

Advancing Small Carnivore Research and Conservation: The Eastern Spotted Skunk Cooperative Study Group Model

David S. Jachowski^{1,*} and Andrew J. Edelman²

Abstract - Nearly half of all small carnivore species are declining globally, with many in danger of extinction and requiring urgent conservation attention. We herein describe the formation of a conservation group focused on the formerly poorly understood *Spilogale putorius* (Eastern Spotted Skunk). The Eastern Spotted Skunk Cooperative Study Group (CSG) was formed in 2015 by experts in the biology and management of the species and currently contains 143 members representing 29 state agencies, 24 universities, 6 federal agencies, 3 non-governmental organizations, and 2 tribal nations. The goals of the CSG are to (1) enhance communication about the species, (2) identify management and research priorities, and (3) facilitate collaborative planning, funding, outreach, monitoring, and research opportunities. This voluntary group has made progress on all 3 goals by facilitating collaborative research and outreach that have greatly advanced our understanding and awareness of the species, including the drafting of a species conservation plan that has been endorsed by every regional government committee that oversees management of Eastern Spotted Skunks across their range. We conclude by profiling the lessons learned and future directions for the CSG, with the hopes that the CSG could be a model for advancing conservation of small carnivores and other species in need of attention around the globe.

Introduction

Novel conservation models are needed for small carnivores given the increasing concern over their conservation globally (Belant et al. 2009, Schipper et al. 2008). Based on a recent review of the International Union for Conservation of Nature (IUCN) Red List of Threatened Species, globally there are more non-apex carnivores (53 species) threatened with extinction than large carnivores (15 species), and proportionally almost half of non-apex carnivore species have declining populations (Marneweck et al. 2021). Thus, small carnivore populations are not increasing at a global scale as hypothesized under the mesopredator release theory, and instead there is an urgent need to understand the factors limiting smaller, non-apex carnivores globally similar to the attention often placed on charismatic, large carnivores (Jachowski et al. 2020).

One small carnivore species that has recently been recognized as vulnerable to extinction is *Spilogale putorius* (L.) (Eastern Spotted Skunk [ESS]) (Gompper and Jachowski 2016). Three ESS subspecies are currently recognized, *S. p. interrupta* (Rafinesque) (Plains Spotted Skunk), *S. p. putorius* (L.) (Appalachian Spotted

¹Department of Forestry and Environmental Conservation, Clemson University, Clemson, SC 29630. ²Department of Biology, University of West Georgia, Carrollton, GA 30118. *Corresponding author - djachow@clemson.edu.

Skunk), and *S. p. ambarvalis* Bangs (Florida Spotted Skunk) (Shaffer et al. 2018). The omnivorous ESS occupies a wide range of habitats including forest, grasslands, shrublands, and agricultural landscapes, but is closely associated with ground-level cover that provides protection from avian and mammalian predators (Crabb 1948; Kinlaw et al. 1995a, b; Lesmeister et al. 2008; Sprayberry and Edelman 2018). The ESS was historically widespread throughout eastern and central North America but has experienced a dramatic decline in distribution and abundance over the last century (Gompper 2017, Gompper and Hackett 2005). Several contributing factors are implicated in the ESS decline including overharvest, loss of habitat, disease, pesticide use, and increased predation and competition (ESSCSG 2020).

Herein, we describe the formation of a small carnivore conservation organization focused on ESS known as the Eastern Spotted Skunk Cooperative Study Group (CSG). We then describe how the CSG has worked to address knowledge gaps and advance conservation decision-making through achieving 3 priority goals: (1) enhancing communication about the species, (2) identifying management and research priorities, and (3) facilitating collaboration. We conclude by profiling the lessons learned and future directions for the CSG, with the hopes that the CSG could be a model for conservation of small carnivores and other species in need of conservation attention around the globe.

