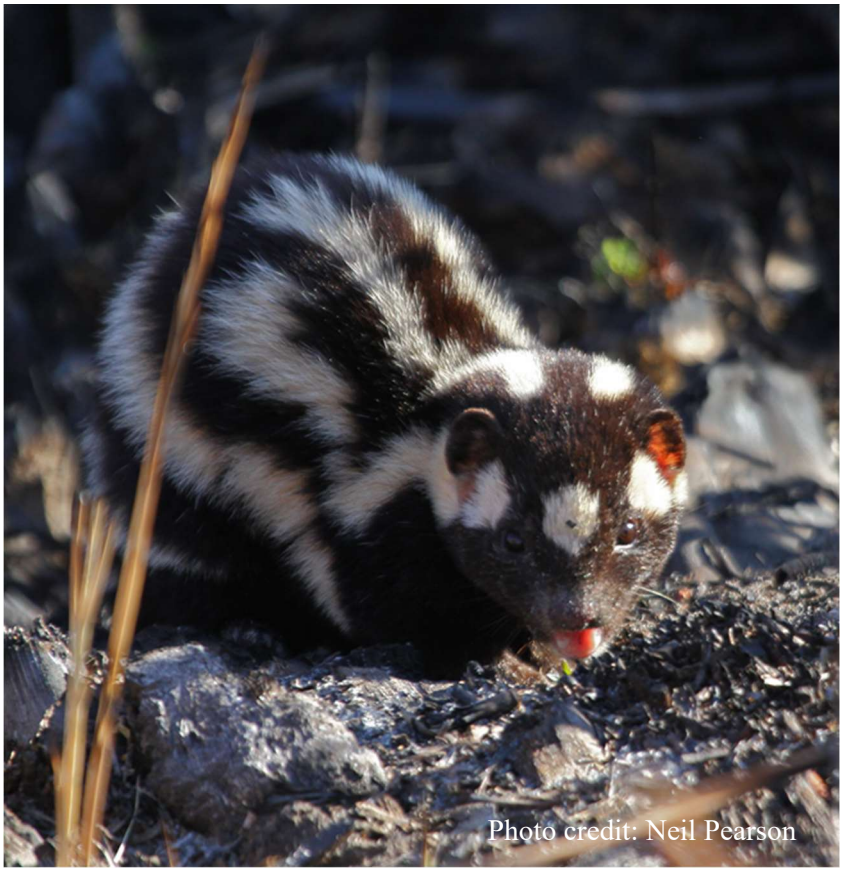
Eastern Spotted Skunk Conservation Plan



Authored by the Eastern Spotted Skunk Cooperative Study Group

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Group Chairs: David S. Jachowski (2015-2018) and Andrew J. Edelman (2018-present)

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1. The Eastern Spotted Skunk Cooperative Study Group

In 2015, the Eastern Spotted Skunk Cooperative Study Group (ESSCSG) was created as a forum for researchers and agency biologists to exchange ideas, share research and survey updates, collaborate on projects, and discuss relevant issues regarding the eastern spotted skunk (*Spilogale putorius*). The goals of the ESSCSG are to: (1) enhance communication about the species, (2) identify management, research, and resource priorities, and (3) facilitate collaborative planning, funding, outreach, monitoring, and research opportunities. As of May 2019, the ESSCSG was comprised of 130 members representing 26 universities, 5 federal agencies, and 28 state agencies. Questions about this group or this document can be directed to the ESSCSG chair, Dr. Andrew Edelman (aedelman@westga.edu), at the University of West Georgia.

2. Purpose of this Document

This conservation plan was put together following discussion by members of the ESSCSG in February 2017 regarding the need for a document that summarizes the current extent of knowledge on the species. In addition, a key goal is not only to summarize what is known about the species and its current status, but to identify the knowledge gaps that should be the target of future research and monitoring attempts across the range of the species.
This plan has been approved by the Southeastern Association of Fish and Wildlife Agencies (SEAFWA) Furbearer Working Group (July 2018) and Wildlife Resources Committee (Oct. 2018) and the Northeast Association of Fish and Wildlife Agencies (NEAFWA) Furbearer Resources Technical Committee (Sept. 2018).

Recommended citation:

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3. Taxonomy and Distribution (Drafted by Stephen Harris)

The eastern spotted skunk (*Spilogale putorius*) is a small skunk in the family Mephitidae native to eastern North America. It historically ranged east from the Continental Divide through much of the central and southeastern United States, southeastern Manitoba, southwestern Ontario and northeastern Mexico (Figure 1, Kinlaw 1995). At the beginning of the twentieth century the eastern spotted skunk was distributed among three disjunct populations: west of the Mississippi from Texas to southern Minnesota and southeastern Nebraska and as far west as eastern Colorado; the southern part of the Florida peninsula, and the Appalachian and karst areas of the southeastern United States (Lantz 1923, Ashbrook and Arnold 1927, Sasse 2017). The species expanded to the north between the Mississippi River and the Rockies in the first half of the twentieth century and also moved into the western Gulf Coastal Plain of eastern Texas, southern Arkansas, and northern Louisiana as well as the Gulf Coast and throughout Georgia (Van Gelder 1959, Hall 1981).

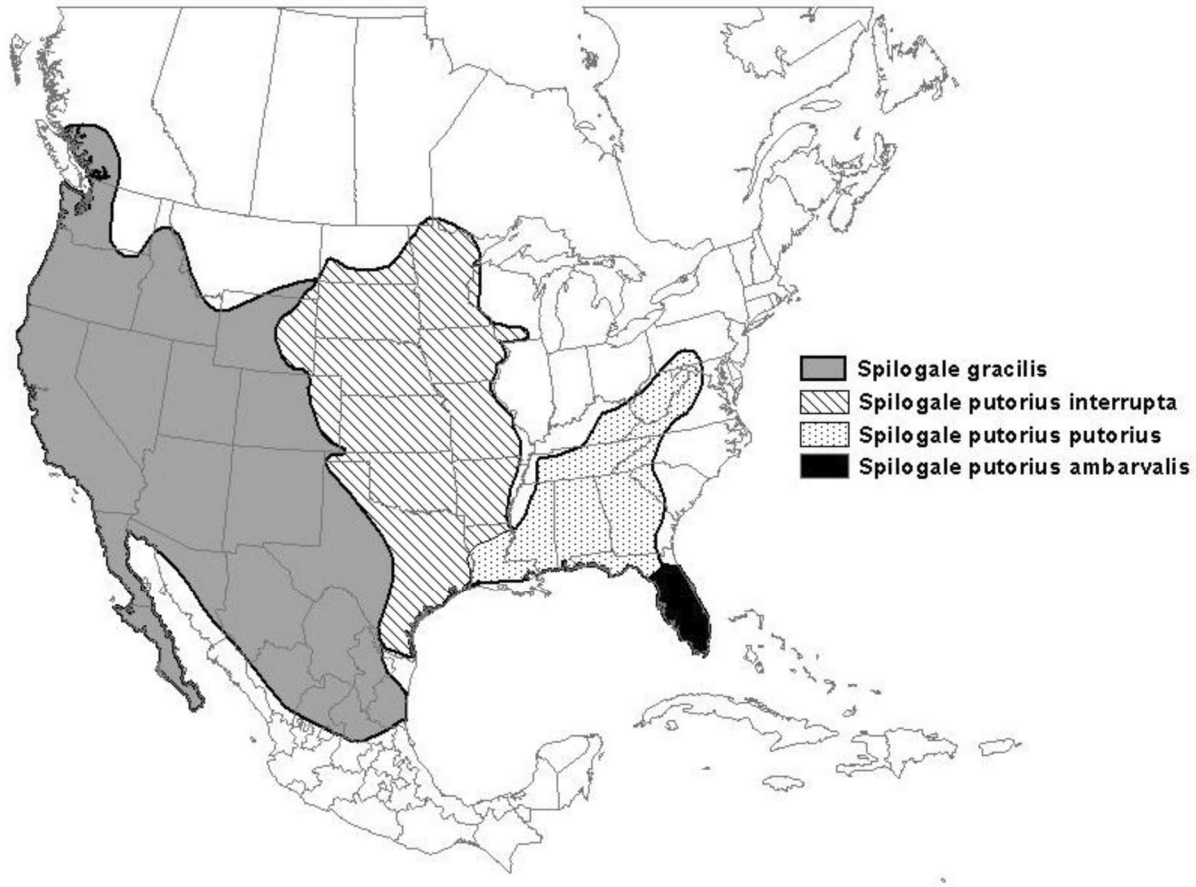

Figure 1. Range map indicating distribution of 3 eastern spotted skunk subspecies in the US (Nilz and Finck 2008).

According to Kinlaw (1995), the eastern spotted skunk currently contains three subspecies, *S. p. ambarvalis* (Florida spotted skunk), *S. p. putorius* (Appalachian, or Allegheny, spotted skunk), and *S. p. interrupta* (plains, or prairie, spotted skunk). Phylogenetic analysis across the species range is currently lacking to determine the validity of these subspecies (Gompper and Jachowski 2016).

The Appalachian spotted skunk extends north from the panhandle of Florida and the Gulf Coast through much of the Appalachian Mountains of the southeastern United States. It has been documented often in high elevation regions of the mountains, such as in red spruce (*Picea rubens*) forests in Virginia (Diggins et al. 2015). In Maryland, the species has historically been documented by fur trappers in areas containing sandstone outcrops and in second-growth forests dominated by hardwood tree species (Larson 1968). This subspecies was observed for the first time in 18 years in South Carolina in 2015 (Wilson et al. 2016), and in 2012 an individual was documented for the first time in Pennsylvania in over 60 years (G. Turner, Pennsylvania Game Commission, pers. comm.)

The plains spotted skunk occurs throughout the American Midwest and represents the species in Canada and Mexico. It has been known to occur in several ecosystems. On the Ozark Plateau in Missouri, skunks were found in oak-hickory (*Quercus-Carya*) forests, more often in areas with considerable ground cover (litter and slash) than those with little cover (McCullough and Fritzell 1984). Similarly, they have been documented in oak-hickory forests, and managed shortleaf pine (*Pinus echinata*) stands, in the Ouachita Mountains of Arkansas (Lesmeister 2007). The subspecies also has been known to frequent prairies and agricultural areas near human settlement (Crabb 1948).

The Florida spotted skunk occurs throughout peninsular Florida and is endemic to the state. It is known to range as far south as Fort Myers (Hamilton 1941). This subspecies has been documented in coastal strand habitats and is known to frequent sandy areas with dense saw palmetto (*Serenoa repens*) thickets that provide ample cover (Bangs 1898, Schwartz 1952). It has even been observed on open beaches with little cover (Howell 1906).