Motivation for Formation of the Eastern Spotted Skunk Cooperative Study Group

Historically, the ESS was a relatively commonly reported furbearer (Gompper and Hackett 2005). The plight of the species was brought into the national and international spotlight in an analysis of historical harvest records, which showed evidence of a >90% range-wide decline in the species since the 1930s (Gompper and Hackett 2005). By 2015, monitoring efforts for the ESS were initiated in at least 11 states, including Alabama, Florida, Georgia, Maryland, Missouri, North Carolina, South Carolina, Tennessee, Texas, Virginia and West Virginia (Fig. 1). By 2020, dedicated monitoring efforts had expanded to 8 more states: Arkansas, Kentucky, Louisiana, Mississippi, Ohio, Oklahoma, South Dakota and Wyoming (ESSCSG 2020). This dramatic growth in monitoring effort was likely due to 2 primary factors. First, the Plains Spotted Skunk was petitioned for listing under the Endangered Species Act in 2012 (US Fish and Wildlife Service 2012). While the species status assessment is not expected until 2022, this petition in combination with the higher profile of the species created by the Gompper and Hackett (2005) paper, likely led several states to prioritize research and monitoring in the years that followed. Second, the rise of camera-trap technology has provided an effective and low-cost method for surveying traditionally cryptic carnivores such as the ESS (Eng and Jachowski 2019).

Similar to monitoring efforts, there were relatively few dedicated field studies of the ESS during the 1900s (Fig. 1). One notable exception is a multi-year study by Crabb (1941, 1944, 1948) conducted in Iowa in the 1940s. Contemporary attempts to study the ESS began with Lesmeister et al. (2008, 2009, 2010, 2013)

capturing and radio-tracking the ESS in Arkansas, providing the first estimates of survival and revealing potential negative effects of forest understory thinning on ESS populations. Since then, similar research projects led by graduate students have been completed in 8 other states, with 7 additional projects that are ongoing (Fig. 2). Given this large increase in the number of field studies being conducted over the past decade, and relatively low rate of detection or capture of study animals across most of their range (Eng and Jachowski 2019, Hackett et al. 2007, Thorne et al. 2017), the need for coordination arose to share ideas on ways to enhance survey methods—particularly related to camera technology, bait and lure type, and camera setup. Following an initial conference call of 21 interested parties on 4 August 2015 when the study group was established, a first in-person meeting of the CSG was held at Lake Guntersville, AL, on 18 February 2016 as part of the 26th Annual Colloquium on the Conservation of Mammals in Southeastern US (ACCMS). During this first meeting, attendees supported formation of the group to move beyond just discussing monitoring and research methods. It was agreed that the CSG would focus on 3 primary goals: (1) enhance communication about the species, (2) identify management and research priorities, and (3) facilitate collaborative planning, funding, outreach, monitoring, and research opportunities.

As of July 2020, CSG membership has grown to include 143 members representing 29 state agencies, 24 universities, 6 federal agencies, 3 non-governmental organizations, and 2 tribal nations. As reviewed below, since formation of the study group, the CSG has made great progress toward achieving the 3 primary goals that collectively have produced a better understanding of ESS distribution, ecology, and

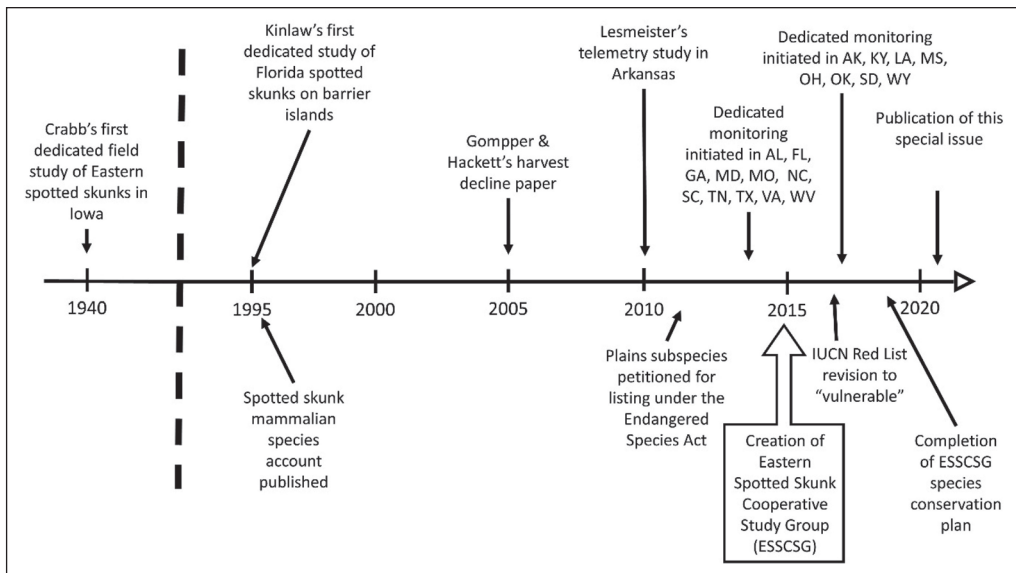


Figure 1. Timeline of major studies (above line) and conservation steps (below line) over the past 95 years for the Eastern Spotted Skunk. Specific studies referenced include Crabb (1941, 1944, 1948), Kinlaw (1995), Kinlaw et al. (1995a, b), Gompper and Hackett (2005), and Lesmeister et al. (2008, 2009, 2010, 2013).

status through expert and citizen science, a widely endorsed conservation plan for the species, and research outputs that have significantly advanced our understanding of the ESS and how to monitor it.

Goal 1: Enhancing Communication

The CSG decided collectively that effective communication to advance conservation of the ESS needed to take several forms, from enhancing the sharing of data and survey methodologies among experts to disseminating information to the public, management agencies, and policy makers. Following an initial conference call, an email listserv was established and opened to anyone interested in the work of the group to enhance communication among experts and policy makers. The group also set annual meetings that coincided with the ACCMS. The listserv is open to the public and allows for more informal and inclusive communications because it reaches all members and is frequently the first step toward sharing ideas

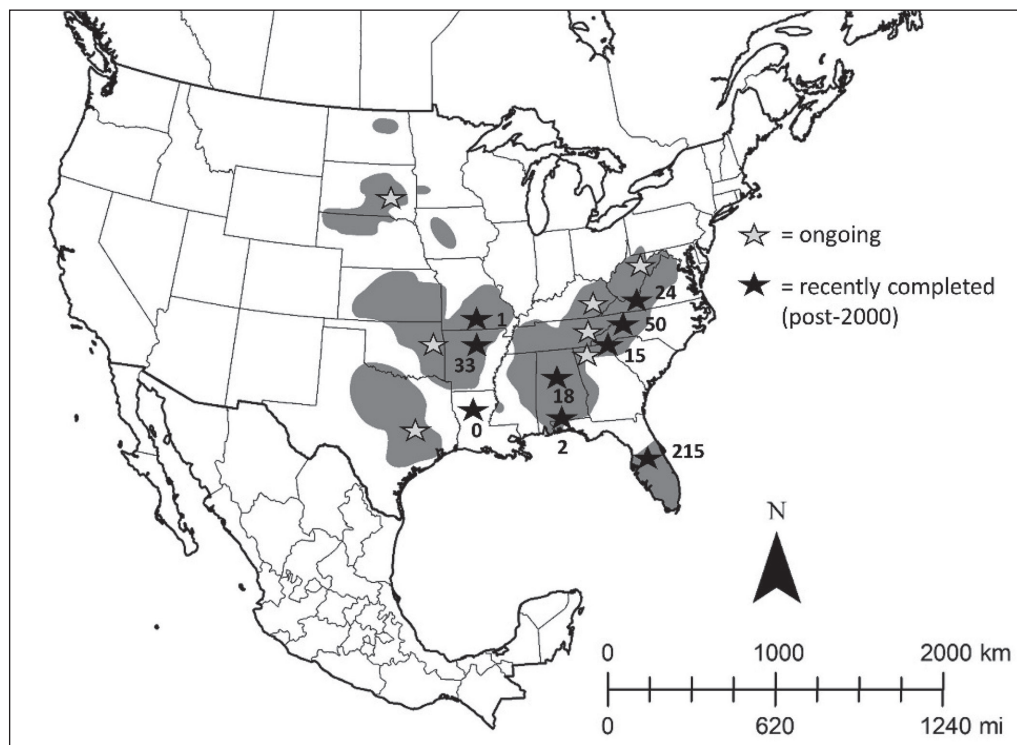


Figure 2. Range map of *Spilogale putorius* (Eastern Spotted Skunk) with stars indicating dedicated, university- or state-agency-led research on the Eastern Spotted Skunk since 2000. Numbers by black stars represent the total number of unique Eastern Spotted Skunks captured over the course of the now-completed studies in Alabama (Arts 2020, Cornelison 2018, Sprayberry and Edelman 2018), Arkansas (Lesmeister et al. 2010), Florida (Harris et al., in press), Louisiana (Leberg and Davis 2014), Missouri (Higdon 2019), North Carolina (Butler et al. this issue), South Carolina (Eng and Jachowski 2019), and Virginia (Thorne 2020). Range map adapted from Jachowski et al. (in press).

and coordinating meetings. The CSG annual meeting allows for face-to-face communication, usually among a more involved segment of the membership (30–50 people), that contributes greatly to the progress of the group's initiatives.