4. Natural History (Drafted by Stephen Harris)

Spotted skunks are smaller than their better-known and more frequently observed relative, the striped skunk (*Mephitis mephitis*; Figure 2). Kinlaw (1995) noted that eastern spotted skunks have an “elongated weasel shaped body”. Adult males are generally larger in size than adult females (Van Gelder 1959, Kinlaw 1995). Eastern spotted skunks have black fur, intermixed with broken white stripes and white spots. They also have a distinctive triangular white spot on the head between the eyes. A variable amount of white fur often is found on the tail. The front claws are much longer than the hind ones and they can be used for climbing, digging, or restraining prey (Zeiner 1975, Kinlaw 1995).

Little is known about the reproductive and activity patterns of eastern spotted skunks. They are primarily nocturnal in nature, though evidence suggests that they may sometimes be active diurnally in Florida (D. Jachowski, Clemson University, pers. comm., Manaro 1961, McCullough and Fritzell 1984, Kinlaw 1995). They are usually solitary, with males and females

generally associating only during the breeding season to mate (Hardy 2013). Eastern spotted skunks mate in March or April and parturition occurs in May or June (Mead 1968, Kinlaw 1995). Mead (1968) determined that the breeding season for the Florida subspecies is extended compared to the other subspecies. An average litter size of 5.5 has been recorded for the species (Mead 1968). Males have larger ranges during the breeding season (in spring) as they are likely searching the landscape for reproductive females to mate with, a behavior known as "questing" (Crabb 1948, McCullough and Fritzell 1984, Lesmeister et al. 2009).

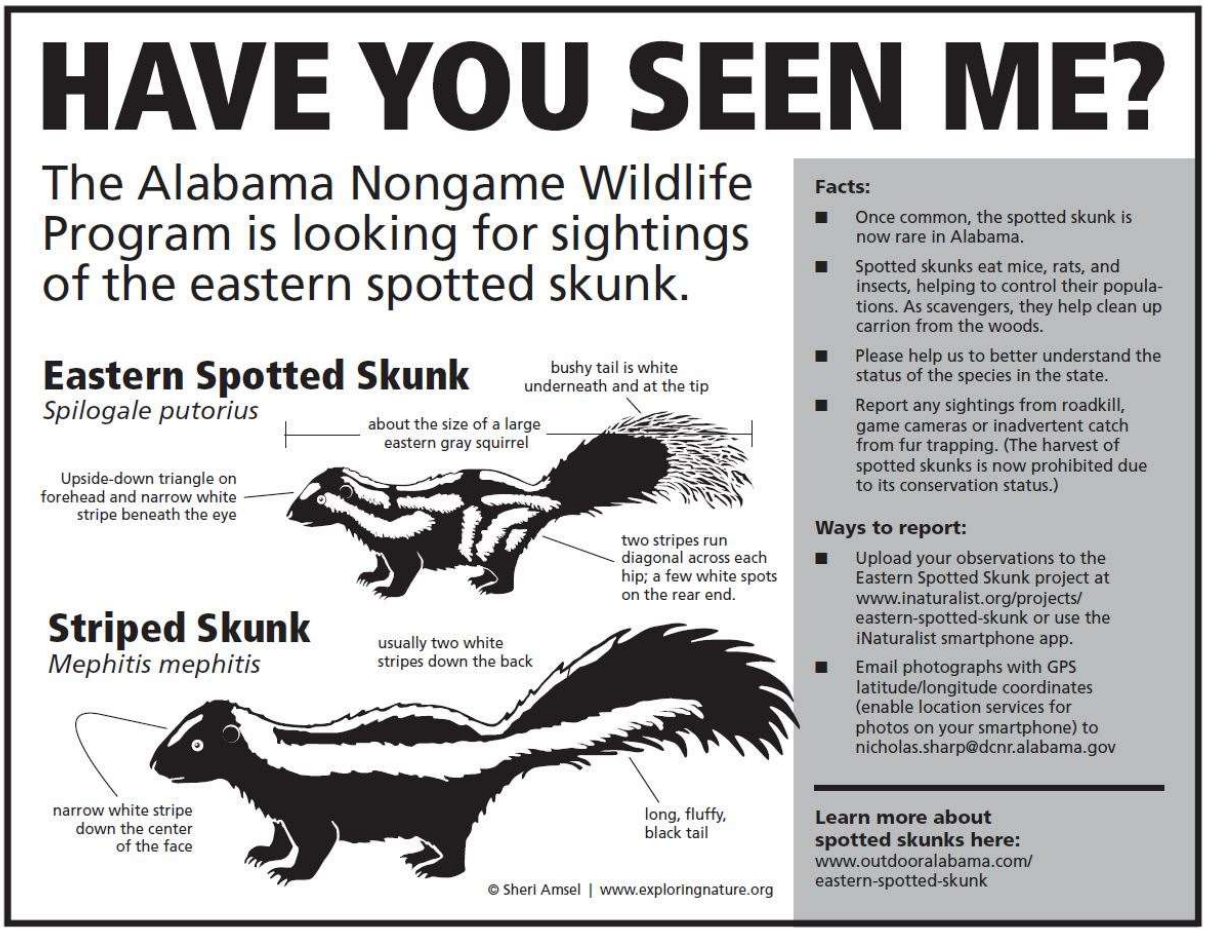

Figure 2. Flyer developed in Alabama for collecting sightings along with an explanatory drawing developed by Sheri Amsel for helping the public differentiate between striped and spotted skunks.

The eastern spotted skunk is an omnivorous species that can have a varied diet (Crabb 1941). Insects are a particularly important food source for the species, with beetles (Coleoptera) and grasshoppers (Orthoptera) being major components of their diet (Howell 1906, Crabb 1941, Kinlaw 1995). Other recorded food items include small mammals, birds, lizards, salamanders, fungi, carrion, and plant material (Howell 1906, Pellett 1913, Selko 1937, Crabb 1941, McCullough and Fritzell 1984).

Survival and cause-specific mortality have not been studied extensively across the range of the eastern spotted skunk. Mean annual survival in a study of 33 skunks in the Ouachita Mountains of Arkansas was determined to be approximately 0.35, and great horned owls (*Bubo virginianus*)

were suspected to be the predominant predator on the study site (Lesmeister et al. 2010). Other literature has documented bobcats (*Lynx rufus*), domestic cats (*Felis catus*), and domestic dogs (*Canis familiaris*) predating eastern spotted skunks (Errington et al. 1940, Crabb 1948, Schwartz and Schwartz 2001). Human-caused mortality has also been documented, in the form of vehicle collisions and trapping and shooting for fur or as a nuisance species (Crabb 1948, Rosatte 1987).

Aside from their notorious ability to expel a noxious, irritating deterrent spray from specialized glands around the anus, eastern spotted skunks have a few other interesting defensive behaviors. Eastern spotted skunks have been called "acrobats" in the scientific literature, lending to the fact that they will take a defensive posture by hand-standing on their two front legs, with their tail extended vertically into the air and their hind legs spread apart (Howell 1920, Johnson 1921). They can also emit their foul spray from this position (Johnson 1921). This species is also known to stomp the ground with its front paws to deter potential predators (Manaro 1961, Zeiner 1975).

More in-depth information on the biology and ecology of the eastern spotted skunk can be found in the mammalian species review provided by Kinlaw (1995). In addition, while there is still much unknown about the species' basic natural history, recent advancements in our understanding of the species' ecology can be found in section 6 of this document.

5. Conservation Status (Drafted by Stephen Harris)

The eastern spotted skunk has experienced a range-wide decline since at least the 1940s (Gompper and Hackett 2005). Gompper and Hackett (2005) assessed harvest records of eastern spotted skunks and found that they had declined in the 1980s to less than one percent of what they had been in the early to mid-1900s. Their analysis indicated that the observed decline was "biologically real" and not simply due to changes in harvest pressure on the species over time (Gompper and Hackett 2005). The exact causes that led to this decline are currently unknown, but hypothesized to be linked to habitat loss, changes in agricultural methods, widespread use of pesticides, overharvest, and disease (Choate et al. 1974, McCullough 1983, Schwartz and Schwartz 2001, Gompper and Hackett 2005). Additionally, Lesmeister et al. (2013) noted that habitat management practices enacted to benefit federally endangered red-cockaded woodpeckers (*Picoides borealis;* increasing stand rotation length in forests and decreasing the availability of early successional forest habitat) could be detrimental to the eastern spotted skunk where the two species overlap.

Currently, the eastern spotted skunk is listed as vulnerable (i.e., considered to be facing a high risk of extinction in the wild) by the International Union for Conservation of Nature (Gompper and Jachowski 2016). Additionally, the plains subspecies is currently under review for listing under the Endangered Species Act by the U.S. Fish and Wildlife Service (Federal Register 2012). Kaplan and Mead (1991) noted that this subspecies has declined in the American Midwest, where it once had been abundant.

The conservation status of spotted skunks differs greatly among states within its historical range (Appendix 1). It is listed as a furbearer in many states and can be harvested typically during the regulated trapping/hunting seasons in 14 states (Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, North Dakota, South Carolina, South Dakota, Tennessee, Texas,

West Virginia, Wisconsin, and Wyoming). In several of these states that allow harvest, the spotted skunk is acknowledged as rare or imperiled. Harvest of spotted skunks is closed in 12 states (Alabama, Colorado, Iowa, Kansas, Kentucky, Maryland, Minnesota, Missouri, Nebraska, Oklahoma, Pennsylvania, and Virginia). Although within historical range maps, no reliable sightings are known from Montana, Ohio, Canada, or Mexico.

6. Priority Research Areas and Knowledge Gaps:

During the February 2017 ESSCSG meeting in Asheville, NC, the study group identified six areas where there are priority knowledge gaps for the species.

A. Status/distribution (Drafted by Blake Sasse)

Over the last thirty years information on the current population status and distribution of this species has only been published in a few states: Arkansas (Sasse and Gompper 2005), Iowa (Bowles et al. 1998), Kansas (Nilz and Finck 2008), Nebraska (Landholt and Genoways 2000), Oklahoma (Stangl et al. 1992, Shaughnessy and Cifelli 2016), South Carolina (Wilson et al. 2016), South Dakota (Blumberg et al. 1997, Higgins et al. 2000), Minnesota and Wisconsin (Boppel and Long 1994, Wires and Baker 1994), and the southern Appalachians (Campbell et al. 2010).

The techniques below can be helpful in gathering occurrence information:

- Examination of museum records
- Examination of fur buyer purchase records
- Post-season surveys of trappers to identify incidental captures
- Surveys of nuisance wildlife control operators and/or examination of any required reports
- Coordination with state health departments to gather information on spotted skunks submitted for rabies testing
- Roadkill surveys
- Identification of nest sites used by great horned owls and examination of their pellets for spotted skunk remains
- General solicitation of sightings from the public
- Game camera surveys using agency personnel and/or citizen scientists
- Live trapping

Key knowledge gaps:

- The current (since 2000) distribution and status of the eastern spotted skunk is poorly understood across most of its range (Appendix 1). Accordingly, states should start by conducting research and survey efforts aimed at determining county-level distribution of this species.
- A central database should be established for recording historical skunk sightings, particularly those in the past 20 years.

- A key next step would be to develop a standardized monitoring protocol (see section 2 below), that allows biologists to begin to assess trends in skunk distribution and population parameters.

B. Monitoring methods (Drafted by Robin Eng)

As a species that has been largely overlooked by scientists for decades, monitoring for eastern spotted skunks provides an imperative jumping-off point for understanding this elusive species. Monitoring efforts yield not only baseline occurrence, distribution, and demographic data, but can also supply general information about habitat selection, behavior, and interspecific interactions useful for developing hypotheses for further investigations. Unfortunately, monitoring for carnivores can prove quite challenging owing to their generally elusive nature and large home ranges (Gompper et al. 2006).

Aside from a study by Hackett et al. (2007), current knowledge regarding best monitoring techniques for eastern spotted skunks is largely anecdotal. Hackett et al. evaluated three common techniques, live-trapping, track plate boxes, and remote-sensor camera traps. Results from this study suggest that monitoring success by any technique is significantly increased in the colder months of the year (September-May in Arkansas and Missouri), and that track plate boxes may be more effective than remote cameras or live-trapping for non-invasively surveying this species (Hackett et al. 2007).

This seasonal variation in detectability has not been explicitly investigated, but may be associated with decreased food availability and a consequent increase in time spent foraging above ground. Additionally, during the breeding season (approximately early March-April) male spotted skunks make large movements in search of females (Mead 1968), and average home range size for males has been observed to quadruple during this season (Lesmeister et al. 2009). This increase in movement could also partially explain the increase in spotted skunk detectability in late winter and early spring. Recent studies, however, have had moderate success detecting eastern spotted skunks in the summer months as well (A. Edelman, University of West Georgia, pers. comm.), suggesting that successful monitoring in the summer also is possible.

Remote camera technology has improved immensely in the decade since the publication of Hackett et al. (2007), and this improvement and the comparative logistical ease of using remote cameras instead of track plates suggests significant benefits to using this method. Currently, a majority of the known monitoring efforts for eastern spotted skunks are relying solely on remote cameras to detect the species (members of ESSCSG in 2017, pers. comm.). Baited camera stations have been successfully used in several states to detect eastern spotted skunks, often where they had not previously been known to persist (Hackett et al. 2007, Lesmeister 2007, Wilson et al. 2016, Sprayberry 2016, Boulerice and Zinke 2017, Thorne et al. 2017). Eastern spotted skunks have been successfully attracted to sites using a variety of baiting methods, though canned sardines in oil is the most commonly used bait in recent years. Scent lures such as Caven's Gusto, fatty acid scent tabs, cherry oil, or other strong-smelling attractants have supplemented the bait at many of these camera stations; however, additional attraction provided by scent lures has yet to be quantified. There are also indications that camera brand may have a significant effect on detection rates (Urbanek et al., in review).

Several efforts to monitor local populations of spotted skunks have also been successfully completed using very high frequency (VHF) transmitters (Lesmeister et al. 2010, Sprayberry 2016). Regional differences in the average mass of spotted skunks must be reflected in transmitter size which correlates to battery life. Most VHF transmitters suitable for eastern spotted skunks have been found to last approximately 9-12 months (R. Eng, Clemson University, pers. comm.). Many studies have reported that the fossorial nature of spotted skunks may cause the antenna of the transmitter to break off after several months of monitoring, resulting in a vastly diminished signal and difficulty maintaining frequent monitoring events.

Because spotted skunks weigh only 200-800 grams, use of GPS transmitter technology for studying this species requires serious consideration regarding trade-offs between number of locations taken and a potentially very short battery life (Moriarty and Epps 2015). While GPS collars have been used successfully in Florida (S. Harris, Clemson University, pers. comm.) and are being deployed in Wyoming (M. Ben-David, University of Wyoming, pers. comm.), re-trapping efforts necessary to accommodate the short battery life of GPS transmitters currently appear to be a severe logistical barrier for using this monitoring technology to study populations of eastern spotted skunks in more difficult terrain.

Key knowledge gaps:

- Guidance on "best monitoring strategies" for eastern spotted skunks
- Utility of techniques to improve detection using camera traps
    - Recommended bait and/or lure combinations for attracting spotted skunks
    - Effect of camera brand, settings, deployment and overall survey design on detection rates
    - Confirmation in seasonal variability in detection rate/alternate techniques for monitoring in non-winter months
- Utility of techniques to estimate abundance
    - Feasibility to detect individuals from pelage spot patterns in photos

C. Habitat (Drafted by Andrew Edelman)

Eastern spotted skunk habitat management concerns consist of several major themes including decline of early successional forest, loss of woody cover, and habitat fragmentation. These issues have historical roots in changes of land use patterns and management over the last 100 years. Given its large range across eastern North America, vegetation types occupied by eastern spotted skunks vary greatly among regions. However, the critical habitat required by eastern spotted skunks is ground-level cover that provides protection from predators. In the Appalachian Mountains, eastern spotted skunks are found in young, dense forest stands (< 50 years old) and mature forest stands with extensive shrub cover (Reed and Kennedy 2000, Diggins et al. 2015, Wilson et al. 2016, Thorne et al. 2017, Sprayberry and Edelman 2018). In Florida, eastern spotted skunks occupy dense xeric shrub habitats dominated by saw palmetto (*Serenoa repens*), wax myrtle (*Myrica cerifera*), and other shrubs (Manaro 1961, Kinlaw et al. 1995). Eastern spotted skunks in the Ouachita Mountains of Arkansas occupy forested areas with extensive sapling and shrub cover, particularly early successional stands (Lesmeister et al. 2008, 2009, 2013). In the midwestern U.S., eastern spotted skunks are associated with grasslands, shrublands, forests, and

agricultural areas often with nearby access to dense thickets, fencerows, woodlots, or human structures (Polder 1968, Choate et al. 1973, Tyler 1980). Dens are also a critical eastern spotted skunk habitat component and might be a limiting factor affecting abundance and distribution (Lesmeister et al. 2008). Dens are used for resting, protection from inclement weather and predation, and raising of young (Crabb 1948). Eastern spotted skunks typically locate dens within existing protective cover including shrubs, debris piles, burrows, hollow logs/stumps, tree cavities, under and between rocks, and in buildings (Crabb 1948, Kinlaw et al. 1995, Lesmeister et al. 2008, Sprayberry and Edelman 2018).

Conversion to modern agricultural practices and regional shifts in farming beginning in the 1930s contributed to negative habitat changes for eastern spotted skunks. Increased use of pesticides (DDT and toxaphene) might have reduced insect prey availability and disrupted eastern spotted skunk reproduction (Nilz and Finck 2008). Consolidation of small farms and use of modern machinery also resulted in clearing of fencerows, thickets, woodlots, and farm buildings, which reduced foraging and denning habitat for eastern spotted skunks (Gompper and Hackett 2005). In addition, modern grain management reduced available food for rodent prey of eastern spotted skunks (Choate et al. 1973, Gompper and Hackett 2005, Nilz and Finck 2008). Farm abandonment led to an increase in second-growth forests across the eastern U.S.; however, as these forests matured, younger forest cover was lost (Trani et al. 2001, Swanson et al. 2011). As a result, a number of wildlife species dependent on early- to mid-successional forests have declined, such as the New England and Appalachian cottontails (*Sylvilagus transitionalis* and *S. obscurus*), bobcat (*Lynx rufus*), Bachman's sparrow (*Peucaea aestivalis*), and American woodcock (*Scolopax minor*) (Litvaitis 2001). Given the eastern spotted skunk's occurrence in these younger forests with dense woody cover, it is likely this species has also declined. Natural stand replacing disturbances such as wildfire, windstorms, flooding, and insect outbreaks traditionally created early successional forests, but various management practices can also mimic stand-replacing disturbances to various degrees (Askins 2001). Much of the younger forest across the eastern U.S. is located on private lands (Trani et al. 2001). However, many private timberlands, particularly in the southeastern U.S., are managed plantations that might lack the structural complexity and species diversity needed for eastern spotted skunks (Mitchell et al. 2006). In addition, the decline in landowner parcel size presents challenges in creating suitably large and connected patches of early successional forest for eastern spotted skunks (Trani et al. 2001). Further research is needed to determine if specific management techniques are effective in creating early successional habitat for eastern spotted skunks and the needed size and configuration of habitat patches.

Fire is a natural disturbance (Guyette et al. 2010), but was widely suppressed across the U.S. during the last century (Nowacki and Abrams 2008). Currently, prescribed fire is a common management tool for forests and grasslands, particularly in the southern part of the eastern spotted skunk's range (Ryan et al. 2013). In particular, prescribed fire is used to restore and maintain fire-adapted longleaf pine (*Pinus palustris*) and shortleaf pine (*P. echinata*) forests. These open-canopy pine savannas are characterized by widely spaced mature pines and an herbaceous understory (Van Lear et al. 2005, Anderson et al. 2016), habitat conditions that lack the protective cover needed by eastern spotted skunks. Management practices for the restoration of open-canopy pine forests include reducing overall stem densities and hardwood abundance and frequent prescribed fire (2–4 year fire intervals) resulting in open canopies, low stem densities, and herbaceous ground cover with little woody midstory and understory cover (Van

Lear et al. 2005, Anderson et al. 2016). Eastern spotted skunks do not commonly occupy the pine-dominated forests with frequent prescribed fire (Lesmeister et al. 2013, Sprayberry and Edelman 2018) and individuals that move through these open forests suffer higher predation rates (Lesmeister et al. 2010). In addition, prescribed fire can reduce the abundance of snags and coarse woody debris used by eastern spotted skunks for foraging and denning (Tiedemann et al. 2000, Innes et al. 2006, Bagne et al. 2008). Restoration of these pine savannas in the southern U.S. are focused on improving habitat for several federally threatened and endangered species such as red-cockaded woodpeckers (*Leuconotopicus borealis*) and gopher tortoises (*Gopherus polyphemus*) (Van Lear et al. 2005, Anderson et al. 2016). Currently, >800,000 ha of U.S. Forest Service land in the southern U.S. are being managed for red-cockaded woodpeckers in addition to other public and private lands (Bowman et al. 1999). The conflict between the habitat needs of the eastern spotted skunk and the red-cockaded woodpecker suggest that landscape-scale pine ecosystem management practices should not be driven by any single species, but should instead strive to create heterogeneous landscapes that meet the needs of a variety of native species. The impact of prescribed fire in hardwood dominated systems is less well understood.