To help disseminate research findings in a broader scientific audience, 2 dedicated research symposia were organized. The first took place in 2017 during the 27th ACCMS at Asheville, NC. The second symposium took place in 2018 at the 25th Annual Meeting of The Wildlife Society in Cleveland, OH.

In an effort to provide a centralized, publicly available source for information, a dedicated CSG website (<https://easternspottedskunk.weebly.com/>) was created that includes content about the study group, the ESS and its status within each range state, and contact information for a representative in each state for more information or to report a sighting. This website is updated at least annually, simultaneously with the conservation plan (see below), to reflect the most current information from each state. The CSG also developed an online blog (<http://easternspottedskunk.blogspot.com/>) on the species to enhance rapid communication of field observations not only among experts, but any interested members of the public. The blog eventually became a source for public sightings of the ESS, including some that informed our knowledge of its geographic range and a number of unique natural history observations.

Finally, in an attempt to reach policy makers, the CSG and its members have created or revised conservation status assessments for this species at the national and international level. First, to reach federal and state policy makers directly, we developed a conservation plan for the ESS that has subsequently been endorsed by multiple organizations (see below). At the same time, to raise awareness of the ESS at a global scale, CSG members worked with the IUCN to revise the ESS status assessment from “least concern” to “vulnerable” under the IUCN Red List (Gompper and Jachowski 2016).

Goal 2: Identifying Management and Research Priorities

Initial meetings of the CSG focused on discussions surrounding management and research priorities, which were formalized in the group's 43-page ESS conservation plan (ESSCSG 2020). First published in 2018, the plan is a collaborative manuscript drafted by 12 members with direct experience as researchers and managers of the ESS, is annually reviewed and revised based on feedback from the entire CSG, and was externally reviewed by multiple regional agency groups prior to endorsement (see below). The goal of the plan is to provide agencies and researchers with a comprehensive guide to current knowledge, gaps in research, potential threats, and recommended conservation actions. In addition, the conservation plan identifies priority research areas, knowledge gaps, and recommended actions for 6 key conservation topics that were identified collectively by CSG members: ESS status/distribution, monitoring methods, habitat, population dynamics, genetics, and diseases. Finally, the plan contains an appendix with information for each state within the ESS range, addressing population status, classification, legal status, monitoring, date of last sighting, current research, and point of contact. The state information

was originally compiled by summarizing publicly available information but is now updated yearly by public agency representatives of each state.

The conceptual basis of the ESS conservation plan was loosely based on those drafted by other working groups (e.g., those focused on *Urus americanus* Pallas [American Black Bear] in the Southeast, *Vulpes velox* [Swift Fox], and *Mustela nigripes* (Audubon and Backman) [Black-footed Ferret]), but with several important differences from many other species conservation plans. First, the plan was drafted by working group members in CSG with diverse affiliations (university, state, and federal). Second, while participation in drafting the plan was voluntary, each section was led by a topic area expert (regardless of job title or affiliation) identified early in the process by CSG members. Third, initial meetings regarding the drafting of the plan were open to the public and linked with a scientific meeting (ACCMS) rather than being hosted by state or federal agencies and restricted to agency biologists within specific duty areas. Thus, the plan was drafted by topic-area experts, with agency decision- and policy-makers typically only informally advising—a reversal of the typical conservation planning process. As a result, the CSG was able to draft a document quickly (~1 year) and update the document annually rather than going through a multi-year process typical of conservation plans drafted for listed species by state and federal governments (Boersma et al. 2001).

To familiarize agency decision- and policy-makers with this conservation plan and associated recommendations, the CSG sought endorsements from regional fish and wildlife agency associations (i.e., northeast, southeast, and midwest) that represented biologists who have traditionally managed furbearers including the ESS. All the committees and working groups in these regional associations that oversee the ESS have endorsed the original ESS conservation plan including the Southeastern Association of Fish and Wildlife Agencies Furbearer Working Group (July 2018) and Wildlife Resources Committee (October 2018), the Northeast Association of Fish and Wildlife Agencies Furbearer Resources Technical Committee (September 2018), and the Midwest Association of Fish and Wildlife Agencies Furbearer Group (April 2019).