In addition to fire, other forest management practices that reduce protective woody cover likely have the potential to negatively affect eastern spotted skunks. These techniques include thinning of the overstory and/or midstory trees and removal of woody understory cover via mechanical methods and herbicides. Reduction of woody cover often is used in conjunction with prescribed fire to restore pine savannas by reducing stem densities and promoting herbaceous understories (Landers et al. 1995, Anderson et al. 2016). Research is needed to understand the potential for direct (injury and mortality) and indirect effects (habitat loss, food availability, den site availability, susceptibility to predation, competition, etc.) of prescribed fire and woody cover reduction in different vegetative communities and regimes.

Based on the historical and current land use patterns, habitat loss and fragmentation are continued threats to the eastern spotted skunk. Eastern spotted skunks in Arkansas did not occupy early successional or regeneration forest stands that were too small in area or isolated from larger forested patches; smaller forested patches have greater edge-to-core ratios, which might increase mortality risk for eastern spotted skunks from open-habitat predators along patch edges or when moving between patches (Lesmeister et al. 2010, 2013). Habitat patches for eastern spotted skunks should be larger than the average home range (80 ha) of females and maintain connectivity through corridors to reduce predation risk for dispersing skunks and facilitate gene flow (Lesmeister et al. 2013). Further research, particularly at the landscape scale, is needed to better understand eastern spotted skunk habitat requirements (land cover composition, patch size, and connectivity) and to institute appropriate management actions.

Knowledge gaps:

- Impacts of prescribed fire and mechanical/chemical reduction of forest and understory cover
- Habitat use and den site selection in open/prairie habitats
- Landscape scale habitat needs (composition, patch size, and connectivity), particularly in the following landscapes:
    - Prairie

- Rowcrop agriculture
- Pasture and hay agriculture
- Gulf coastal plain pinelands
- Savannah/woodlands

D. Population dynamics (Drafted by Damon Lesmeister and Andrew Edelman)

Population viability analyses are an important component of wildlife conservation plans because they can identify risks to a population, timing of extinction or decline, and potential for population recovery under a range of scenarios (Akçakaya and Sjögren-Gulve 2000). Population performance measures have been identified as an important need for eastern spotted skunk conservation plans, but very little is known about any aspect of population dynamics for the species. The few population density estimates reported are from locations where eastern spotted skunks were abundant and easily captured, and all recent population studies were of relatively short duration (<3 years). In dense coastal shrub habitat of Florida, population density of eastern spotted skunks was estimated at 40 individuals/km^2 (Kinlaw et al. 1995). In agricultural lands of Iowa, eastern spotted skunk population density was estimated at 5 individuals/km^2 (Crabb 1948), but very few individuals have been sighted in the state over the past several decades (Gompper and Hackett 2005). Eastern spotted skunks appear to be localized in distribution (Lesmeister et al. 2013); therefore, population density is undoubtedly much lower across much of the eastern spotted skunk's range based on low capture success and documented population declines (Choate et al. 1973, McCullough and Fritzell 1984, Reed and Kennedy 2000, Gompper and Hackett 2005, Hackett et al. 2007). Males are more easily captured than females due to larger home ranges and being less trap shy, often resulting in skewed sex ratio estimates (Kinlaw et al. 1995). Reported sex ratios are 2.5M:1.0F in Florida (Kinlaw et al. 1995), 1.8M:1.0F in Iowa (Crabb 1948), and 1.1M:1.0F in Arkansas (Lesmeister et al. 2010).

The only reported population survivorship and mortality estimates are from Arkansas in a landscape dominated by management actions to provide suitable habitat for red-cockaded woodpeckers (*Leuconotopicus borealis*) (Lesmeister et al. 2010). Eastern spotted skunks had relatively low annual survival rates (0.354) similar to other small carnivores such as weasels and foxes (Lesmeister et al. 2010). Annual survival rates varied based on sex and body condition, where males exhibited a decrease in survivorship as body condition decreased, but females showed the opposite trend (Lesmeister et al. 2010). Larger mammalian carnivores were important predators (26% of documented mortalities), but most eastern spotted skunk mortalities were due to avian predation (63% of mortalities) when moving through open habitats such as mature shortleaf pine (*Pinus echinata*) stands that have little overhead cover (Lesmeister et al. 2010).

Parturition in eastern spotted skunks generally occurs from May to June and varies with latitude; gestation length is 50-65 days (Mead 1968, Lesmeister 2007). Females likely only produce one litter per year, but eastern spotted skunks in Florida may have a second litter in July or August (Mead 1968). Average reported litter size is 5.5 (Crabb 1941, Crabb 1948, Mead 1968). Average litter sex ratio (males:females) is 1.3:1 (Crabb 1948). The young are weaned at 54 days of age, but can remain with the mother through autumn of their birth year (Crabb 1944).

Key knowledge gaps:

- Monitoring of long-term population trends to determine if eastern spotted skunks are declining, stable, or increasing in abundance
- Population density, survival, mortality, and reproduction estimates from different regions and habitat types
- Abiotic and biotic factors that affect vital rates of survivorship, mortality, and reproduction

E. Genetics (Drafted by Alexandra Shaffer, Robert Dowler, and Loren Ammerman)

Genetic markers, such as microsatellites, are especially useful when researching rare and understudied species, as they are capable of amplifying homologous sequences in closely related taxa, thus eliminating the need to develop *de novo* markers on a species-by-species basis. Specifically within *Spilogale*, cross-species microsatellites have been utilized by Floyd et al. (2011) to determine genetic differentiation within and among mainland western spotted skunks (*S. gracilis*) and island spotted skunks (*S. g. amphiala*) and by Jones et al. (2013) to determine the spatial and genetic organization of the island spotted skunk. Shaffer et al. (2018) used microsatellite markers to determine the genetic variability of the three subspecies of eastern spotted skunks and tested the validity of those subspecies designations using molecular techniques, as morphological differences among them were the only metric currently supporting their distinction. Shaffer et al. (2018) analyzed 119 specimens and established that genetic patterns were consistent with the currently accepted taxonomy of the recognized subspecies: *S. p. putorius*, *S. p. ambarvalis*, and *S. p. interrupta*. Tests of genetic structure placed individuals belonging to each of the subspecies into their respective, separate clusters. Structure plots presented by Shaffer et al. (2018) indicated a very low degree of admixture among subspecies with high averaged membership coefficients within subspecies ($\bar{X} \pm SE$): *S. p. interrupta* (99.45 ± 0.001%), *S. p. putorius* (98.23 ± 0.005%), and *S. p. ambarvalis* (97.90 ± 0.006%). Mitochondrial cytochrome *b* data have also been analyzed phylogenetically using Maximum Likelihood for 85 *S. putorius* to confirm the patterns seen in the nuclear data (unpublished data). The plains subspecies formed a monophyletic lineage with high bootstrap support (91%). The Appalachian and Florida subspecies formed a single lineage with 89% bootstrap support, but these two subspecies were not distinct from each other. Average sequence divergence (K2P) based on the cyt*b* gene was 9.8% between *S. putorius* and the outgroup *S. gracilis.* The *interrupta* subspecies was 2.9% divergent from individuals in the *ambarvalis/putorius* clade. The *ambarvalis* and *putorius* subspecies were an average of 1.2% divergent.

The differentiation between *S. p. putorius* and *S. p. ambarvalis* was less pronounced (F_{ST} = 0.178; cytochrome b sequence divergence = 1.2%) than between these subspecies and the plains spotted skunk (average F_{ST} = 0.278; cytochrome *b* sequence divergence = 2.9%). Levels of genetic diversity did not significantly differ among the three subspecies, therefore suggesting that the plains spotted skunk is no more depauperate genetically than the Appalachian or Florida spotted skunks. However, trends in sightings and capture rates for the three subspecies are not equal, suggesting relative abundances vary by subspecies. Interestingly, despite all Florida spotted skunk samples being deriving from a single population, this subspecies displayed a pattern of genetic variation similar to that observed in the plains and Appalachian subspecies,

whose samples originated from as many as six states with a distance of >1,500 km separating some individuals (Shaffer et al. 2018).

Shaffer et al. 2018 and others (unpublished data) also determined that there was no evidence for hybridization with the congener, *S. gracilis* (western spotted skunk), a species co-occurring with the eastern spotted skunk in parts of Texas. Overall, genetic variability (observed heterozygosity = 0.474, allelic richness = 6.64) in the plains spotted skunk was lower than that seen in common carnivores (striped skunks, raccoons), but slightly higher than some endangered carnivores (black-footed ferret). The heterozygosity levels more closely resemble those found within the island spotted skunk (*S. gracilis amphiala*) from the Channel Islands of California and other vertebrates that have a "threatened" conservation status (Shaffer et al. 2018). Given the vulnerable status of the eastern spotted skunk by the IUCN, and that the conservation status of the plains subspecies is currently under review, the lower-than-average genetic diversity observed within each subspecies conforms to the pattern evidenced by Willoughby et al. (2015).

Based on microsatellite and mitochondrial DNA sequences, the eastern spotted skunk displays strong patterns of genetic structuring and differentiation among subspecies, which are commensurate with previously reported morphological differences (Van Gelder 1959). The presence of private alleles found in all three subspecies, the degree of differentiation among them, the lack of gene flow, and high individual membership coefficients indicate the need to consider each subspecies as a unique evolutionarily significant unit (Moritz 1994). A similar suggestion was provided by Floyd et al. (2011) for the island spotted skunk, as they determined that populations occupying two separate Channel Islands (Santa Cruz Island and Santa Barbara Island), were just as differentiated from each other as they were from mainland western spotted skunk subspecies. Future management strategies for the eastern spotted skunk should therefore consider the genetic dissimilarities present among subspecies, as it is possible that these genetic differences reflect behavioral, physiological, or habitat differences, as well. Furthermore, the intensification of anthropogenic activities throughout the central United States has the potential to restrict gene flow in this region, especially between the central/south Texas and north Texas/northern states groups.

In addition to the need for more information related to subspecific genetic differentiation, data is also lacking to assess the genetic relatedness of subpopulations within the same subspecies. No information exists to determine if spotted skunks display a panmictic population structure, in which individuals are able to move about freely within their habitat and breed with other members of the population without barriers to dispersal. Alternatively, the hypothesis that natural or anthropogenic habitat fragmentation may be constraining dispersal and genetic exchange has not been explored. Research is needed to measure the level genetic diversity within and among isolated populations in relation to dispersal movement patterns.