Despite the CSG being in existence for only 4 years, and the conservation plan being in existence for 2 years, there is evidence to suggest both have been instrumental in advancing research and management action across the species' range. As noted above, the number of states actively researching and/or monitoring the ESS has rapidly expanded since 2015, and as a result, scientific publications on the ESS have increased dramatically since the CSG was founded. We searched for scientific publications (journal articles, book chapters, proceedings, and theses/dissertations) via Google Scholar using the keywords “Eastern Spotted Skunk” and “*Spilogale putorius*.” During 2000–2015, 15 research papers (11 journal articles or book chapters and 4 theses) focused on the ESS were published (mean = 0.94 publications/yr). During 2016–2020, 29 research papers (20 journal articles or book chapters and 9 theses) focused on the ESS were published (mean = 5.8 publications/yr), representing a >600% increase in the yearly rate of peer-reviewed scholarly output on the ESS. This activity indicates that beyond monitoring, agencies and

universities are investing funds, equipment, and personnel in rigorous and often labor-intensive studies that are rapidly filling key knowledge gaps to inform conservation of the ESS.

Goal 3: Facilitating Collaboration

As addressed in the sections above, collaboration has been a recurring theme throughout the formation of the CSG, from drafting of the species conservation plan to research intensification to acquire knowledge about the species. In addition to these broader collaborative efforts, dedicated multi-year and multi-state CSG-wide collaborations have formed around 3 main issues: (1) encouraging range-wide collection of tissue specimens for genetic and disease research, (2) providing promotional materials and a centralized online platform for crowdsourcing ESS sightings, and (3) combining knowledge from multiple studies to provide standardized methodology and examine broader biological patterns.

Two leading questions that need to be addressed to advance conservation of the ESS are a better understanding of genetic differentiation across its range, and the extent to which disease is impacting its populations. To collect biological samples from throughout the range of the ESS to address these questions, CSG members have developed a standardized protocol that identifies how specimens should be stored and recorded, as well as a central storage location of all samples collected by CSG members. To date, CSG members have contributed tissue samples to 2 important ESS research projects that have helped revise and refine our understanding of subspecies designations and differentiation across the species' range: (1) genetic variability based on microsatellite markers and cytochrome b (*Cytb*) gene sequences of 118 ESS specimens from 13 states (Shaffer et al. 2018), and (2) genetic differentiation across the range using single nucleotide polymorphisms of 153 *Spilogale* spp. specimens from 14 states (Bell 2020).

Given our limited knowledge of the current distribution of the species and the low number of reported sightings, the CSG has strived to engage state agencies, scientists, and the public in reporting sightings. States such as Alabama and Texas have successfully improved their knowledge of current ESS distribution through crowdsourcing of photographs (e.g., roadkill, game cameras, live traps). Members from these states created freely available promotional materials (species drawings and text) and maintained a centralized platform for reporting and verifying ESS sightings on iNaturalist.org (<https://www.inaturalist.org/projects/eastern-spotted-skunk>). Other state agencies (including Florida, Georgia, and Louisiana) are now following their example by conducting their own community science efforts (ESSCSG 2020). The ESS iNaturalist.org project allows photographs of suspected ESS to be uploaded by anyone and then verified by knowledgeable experts from CSG. Sightings must contain an identifiable photograph, location, time, and date to be usable for distributional knowledge. To date, 121 ESS observations from 12 states have been reported by 42 persons on iNaturalist.org (iNaturalist.org 2020).

Most ESS research to date has been conducted by investigators operating in a specific localized study area or state. As a result, the sample size (Fig. 2), time span,

and geographic scale of most studies do not allow us to address data-intensive questions such as population demography and broad, landscape-level patterns across multiple habitat types. Members of the CSG are overcoming these limitations by pooling datasets at the regional and range scales. In this special issue, there are collaborative reports incorporating results from multiple study areas, including (1) across-study survival estimation (Butler et al. 2021 [this issue]) and (2) range-wide distribution (Perry et al. 2021 [this issue]). These collaborative efforts assist in identifying similarities and differences in biology and management across the range and facilitate more rigorous research in the future.