Key knowledge gaps:

- Lack of representative specimens at subspecies contact zones to better evaluate gene flow patterns among subspecies and refinement of the edges of the subspecies range
- Identifying the timing of subspecies divergences
- Estimates of effective population sizes using microsatellite data

- Genetic relatedness within and among isolated subpopulations
- Effects of habitat fragmentation on dispersal and genetic exchange between subpopulations

F. Disease (Drafted by Bonnie Gulas-Wroblewski, Nikki Castleberry, and Summer Higdon)

Disease can affect the viability of a species directly by causing host mortality and/or indirectly by incrementally decreasing survivorship and reproduction in threatened populations (Dobson and May 1986, Deem et al. 2001). Their omnivorous diet, diversity of den sites, foraging behaviors, and other aspects of habitat use and natural history traits expose eastern spotted skunks (*Spilogale putorius*) to a wide variety of infectious diseases agents. In addition to the parasites listed in Appendix 2, *S. putorius* have been identified as carriers of and potential reservoirs for the bacteria *Francisella tularensis* (McKeever et al. 1958) and *Leptospira ballum* (Gorman et al. 1962) and the fungus *Histoplasma capsulatum* (Emmons et al. 1949). All North American members of the genus *Spilogale* play an integral role in the enzootic and epizoonotic cycles of the rabies virus (Krebs et al. 2000, Krebs et al. 2001).

Evaluating the ecological and environmental determinants of the interactions between eastern spotted skunk populations and their infectious diseases is as important as performing a complete survey of pathogens in this mephitid species. The ecological balance between pathogens and their *Spilogale* hosts is threatened by skunks' exposure to novel, more virulent strains of, and/or a greater diversity of pathogens through: (1) human-induced habitat fragmentation, (2) transmission of disease across the domestic-wildlife interface, (3) wide-scale and local climate change, and (4) contact with immunosuppressive and toxic chemicals, quickly evolving recombinant strains of infectious disease, and antimicrobial-resistant pathogens (Daszak et al. 2000, Gompper and Hackett 2005, Martin et al. 2010, Gortazar et al. 2014, Knobel et al. 2014, Kaffenberger et al. 2017). Addressing the "knowledge gaps" delineated below will provide a greater understanding of the impact infectious diseases have on the population dynamics of eastern spotted skunks, facilitating more accurate predictive modeling and more effective management planning for threatened populations. Furthermore, if eastern spotted skunks are identified as "sentinels" or "dilutors" of zoonotic diseases, their value to public health will increase and potentially justify higher conservation priority status for the species (LoGiudice et al. 2003, Galvani et al. 2016).

Key knowledge gaps:

- Parvovirus: When canine parvovirus mutated from the feline panleukopenia virus in the 1980s, it quickly expanded into a global pandemic, causing up to 90% mortality in some wildlife populations (Parrish 1994, Steinel et al. 2001). While the extent to which parvoviruses contributed to the decline of S. putorius interrupta is unclear (Gompper and Hackett 2005), mink viral enteritis, feline panleukopenia, canine parvovirus, and Aleutian mink disease parvovirus undoubtedly cause morbidity and mortality in current populations of eastern spotted skunks as they do in western spotted skunks (Spilogale gracilis) and striped skunks (*Mephitis mephitis*) (Barker et al. 1983, Oie et al. 1996, Gehrt 2005, Suzán and Ceballos 2005, Bakker et al. 2006, Pennick et al. 2007, Allender et al. 2008).

- Toxoplasmosis: As its primary definitive hosts, domestic cats (*Felis catus*), spread across the North American continent, so too does the coccidian parasite *Toxoplasma gondii*. There is serologic evidence of exposure to *T. gondii* in western spotted and striped skunks (Franti et al. 1976, Tizard et al. 1976, Diters and Nielsen 1978, Riemann et al. 1978, Suzán and Ceballos 2005, Gabriel et al. 2008), and the parasite has caused clinical illness and significant population declines in closely-related wild mustelids (Burns et al. 2003, Conrad et al. 2005).
- Ectoparasite-borne diseases: Although Q fever, Powassan virus, plague (*Yersinia pestis*), babesiosis (*Babesia* spp.), Rocky Mountain spotted fever (*Rickettsia rickettsii*), tick-borne relapsing fever (*Borrelia turicatae*), and Lyme disease (*Borrelia burgdorferi*) have not been sampled in eastern spotted skunks, these arthropod-borne pathogens have been isolated in western spotted and striped skunks (Holbrook and Frerichs 1970, Alexander et al. 1972, Riemann et al. 1978, Magnarelli et al. 1983, Smith et al. 1984, Johnson 1987, LoGiudice et al. 2003, Salkeld and Stapp 2006, Brinkerhoff et al. 2009, Clark et al. 2012, Wormser and Pritt 2015, Gulas-Wroblewski et al. 2017). Additionally, the ectoparasite taxa found on eastern spotted skunks (see Appendix 2) are known vectors of a diverse array of infectious pathogens (Norman et al. 1999, Parola and Raoult 2001, Bitam et al. 2010, Eisen and Gage 2012), the only one of which that has been definitively described in *S. putorius* being *Francisella tularensis* (McKeever et al. 1958). Ectoparasites and their accompanying pathogens are frequently shared across the domestic-wildlife interface (Poo-Muñoz et al. 2016), increasing the risk of disease transmission to *S. putorius* in territories shared by domestic animals. Climate change models predict shifting distribution of ectoparasites and their associated diseases, which will impact the degree and diversity to which eastern spotted skunks will be exposed to ectoparasite-borne pathogens in the future (Esteve-Gassent et al. 2016).
- Filarial diseases: Despite the importance placed on heartworm (*Dirofilaria immitis*) disease in domestic animal veterinary medicine, the impact that *D. immitis* and other filarial diseases have on wildlife populations remains largely unstudied (Venco et al. 2015). Microfilarial diseases have been recorded in striped skunks (Chandler 1947, Webster and Beuregard 1964, Saito and Little 1997), and heartworm was detected in an island spotted skunk (*S. g. amphiala*) (Bakker et al. 2006). The geographic areas of highest *D. immitis* prevalence in dogs overlaps heavily with the current range of *S. p. interrupta* (Bowman et al. 2016).
- Chagas disease: Infections with the protozoan parasite *Trypanosoma cruzi* (Chagas disease) typically lead to acute or chronic cardiac disease in mammalian hosts and resulted in myocarditis in a striped skunk in California (Ryan et al. 1985). A plains spotted skunk (*S. p. interrupta*) tested positive for Chagas disease in Texas (Gulas-Wroblewski et al. 2017), and the extended range of eastern spotted skunks includes regions with confirmed *T. cruzi*-infected triatomid insect vectors, domestic dogs (*Canis familiaris*), humans, and other wild mammals (Bern et al. 2011, Snowden and Kjos 2011, Garcia et al. 2015). Transboundary human migration coupled with climate change is expected to foster the spread of *T. cruzi*, novel genotypes of *T. cruzi*, and triatomid vectors into new geographic areas of the U.S., including territories currently inhabited by *S. putorius* (Garza et al. 2014).
- Other mosquito- and fly-borne diseases: In addition to filaria, North American mephitids host several other mosquito-borne pathogens, most notably West Nile virus in striped and

western spotted skunks and an undetermined *Flavivirus* in striped and hooded skunks (*Mephitis macroura*) (Anderson et al. 2001, Bentler et al. 2007, Gabriel et al. 2008). The increased periods of drought punctuating future climatic patterns may exacerbate the severity of West Nile virus outbreaks throughout the United States (Paull et al. 2017). Increased periods of drought, high temperatures, and dry weather patterns likewise amplify the spread of sand-fly-borne diseases, such as leishmaniasis (Cardenas et al. 2006, Kaffenberger et al. 2017). *Leishmania* strains have been recovered from hog-nosed skunks, *Conepatus chinga* (Buitrago et al. 2011), whereas pygmy spotted skunks (*Spilogale pygmaea*) and eastern spotted skunks have been identified as probable reservoirs for the protozoan parasites in Mexico (Stephens et al. 2009). The distribution of canine and human leishmaniosis in North America largely overlaps with the range of *S. p. interrupta*, increasing the likelihood of this subspecies' exposure to the disease (Baneth and Solano-Gallego 2012).

- Other endoparasites (protozoans and helminths): The abiotic and biotic factors influencing the host-parasite interrelationships between *S. putorius* and the endoparasites listed in Appendix 2 still need to be explored. Investigating the patterns and factors involved in the transmission of endoparasites across the domestic-wildlife interface is critical in the case of eastern spotted skunks that share habitat with free-ranging domestic cats, dogs and livestock (Knobel et al. 2014, Allwin et al. 2016, Curia et al. 2016).
- Fungal disease: Fungal infections are emerging as driving forces in population crashes of a variety of wildlife species (Hayman et al. 2016, Lorch et al. 2016, Scheele et al. 2017). *Histoplasma capsulatum* was recovered from an eastern spotted skunk (Emmons et al. 1949), while cases of histoplasmosis and aspergillosis have been reported in striped skunks (Durant and Doll 1939, Emmons et al. 1955, Menges et al. 1955, Verts 1967). To date, the type, clinical manifestations, and influence on overall health of pathogenic fungi in eastern spotted skunks have been poorly investigated. It will be critical to establish a comprehensive assessment of mycosis in this species, especially as new and more heat-tolerant fungal pathogens evolve in response to rising global temperatures (Robert et al. 2015).
- Other viral diseases: Although neither distemper nor rabies was a likely cause of the initial rapid decline of *S. putorius* (Gompper and Hackett 2005), these viruses are most likely contributing factors in continued morbidity and mortality in eastern spotted skunk populations. Members of the genus *Spilogale* are among the principal hosts of rabies (Krebs et al. 2000, Krebs et al. 2001, Suzán and Ceballos 2005), while distemper is widespread in North American mephitids overall (Goss 1948, Helmboldt and Jungherr 1955, Verts 1967, Diters and Nielsen 1978, Gehrt 2005). Other pathogenic viral diseases have been recovered from striped skunks, such as infectious canine hepatitis, canine herpesvirus, and rotaviruses (Alexander et al. 1972, Karstad et al. 1975, Charlton et al. 1977, Diters and Nielsen 1978, Evans 1984), however, an extensive survey of viruses infecting eastern spotted skunks and their impact on population health has yet to be undertaken.
- Other bacterial diseases: Leptospirosis has been described in *S. putorius* (Gorman et al. 1962), while *Staphylococcus* and *Listeria* infect striped skunks (Bolin et al. 1955, Osebold et al. 1957, Verts 1967, Aarestrup 2001), and *Brucella abortus* infects western spotted and striped skunks (Moore and Schnurrenberger 1981). The degree to which non-

arthropod-borne bacterial pathogens contribute to morbidity and mortality in eastern spotted skunk populations needs to be determined.

7. Conservation Actions

With the development of this plan and associated background information, a key next step is the prioritization and accomplishment of conservation actions. Based on an initial review, the following tasks have been identified:

- Stay engaged in current plains subspecies ESA listing review process, and evaluate the need for Appalachian and Florida subspecies conservation assessments
- Develop a guidance document on "best" monitoring strategies to provide comparable data among range states
- Develop region-specific habitat management recommendations to protect and improve spotted skunk habitat conditions at a local and landscape level
- Improve our understanding of the species' distribution by developing a centralized database of spotted skunk detections, particularly in the past 20 years
- Continue annual ESSCSG meetings toward the goal of conducting collaborative research efforts and identifying funding sources to address key knowledge gaps
- Conduct symposia at professional meetings and other outreach to help integrate new findings into management actions to recover the species
- Better integrate midwestern states in ESSCSG participation, planning, and meetings

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Appendix 1. State-by-state summary of status, classification, legal status, monitoring, date of last sighting, research, and contact information.

Alabama

- *Population status*: Little is known about the current status of the species in Alabama. Incidental observations from public outreach efforts suggest the species maintains a statewide distribution, with perhaps highest densities living in an arc around the toe of the Appalachians and Piedmont.
- *Classification*: Nongame Vertebrate Protected by Regulation.
- *Legal status*: No hunting or trapping season.
- *Monitoring*: The Alabama Department of Conservation and Natural Resources and the University of West Georgia conducted a statewide game camera survey January – May 2017 that yielded captures at only 2 of 201 camera sites. ADCNR conducted camera surveys limited in scope in winter of 2018-2019, revealing populations in northwest Alabama. A survey by University of West Georgia at Conecuh National Forest in 2017-2018 documented only two skunks.
- *Date of last sighting*: 2019.
- *Research*: Dr. Andrew Edelman and student Kassandra Arts, University of West Georgia, are currently conducting research on a population located at Freedom Hills WMA. Data from GPS collars have been retrieved from two skunks.
- *Contact*: Nicholas Sharp, Nongame Biologist, Alabama Nongame Wildlife Program, Division of Wildlife and Freshwater Fisheries, 21453 Harris Station Rd., Tanner, AL 35671-3308, P: (256) 308-2517, nicholas.sharp@dcnr.alabama.gov

Arkansas

- *Population status*: The eastern spotted skunk is assumed to occur statewide but almost all recent records have been restricted to the Ozark and Ouachita Mountains. More research is required to determine the abundance of this species.
- *Classification*: Furbearer, S2S3 imperiled in Arkansas.
- *Legal status*: No hunting season. Trapping season with no bag limits.
- *Monitoring:* Arkansas monitors harvest through required reports of purchases made by licensed fur dealers and conducts a survey of resident and non-resident trappers each year in which they inquire about incidental take of spotted skunks. From 2012-2016 a minimum of 56 spotted skunks were taken by trappers, 53 of which were incidental to trapping targeted at other species.
- *Date of last sighting*: March 2019.
- *Research*: A habitat use study was recently completed in the Ozark Mountains, but due to difficulty in capturing skunks very little information was gathered. The University of Missouri recently completed a model of potential spotted skunk habitat based on recent occurrences in Arkansas and Missouri. Additional research needed to conduct status surveys, determine habitat use relationships, and determine home range. More data are needed to determine conservation actions.
- *Contact*: Blake Sasse, Nongame Mammal/Furbearer Program Leader, P: (501) 470-3650 ext. 1235, Blake.Sasse@agfc.ar.gov

Colorado

- *Population status:* Thought to be extremely rare or extirpated.
- *Classification:* Non-game species.
- *Legal status:* No hunting or trapping season.
- *Monitoring:* Known only from a few specimens found at the eastern border.
- *Date of last sighting:* Unknown.
- *Research:* No CPW sponsored studies currently underway or planned.
- *Contact:* Eric Odell, eric.odell@state.co.us

Florida

- *Population status:* Recent genetic work by Dr. Robert Dowler and his students at Angelo State University (Shaffer et al. 2018) supports recognition of 2 subspecies of eastern spotted skunk in Florida. The range of the Appalachian, or Allegheny, spotted skunk (*S. p. putorius*) is recognized as extending into north Florida. The accepted range of the Florida spotted skunk (*S. p. ambarvalis*) covers peninsular Florida, south from, approximately, the Suwannee River. However, where the break between the distributions of the 2 subspecies actually occurs is not known. Based on recent work by researchers from Clemson University and Florida Fish and Wildlife Conservation Commission (FWC) staff (see below) and anecdotal observations at other sites in central Florida, it appears the Florida spotted skunk is at least locally abundant in some areas. At this time, the status of the Appalachian spotted skunk in Florida is not well understood, but it may be rare. Few records of spotted skunks have been reported in the Florida panhandle, and a recent camera trap-based monitoring effort in the panhandle produced few observations of spotted skunks (J. Gore, FWC, personal communication).
- *Classification:* Furbearer.
- *Legal status:* Trapping season (year-round with no bag limit).
- Monitoring: No current dedicated monitoring. Efforts are being made to fund additional surveys for spotted skunks and other mesomammal species. Citizen science projects (e.g., iNaturalist) are being considered to bolster monitoring efforts. FWC biologist are hopeful additional work can begin in the near future.
- *Date of last sighting:* Other than limited numbers of anecdotal roadkill reports the last reported sighting was in March 2019 in Miami-Dade County in south Florida. This sighting was submitted to iNaturalist with photo documentation.
- *Research:* Dr. David Jachowski (djachow@clemson.edu) and Stephen Harris at Clemson University conducted a 2016-2017 study of a population in south-central Florida. Their research focused on den site selection, movement ecology and diet. The FWC staff at the Three Lakes WMA in south-central Florida conducted a 2016-2018, grid-based, mark-recapture study of the population there to assess density and other population parameters.
- *Contact:* Megan Wallrichs, Florida Fish and Wildlife Conservation Commission, Megan.Wallrichs@MyFWC.com

Georgia

- *Population status:* Present but thought to be rare or extirpated across most of their range.

- *Classification:* Furbearer species; State high priority species. Classified as S3 vulnerable.
- *Legal status:* Legal to trap during the furbearer trapping season.
- *Monitoring:* Spotted skunks are reported yearly with some being trapped every year during the trapping season.
- *Date of last sighting:* March 2019.
- *Research:* Research currently being undertaken by several universities in Georgia. Citizen science camera trapping project set to start in spring 2019.
- *Contact:* Katrina Morris, Wildlife Conservation Section, GA DNR, Katrina.morris@dnr.ga.gov

Iowa

- *Population status:* Eastern spotted skunks are listed as endangered (S1) on the Iowa State Wildlife Action Plan.
- *Classification:* Endangered.
- *Legal status:* No hunting or trapping season.
- *Monitoring:* Currently, there is no dedicated monitoring occurring in Iowa for the spotted skunk. However, wildlife monitoring occurs throughout the state for the wildlife action plan.
- *Date of last sighting:* The most recent sightings in Iowa include the following: two to three spotted skunks were reported/documented in the Camp Dodge (Polk Co.) area on 7/20/14. This was the first documented case of spotted skunks in Iowa in the past 20 years; one spotted skunk was found dead on a road in Sac County, Iowa, April 2016.
- *Research:* No ongoing research, neither is any planned.
- *Contact:* Vince Evelsizer, Vince.Evelsizer@dnr.iowa.gov

Kansas

- *Population status:* Kansas lists all spotted skunks as a tier 1 high-priority species.
- *Classification:* Furbearer, considered threatened.
- *Legal status:* No hunting or trapping season.
- *Monitoring:* Attempt to verify every spotted skunk report we receive and collect all carcasses of dead animals. KDWPT has also been monitoring baited camera stations in the winter and spring.
- *Date of last sighting:* Last confirmation was in March 2019.
- *Research:* No research is currently ongoing or planned.
- *Contact:* Zack Cordes, Zackary.cordes@ks.gov

Kentucky

- *Population status:* Imperiled because of rarity due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the state.

- *Classification:* Special Concern (Office of Kentucky Nature Preserve's Monitored Species and Natural Communities of Kentucky); Furbearer, S2: imperiled (Kentucky Department of Fish and Wildlife Resources Mammal CWCS Species).
- *Legal status:* No hunting or trapping season.
- *Monitoring:* Formal monitoring is occurring as part of a project funded by the Office of Kentucky Nature Preserves. Records submitted to the Office of Kentucky Nature Preserves or the Kentucky Department of Fish and Wildlife Resources are also taken into account.
- *Date of last sighting:* March 2019.
- *Research:* Drs. Luke Dodd and Kelly Watson and M.S. student Courtney Hayes at Eastern Kentucky University are working to detect eastern spotted skunks throughout the state using baited camera trap surveys. Habitat associations are being explored, and pilot efforts to radiotrack the species to den sites is planned to begin in winter of 2018-2019.
- *Contact:* Sunni Carr, Wildlife Diversity Coordinator with the Kentucky Department of Fish and Wildlife Resources, Sunni.Carr@ky.gov; and Shelby Fulton, Terrestrial Zoologist with the Office of Kentucky Nature Preserves, shelby.fulton@ky.gov

Louisiana

- *Population status:* Critically imperiled in the state because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state. Believed to be extirpated.
- *Classification:* Louisiana classifies eastern spotted skunks as S1 = Critically Imperiled.
- *Legal status:* Open to harvest during furbearer trapping season (Louisiana does not distinguish between striped or spotted skunk in their furbearer regulations).
- *Monitoring:* Dr. Paul Leberg with University of Louisiana, Lafayette, sampled throughout the state from 2009 to 2012 and was unable to come up with a single detection.
- *Date of last sighting:* George H. Lowery wrote of a few roadkill sightings in "The Mammals of Louisiana and its Adjacent Waters" published in 1974. He also wrote that fur harvest of spotted skunks had declined to almost nothing in the decade prior to the book being written. This may be due to lack of interest in harvesting skunks, but they were likely in decline at this time as well.
- *Research:* None ongoing; Research needed: Intensive, targeted research is needed within historical range to determine current status in state.
- *Contact:* Jennifer Hogue Manuel, Furbearer Biologist, Louisiana Department of Wildlife and Fisheries, 200 Dulles Dr., Lafayette, LA 70506, P: (337) 735-8674; Keri Lejeune, Wildlife Diversity Program, Louisiana Department of Wildlife and Fisheries, 200 Dulles Dr., Lafayette, LA 70506, P: (337) 735-8676

Maryland

- *Population status:* Historical, possibly extirpated from the state.
- *Classification:* The species is legally classified in Maryland as a "Protected Nongame Mammal" (COMAR 08.03.08.15) which limits take to the following conditions: (1)

Permits to take protected nongame mammals may only be issued for: (a) Scientific research; (b) Educational purposes designed to further public awareness regarding the species; (c) Protection of human health and safety; or (d) To address damage to property. (2) Incidental taking permits are not required for protected nongame mammals. MD DNR currently ranks it as S1. However, the state conservation rank is likely to soon change to SH given the lack of any detections during a recently completed, intensive, multi-year survey and the lack of any records since 1967 (see below). The SH rank is defined as "Known only from historical records and some hope of rediscovery remains. There is some evidence that the species may no longer be present, but not enough to know with certainty." The species is also designated as a species of greatest conservation need (SGNC) in the Maryland 2015 State Wildlife Action Plan.