Lessons Learned

Through the process of developing the CSG, we have learned several lessons that could be used to help other groups interested in adopting this species conservation model. First, the productivity of the group illustrates that with proper direction and engaged members, expert-led, voluntary conservation groups of this type can make significant progress in advancing both research and conservation planning. Notably, the CSG has no budget, but has delivered impressive products through voluntary collaborative buy-in, illustrating that progress can be achieved with no direct monetary input. An important factor in our success was initially identifying 1–2 persons to lead this effort in coordinating meetings, keeping action items alive, and working with the group to set clear goals for the future that are aspirational and relevant. David Jachowski served as first chair of the CSG during 2015–2018, overseeing the founding of the group, editing the original ESS conservation plan, organizing the research symposia, and establishing the listserv and website/blog. Andrew Edelman replaced David as chair in 2018 and has continued the primary chair functions while working to expand CSG membership to include all states within the species range, revise the conservation plan annually, and organize special publications. To assist with managing the organization and its initiatives as the group gained momentum, a 3-person advisory committee (composed of the past chair and 2 other volunteers) recently has been formed. Thus, a key lesson learned has been the importance of having at least 1 dedicated point person, and preferably 2 or more, to sustain the group over time by regularly engaging group members through action items and annual CSG meetings.

One of the most striking benefits to establishing the CSG was the speed at which our group was able to make decisions and progress on each of our 3 goals. Most state and federal agencies only start to develop conservation teams and plans surrounding a species once that species receives state or federal legal protection. Then, once set in motion, federal or state species conservation or recovery plans are typically drafted by agency personnel, followed by public review and comment prior to publication—often leading to a long (>5-year) delay between a listing decision and release of a recovery plan. We flipped this process by directly including experts in identifying needs and working collaboratively to draft sections of the plan that were edited into a single final document for review and comment by the CSG, then shared with regional associations of fish and wildlife agencies for endorsement. Thus, the

CSG filled a key gap in species conservation planning for an as yet unlisted species, and it provides a potentially important model for more rapid advancement of conservation planning for other species of concern outside of an agency-led approach.

We realized that by not following a more traditional government-led conservation planning approach, our bottom-up approach would lack a built-in conduit for relating research findings and conservation recommendations to policy makers. Therefore, we made concerted efforts to build acceptance of the conservation plan we drafted in 2 ways. First, we reached out to state and federal agency representatives early on when first considering forming a group, and then again when considering drafting a conservation plan, to have them join the group and provide feedback on priorities for their current and potential future listing decisions. Second, as discussed above, we sought and acquired regional endorsements of our plan. We realize these endorsements do not ensure that the US Fish and Wildlife Service or other state and federal agencies will utilize our plan in making management or policy decisions. However, given that this plan represents the best available science and perspectives from state representatives across the known range of the ESS, we hope that the plan developed by our group of experts provides a mechanism for rapidly advancing conservation action items to meet future state and federal conservation and listing-decision needs.

Future Direction

Given that the CSG was created during a period when members were just beginning to document the distribution and ecology of the ESS, there are a number of important next steps the study group can take to help advance our understanding of its status and trends. First, there is a need to develop and implement range-wide monitoring guidelines so that states can produce comparable data for long-term trend monitoring across the species' range. We believe the CSG can serve as conduit for establishing consensus on a monitoring approach for the ESS that could likely also enhance monitoring for other furbearers across North America. Second, as evidenced from community science efforts, it is apparent that isolated survey efforts by researchers and state biologists are not enough to track the extent of the species across its range. Therefore, we view the CSG as providing a critical venue for advancing citizen involvement through outreach and guidance on a centralized reporting structure (currently iNaturalist.org). Third, we view the CSG as being a central source for educational information on the species for the public and providing guidance documents for researchers on standardized sampling protocols. These include providing data on historical distribution, guidelines for specimen collection, and guidelines for where to submit samples for archiving or for analysis. Fourth, we have now likely reached a point where enough information exists on the species to begin considering implementation of conservation actions to improve the status of the ESS and potentially limit the need for listing actions. To that end, we recommend that the CSG compile a list of priority conservation actions to inform the activities of state and federal agencies, particularly for the Plains and Appalachian subspecies that are of greatest conservation concern.