- *Legal status:* No hunting or trapping season.
- *Monitoring:* No current monitoring.
- *Date of last sighting:* The last documented sightings were in 1967 in Garrett and Washington Counties. Other records exist from these counties as well as Allegany.
- *Research:* Baited camera-trap surveys were conducted at 35 sites on Maryland Department of Natural Resources, National Park Service, and Army Corp of Engineers lands, in Garrett, Allegany, and Washington counties between 2015 and 2018. Camera traps were conducted both at historical sites that retained potential spotted skunk habitat, and sites throughout the species historic range identified as having suitable habitat. We requested information from the public, outdoor recreationists, and natural resource professionals via "wanted posters", sportsmen meetings, and questionnaires. No spotted skunks were detected during our camera-trap surveys, and there were no reports that resulted in a verified sighting.
- *Contact:* Dr. Tom Serfass, Tserfass@frostburg.edu; Kelly Pearce, kpearce@allegheny.edu; James McCann, james.mccann@maryland.gov

Minnesota

- *Population status:* Since 1996, the eastern spotted skunk has been considered threatened. In Minnesota, a species is considered as threatened if it is likely to become endangered within the foreseeable future in a significant portion or all of the state's range.
- *Classification:* Although listed as a furbearer, the eastern spotted skunk is not to be harvested, trapped, or taken due to its status as threatened.
- *Legal status:* Due to its status as threatened, the eastern spotted skunk does not have a season for harvesting. If one does accidently harvest an eastern spotted skunk, it should be reported immediately to the state's Department of Natural Resources (DNR).
- *Monitoring:* Though the last effort of live-trapping to survey for the eastern spotted skunk was done in 1995, Minnesota requests that citizens who see a spotted skunk report to the state's DNR. Periodically, request for recent sightings is sent out to groups of people that are most likely to have encountered them: farmers, trappers, fur-buyers, and wildlife managers.
- *Date of last sighting:* Since 2013, only 6 individual spotted skunks have been sighted.
- *Research:* If an eastern spotted skunk is verified, Minnesota may conduct surveys around the area of sighting to determine if a population exists.
- *Contact:* Gerda Nordquist, gerda.nordquist@state.mn.us; John Erb, john.erb@state.mn.us

Mississippi

- *Population status:* According to Mississippi's State Wildlife Action Plan 2015-2015, the eastern spotted skunk has a Heritage Rank of S1 and is considered a Tier 1 species. S1 species are considered critically imperiled because of extreme rarity or because of factors that would make it vulnerable to extirpation. Rarity is 5 or fewer occurrences or very few remaining individuals or few acres of habitat. Tier 1 species are in need of immediate conservation and/or research due to factors listed above.
- *Classification:* Nuisance wildlife.
- *Legal status:* Furbearers season: November 1st- March 15th, with no bag limit with a trapping license.
- *Monitoring:* Most spotted skunk records in Mississippi predate 1960. There are 4 more recent records beginning in 2002. From 2008–2010, Mississippi conducted intensive surveys using live traps and focusing on areas of historic occurrence based on specimen records at the museum. They failed to capture any specimens during these surveys. However, in January 2012 a trapper in eastern Yalobusha County captured a spotted skunk (identity was verified and a skin was collected). In February 2013, MS live trapped at Calhoun WMA (Calhoun Co.) not far from the location where the 2012 specimen was captured, and we captured one specimen. In January of 2019, a spotted skunk was photographed during a camera trap survey on Canemount WMA by MDWFP biologists. Plans currently underway for follow-up camera surveys and potentially surveys on other public lands in SW Mississippi.
- *Date of last sighting:* January 29, 2019.
- *Research:* None.
- *Contact:* Ricky Flint, RickyF@mdwfp.state.ms.us

Missouri

- *Population status:* Endangered.
- *Classification:* Furbearer.
- *Legal status:* No hunting or trapping season.
- *Monitoring:* Sighting reports are being solicited from the public, trapping community, and Department of Conservation Staff; and are cataloged in the Department's Natural Heritage Database.
- *Date of last sighting:* last confirmed report January 2016.
- *Research:* Occupancy modeling and relative abundance project is currently being proposed.
- *Contact:* Laura Conlee, Laura.Conlee@mdc.mo.gov

Montana

- *Population status:* Although the historic range of this species included Montana, this may have just been from the connecting of Wyoming and North Dakota in range maps, as Montana has never had a sighting of the eastern spotted skunk. The University of Montana and the Montana Natural Heritage Program has done, and continues to do,

extensive trapping throughout the state with no success of sighting an eastern spotted skunk.

- *Classification:* Predatory animal.
- *Legal status:* No license or reporting required for take by residents.
- *Monitoring:* None.
- *Date of last sighting:* None.
- *Research:* None.
- *Contact:* Dr. Kerry Foresman, kerry.foresman@mso.umt.edu

Nebraska

- *Population status:* The plains spotted skunk is considered critically imperiled in the state of Nebraska.
- *Classification:* Plains spotted skunks are listed as furbearers and at-risk species (S1 Tier 1) in the Nebraska State Wildlife Action Plan.
- *Legal status:* No hunting or trapping season.
- *Monitoring:* The Nebraska Game and Parks Commission collects carcasses/observation reports from the public. Citizen science surveys utilizing camera traps have been conducted since 2017.
- *Date of last sighting:* 2017.
- *Research:* None.
- *Contact:* Sam Wilson, sam.wilson@nebraska.gov; Shaun Dunn, shaun.dunn@nebraska.gov

North Carolina

- *Population status:* Unknown.
- *Classification:* Furbearer, Wildlife Action Plan Priority Species (S3, rare or uncommon in North Carolina).
- *Legal status:* Statewide the regulated trapping season is from November 1st through the end of February. No bag limits.
- *Monitoring:* Recording confirmed observations (1959-Present) and a winter camera survey (2015-Present).
- *Date of last sighting:* April 8, 2019 (Confirmed staff observation from recreational trapping).
- *Research:* Since little is known of the eastern spotted skunk's status, population size and trends, North Carolina initiated a western regional camera survey in the winter of 2015. Winter 2019 was the fifth year of the study and while the data is still being processed, they had a minimum of 23 detections. North Carolina also contracted with Clemson University to conduct a research project that will increase the understanding of the basic life history traits (e.g., mortality factors, survivorship rates, habitat use, movements, reproduction) of the eastern spotted skunk in order to determine its population status (i.e., increasing, decreasing, stable) and to inform the agency on actions that can be taken to better survey, monitor and manage this species. In 2018, they captured and fit 15 individuals with radio collars. This PhD project will be complete by Dec. 31, 2021.

- *Contact:* Colleen Olfenbuttel, P: (919) 920-6302, colleen.olfenbuttel@ncwildlife.org

North Dakota

- *Population status:* North Dakota lists the eastern spotted skunk as a level 3 species of concern due to the belief that they are peripheral or non-breeding in the state. They have a moderate level of conservation priority.
- *Classification:* Furbearer unprotected.
- *Legal status:* Trapping permitted during open season, no limit.
- *Monitoring:* We record reports of occurrence when they are received.
- *Date of last sighting:* 5/25/2016 in Benson County.
- *Research:* None specifically for spotted skunks.
- *Contact:* Stephanie Tucker, satucker@nd.gov; Patrick Isakson, piskason@nd.gov

Ohio

- *Population status:* No reliable historical records found for eastern spotted skunks throughout the state.
- *Classification:* All skunk species are considered a furbearer.
- *Legal status:* Skunks can be trapped or hunted during designated seasons with no bag limit.
- *Monitoring:* None.
- *Date of last sighting:* None.
- *Research:* There is no research being conducted to monitor for eastern spotted skunks.
- *Contact:* Katie Dennison, catherine.denison@dnr.state.oh.us

Oklahoma

- *Population status:* Status generally unknown, but most recent reports of live animals have been in the Ozark Highlands / Ouachita Mountains areas in the eastern third of the state.
- *Classification:* Furbearer, designated as a species of greatest conservation need (SGCN) in the Oklahoma Comprehensive Wildlife Conservation Strategy.
- *Legal status:* Closed to hunting and trapping.
- *Monitoring:* No formal monitoring is in place, though ODWC does gather sighting reports from the public.
- *Date of last sighting:* August 2016.
- *Research:* In addition to gathering annual records and reports, the Oklahoma Department of Wildlife Conservation has been coordinating with Oklahoma State University and the University of Central Oklahoma to conduct a survey and status assessment of the plains (eastern) spotted skunk in the state. Trapping efforts will be initially concentrated in the Ozark Highlands, Boston Mountains, and Ouachita Mountains regions in far eastern Oklahoma. This work is anticipated to begin in 2018-19.
- *Contact:* Matt Fullerton, matthew.fullerton@odwc.ok.gov; Jerrod Davis, jerrod.davis@odwc.ok.gov

Pennsylvania

- *Population status:* State biologists are unable to predict the population trend, because there have been no more than 5 individuals reported. The conservation goal is to establish a self-sustaining population by 2025.
- *Classification:* Imperiled. Pennsylvania lists spotted skunks as a species of greatest conservation need.
- *Legal status:* Spotted skunks are protected within the state, meaning there is no season for take by any type of trapper.
- *Monitoring:* Pennsylvania Game Commission recognizes there are many threats to the spotted skunk population - mortality from natural predation (biggest threat), mortality from incidental take by trapper, mortality from vehicle collision, habitat modification and lower food availability due to agricultural management.
- *Date of last sighting:* Most current sighting occurred in 2012 by a wildlife consultant in Fayette County, just north of West Virginia. The sighting was verified via trail cameras by the Pennsylvania Game Commission. Surveys in adjacent areas were unsuccessful. Before then, the most current sighting was in the 1950s in two counties to the east (Bedford and Fulton).
- *Research:* Since the 2012 sighting in Fayette County, Pennsylvania has established a camera trap survey. In addition, Pennsylvania Game Commission has a 10-year ongoing project to capture the current distribution of mammals, ultimately including spotted skunks in the research. Pennsylvania is in the middle of conducting trail camera surveys. The state is also in the middle of developing a hair snare that is conducive to eastern spotted skunks, but also raccoon and bear resistant.
- *Contact:* Gregory Turner, grturner@pa.gov