One of the most exciting future opportunities is the application of the CSG model to other species. In January 2020, the Island Spotted Skunk Cooperative Study Group was formed during a meeting in Ventura, CA. Their first task was to develop a conservation plan that was explicitly based on the ESS conservation plan to help advance the conservation of declining *Spilogale gracilis amphialus* Dickey (Island Spotted Skunk). Beyond spotted skunks, we foresee wide applicability of this model to address the growing list of declining small carnivores globally. In particular, given that no dedicated funding was required to start or implement products of the CSG we have outlined in this review, with enough collaborative buy-in, we view the CSG model as something that could particularly be useful in developing countries where funds for conservation are limited. Collectively, in the face of increasing uncertainty of how to address conservation challenges presented during the current sixth mass extinction event (Ceballos et al. 2017), the CSG model illustrates how conservation progress can be made, provided an engaged group of experts are willing to invest in the future of a species about which they are concerned.

Acknowledgments

We thank the members of the Eastern Spotted Skunk Cooperative Study Group for their generous involvement in this volunteer organization. We particularly thank L. Ammerman, N. Castleberry, R. Dowler, R. Eng, B. Gulas-Wroblewski, S. Harris, D. Lesmeister, B. Sasse, A. Shaffer, and S. Higdon for their assistance in drafting the Conservation Plan.

Literature Cited

- Arts, K.J. 2020. Environmentally driven activity and movement patterns of Eastern Spotted Skunks based on accelerometer-informed GPS telemetry. M.Sc. Thesis. University of West Georgia, Carrollton, GA. 40 pp.
- Belant, J.L., J. Schipper, and J. Conroy. 2009. The conservation status of small carnivores in the Americas. *Small Carnivore Conservation* 41:3–8.
- Bell, Z.H. 2020. Genomic markers recognition of at least four forms of spotted skunks in the United States. M.Sc. Thesis. University of Wyoming, Laramie, Wyoming. 41 pp.
- Boersma, P.D., P. Kareiva, W.F. Fagan, A.J. Clark, and J.M. Hoekstra. 2001. How good are endangered species recovery plans? The effectiveness of recovery plans for endangered species can be improved through incorporation of dynamic, explicit science in the recovery process, such as strongly linking species' biology to recovery criteria. *BioScience* 51:643–649.
- Butler, A.R., A.J. Edelman, R.Y.Y. Eng, S.N. Harris, E. Thorne, W.M. Ford, and D.S. Jachowski. 2021. Demography of the Appalachian Spotted Skunk (*Spilogale putorius putorius*). *Southeastern Naturalist* 20(Special Issue 11):95–109.
- Ceballos, G., P.R. Ehrlich, and R. Dirzo. 2017. Biological annihilation via the ongoing sixth mass extinction signaled by vertebrate population losses and declines. *Proceedings of the National Academy of Sciences* 114:E6089–E6096.
- Cornelison, W.C. 2018. LiDAR-based assessment of habitat selection by Eastern Spotted Skunks in Alabama. M.Sc. Thesis. University of West Georgia, Carrollton, GA. 39 pp.
- Crabb, W.D. 1941. Food habits of the Prairie Spotted Skunk in southeastern Iowa. *Journal of Mammalogy* 22:349–364.