South Carolina

- *Population status:* Little is known about the spotted skunk population within the state of South Carolina. Until recently, South Carolina had no spotted skunk recorded in 16 years. Under the South Carolina State Wildlife Action Plan spotted skunks are listed as a species of moderate priority. Skunks may have been taken during trapping seasons over the years, but there was no differentiation between spotted or striped skunks on the harvest report form until recently.
- *Classification:* Furbearer.
- *Legal status:* May be hunted/trapped during the open season.
- *Monitoring:* During 2015-2017, intensive camera trap monitoring was conducted by Clemson University in the northwestern part of the state, confirming the presence of the species in National Forests in that region. There are no ongoing dedicated monitoring efforts.
- *Date of last sighting:* August 2017.
- *Research:* In 2015-2017, Clemson University graduate student Robin Eng conducted camera trap surveys to determine distribution and occupancy patterns of spotted skunk populations in the northwest corner of the state. She also conducted radiotracking of spotted skunks to determine fine-scale patterns in den site selection. Her thesis is

published online, and papers regarding these two projects are in press at Journal of Wildlife Management and Journal of Mammalogy. Contact: djachow@clemson.edu
- *Contact:* Jay Butfiloski, ButfiloskiJ@dnr.sc.gov

South Dakota

- *Population status:* Besides the annual furbearer harvest report, little is known about eastern spotted skunks in South Dakota.
- *Classification:* Furbearer, grouped with striped skunks under state law as "skunks." Also monitored by the South Dakota Natural Heritage Program as a sensitive species and included as a species of greatest conservation need in the South Dakota Wildlife Action Plan. These latter two designations do not provide legal protection for this species, but encourage reporting by the public and other wildlife agencies and allow State Wildlife Grant expenditures on this species.
- *Legal status:* May be trapped year-round statewide.
- *Monitoring:* Information is solicited opportunistically through the South Dakota Natural Heritage Program and South Dakota Wildlife Action Plan websites.
- *Date of last sighting:* An estimated 240 spotted skunks were harvested during the 2017 season by furbearer license holders.
- *Research:* SD Game, Fish and Parks will be conducting a State Wildlife Grant-funded project with the following objectives: 1. Delineate the distribution of plains spotted skunks in South Dakota; 2. Quantify ecological and biological correlates with habitat selection by plains spotted skunks; and 3. Estimate survival rates of plains spotted skunks in South Dakota.
- *Contact:* Eileen Dowd Stukel, eileen.dowdstukel@state.sd.us

Tennessee

- *Population status:* Uncommon but widely distributed, primarily in the eastern mountain and plateau regions. Tennessee lists ESS as a Tier 1 species, primary focus of priority (S3, G4).
- *Classification:* Furbearer.
- *Legal status:* Open to seasonal trapping, no limit. The trapping season for the species is the Friday before Thanksgiving through the last day of February.
- *Monitoring:* Reports of sightings by public are requested through social media and a request is published in hunting/trapping guide. The Tennessee Wildlife Resources Agency is conducting camera trap surveys to assess the species occurrence across the state.
- *Date of last sighting:* February 10, 2019.
- *Research:* No ongoing research, but several aspects of the species ecology within the state need to be assessed.
- *Contact:* Roger Applegate, State Furbearer, Small Game, and Wildlife Health Program Leader, Tennessee Wildlife Resources Agency, PO Box 40747, Nashville, TN 37204, P: (615) 781-6616, Fax (615) 781-6654, Cell (615) 788-6433, Roger.Applegate@tn.gov

Texas

- *Population status:* Rare animal in need of attention. State Abundance Ranking: S1S3.
- *Classification:* Furbearer.
- *Legal status:* Can be trapped during the regulated seasons.
- *Monitoring:* No ongoing monitoring is currently taking place.
- *Date of last sighting:* Sighting reports from public are fairly common. Several from this year.
- *Research:* Angelo State University has an ongoing project, contact is Dr. Robert Dowler (robert.dowler@angelo.edu).
- *Contact:* Jonah Evans, Mammalogist. Texas Parks and Wildlife Department, 140 City Park Rd., Boerne, Texas 78006, P: (830) 331-8739.

Virginia

- *Population status:* Uncommon but widely distributed in the western half of the state, primarily in the western mountain region with a few scattered reports in the central Piedmont.
- *Classification:* Legally classified as furbearer, also listed as Tier IV species of special concern in 2015 Virginia Wildlife Action Plan.
- *Legal status:* Continuous closed season for hunting and trapping, pelts may not be sold (spotted skunks may be killed by landowners when they are causing damage).
- *Monitoring:* Reports of sightings by public (request published in hunting/trapping regulation digest), citizen science project at Virginia Tech.
- *Date of last sighting:* March 10, 2019.
- *Research:* Ongoing: Distribution, habitat use, and genetic status of spotted skunks in Virginia. Emily Thorne and Dr. Mark Ford, Virginia Tech, principal investigators.
- *Contact:* Michael Fies, P: (540) 248-9390 (office), (540) 569-0824 (cell), mike.fies@dgif.virginia.gov

West Virginia

- *Population status:* Spotted skunks seem to be confined to high elevation areas of the state, but recent efforts to collect observations from the state trappers association and state natural resources professionals has expanded the known range of the species.
- *Classification:* Listed as a furbearer.
- *Legal status:* May be trapped during the legal trapping season or hunted year-round.
- *Monitoring:* Fur dealer reports, reported incidental catches, and collected observations remain a consistent form of monitoring in WV. Standardized monitoring protocols will be developed following the completion of current research by WVDNR and Frostburg State University.
- *Date of last sighting:* April 2019.
- *Research:* WVDNR and Frostburg State University are studying eastern spotted skunk spatial ecology and natural history in the eastern panhandle. GPS collars and standard

VHF collars are being used to track skunks to den sites and identify night-time movements.
- *Contact:* Kevin Oxenrider, P: (304) 822-3551 (Office), kevin.j.oxenrider@wv.gov

Wisconsin

- *Population status:* Typically, spotted skunks are found in the southwestern part of Wisconsin. There have been no recent sightings for spotted skunks for years now.
- *Classification:* According to the Wisconsin Wildlife Action Plan, eastern spotted skunks are listed as an unprotected, wild animal.
- *Legal status:* Listed as a furbearer species and can be trapped during the regulated season.
- *Monitoring:* Wisconsin DNR Research program conducts annual rare mammal observation surveys by all willing department employees in addition to accepting any rare mammal observations from citizens.
- *Date of last sighting:* Unable to find a specific date. Wisconsin Department of Natural Resources lists the most recent spotted skunk sighting to be several decades ago.
- *Research:* Currently looking for citizens or state employees to report spotted skunks.
- *Contact:* Curtis Twellmann, Curtis.Twellmann@wisconsin.gov

Wyoming

- *Population status:* Vulnerable (population size or distribution is restricted or declining); thought to be rare in the state.
- *Classification:* Classified as a Species of Greatest Conservation Need in Wyoming's State Wildlife Action Plan.
- *Legal status:* Predatory Animal.
- *Monitoring:* Aside from on-going research (see below), the Wyoming Game and Fish Department has solicited reports from the public to refine distribution.
- *Date of last sighting:* The range boundary between eastern and western spotted skunks in Wyoming is unknown, making positive identification of eastern spotted skunks difficult without genetic testing. Spotted skunks have been captured along this potential range boundary as recently as summer 2018; genetic analyses are pending.
- *Research:* Research is on-going through the University of Wyoming to 1) delineate the distribution and habitat associations of spotted skunks in Wyoming, 2) determine the genetic differentiation between eastern and western spotted skunks and the distinctness of the plains subspecies of eastern spotted skunks, and 3) determine the likelihood of hybridization of eastern and western spotted skunks and estimate range boundaries of both species in Wyoming.
- *Contact:* Nichole Bjornlie, nichole.bjornlie@wyo.gov

Appendix 2. Ecto- and endoparasites of the eastern spotted skunk (*Spilogale putorius*).

Ectoparasites		Citation	Endoparasites		Citation
	Species			Species	
Fleas	*Ctenocephalides felis*	1,2	Protozoans	*Eimeria mephitidis*	20
	Ctenophtalmus pseudagyrtes	3		*Isospora sengeri*	20, 21
	Echidnophaga gallinacea	1,4, 5		*Isospora spilogales*	20, 21
	Orchopeas howardi	1		*Sarcocystis* sp. indet.	20
	Orchopeas leucopus	3		*Trypanosoma cruzi*	29
	Polygenis gwyni	1, 2, 5	Helminths	*Acanthocephala* sp. indet.	22
	Pulex irritans	1		*Baylisascaris columnaris*	20
	Xenopsylla cheopis	1		*Capillaria aerophila*	20
	Neotrichodectes (*Trichodectes*) *osborni*	1, 6-10		*Capillaria putorii*	20
Lice	*Trichodectes mephitidis*	11		*Capillaria procyonis*	20
	Androlaelaps casalis	12		*Centrorhynchus conspectus*	23
Mites	*Androlaelaps fahrenholzi*	12, 13		*Crenosoma* sp. indet.	20
	Androlaelaps [*Haemolaelaps*] *geomys*	1, 12		*Mesocestoides* sp. indet.	22
	Androlaelaps [*Haemolaelaps*] *glasgowi*	1		*Molineus* sp. indet.	20, 22
	Androlaelaps [*Haemolaelaps*] *megaventralis*	1		*Physaloptera maxillaris*	22
	Echinonyssus staffordi	12, 13		*Physaloptera* sp. indet.	20
	Eucheyletia bishoppi	13		*Placoconus lotoris*	20
	Eulaelaps stabularis	1, 12, 13		*Skrjabingylus chitwoodorum*	22
	Haemogamasus reidi	13		*Skrjabingylus* sp. indet.	20, 24, 25

	Hirstionyssus staffordi	1		*Trichinella spiralis*	26, 27
	Ornithonyssus bacoti	1, 12		*Trichodectes osborni*	28
	Pygmephorus designatus	13			
	Xenoryctes latiporus	13			
	Amblyomma americanum	1			
Ticks	*Amblyomma auricularium*	14			
	Dermacentor variabilis	1, 15, 16			
	Ixodes bishoppi	1			
	Ixodes cookei	1, 15-17			
	Ixodes minor	18			
	Ixodes scapularis	19			

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