- Crabb, W.D. 1944. Growth, development, and seasonal weights of spotted skunks. *Journal of Mammalogy* 25:213–221.
- Crabb, W.D. 1948. The ecology and management of the Prairie Spotted Skunk in Iowa. *Ecological Monographs* 18:201–232.
- Eastern Spotted Skunk Cooperative Study Group (ESSCSG). 2020. Eastern Spotted Skunk conservation plan. 43 pp. Available online at https://easternspottedskunk.weebly.com/uploads/3/9/7/0/39709790/ess_conservation_plan_dec92020.pdf. Accessed 20 February 2021.
- Eng, R.Y., and D.S. Jachowski. 2019. Evaluating detection and occupancy probabilities of Eastern Spotted Skunks. *Journal of Wildlife Management* 83:1244–1253.
- Gompper, M.E. 2017. Range decline and landscape ecology of the Eastern Spotted Skunk. Pp. 478–492, *In* D.W. Macdonald, C. Newman, and L.A. Harrington (Eds.). *Biology and Conservation of Musteloids*. Oxford University Press, Oxford, UK. 672 pp.
- 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*). *Animal Conservation* 8:195–201.
- Gompper, M., and D. Jachowski. 2016. The IUCN Red List of Threatened Species: *Spilogale putorius*. Available online at <https://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T41636A45211474.en>. Accessed 18 September 2020.
- Hackett, H.M., D.B. Lesmeister, J. Desanty-Combes, W.G. Montague, J.J. Millspaugh, and M.E. Gompper. 2007. Detection rates of Eastern Spotted Skunks (*Spilogale putorius*) in Missouri and Arkansas using live-capture and non-invasive techniques. *American Midland Naturalist* 158:123–131.
- Harris, S.N., T.J. Doonan, E.L. Hewett Ragheb, and D.S. Jachowski. In press. High density and survival of a native small carnivore, the Florida Spotted Skunk (*Spilogale putorius ambarvalis*) in south-central Florida. *Journal of Mammalogy*.
- Higdon, S. 2019. Spatial and disease ecology of the Plains Spotted Skunk. M.Sc. Thesis. University of Missouri, Columbia, MO. 115 pp.
- iNaturalist.org. 2020. Eastern Spotted Skunk. Available online <https://www.inaturalist.org/projects/eastern-spotted-skunk>. Accessed 4 August 2020.
- Jachowski, D.S., A. Butler, R.Y.Y. Eng, L. Gigliotti, S. Harris and A. Williams. 2020. Identifying mesopredator release in multi-predator systems: A review of evidence from North America. *Mammal Review* 50:367–381.
- Jachowski, D.S., A. Edelman, and D.B. Sasse. In press. Eastern Spotted Skunk. *In* T.L. Hiller (Ed.). *Wild Furbearer Management and Conservation in North America*. Wildlife Ecology Institute, Helena, MT.
- Kinlaw, A.E., L.M. Ehrhart, and P.D. Doerr. 1995a. Spotted Skunks (*Spilogale putorius ambarvalis*) trapped at Canaveral National Seashore and Merritt Island, Florida. *Florida Field Naturalist* 23:57–86.
- Kinlaw, A.E., L.M. Ehrhart, P.D. Doerr, K.P. Pollock, and J.E. Hines. 1995b. Population estimate of Spotted Skunks (*Spilogale putorius*) on a Florida barrier island. *Florida Scientist* 58:47–54.
- Lesmeister, D.B., M.E. Gompper, and J.J. Millspaugh, 2008. Summer-resting and den site selection by Eastern Spotted Skunks (*Spilogale putorius*) in Arkansas. *Journal of Mammalogy* 89:1512–1520.
- Lesmeister, D.B., M.E. Gompper, and J.J. Millspaugh. 2009. Habitat selection and home-range dynamics of Eastern Spotted Skunks in the Ouachita Mountains, Arkansas, USA. *Journal of Wildlife Management* 73:18–25.

- Lesmeister, D.B., J.J. Millspaugh, M.E. Gompper, and T.W. Mong. 2010. Eastern Spotted Skunk (*Spilogale putorius*) survival and cause-specific mortality in the Ouachita Mountains, Arkansas. *American Midland Naturalist* 164:52–60.
- Lesmeister, D.B., R.S. Crowhurst, J.J. Millspaugh, and M.E. Gompper. 2013. Landscape ecology of Eastern Spotted Skunks in habitats restored for Red-cockaded Woodpeckers. *Restoration Ecology* 21:267–275.
- Marneweck, C., A.R. Butler, L. Gigliotti, S. Harris, A. Jensen, M. Muthersbaugh, B. Newman, E. Saldo, K. Titus, S.W. Yu, and D.S. Jachowski. 2021. Shining the spotlight on small mammalian carnivores: Global status and threats. *Biological Conservation* 255:109005.
- Perry, R.W., D.B. Sasse, J.C. Perkins, and N.W. Sharp. 2021. Distribution and relative abundance of Eastern Spotted Skunk records across their range. *Southeastern Naturalist* 20(Special Issue 11):13–23.
- Schipper, J., M. Hoffmann, J.W. Duckworth, and J. Conroy. 2008. The 2008 IUCN red listings of the world's small carnivores. *Small Carnivore Conservation* 39:29–34.
- Shaffer, A.A., R.C. Dowler, J.C. Perkins, A.W. Ferguson, M.M. McDonough, and L.K. Ammerman. 2018. Genetic variation in the Eastern Spotted Skunk (*Spilogale putorius*) with emphasis on the Plains Spotted Skunk (*S. p. interrupta*). *Journal of Mammalogy* 99:1237–1248.
- Sprayberry, T.R., and A.J. Edelman. 2018. Den-site selection of Eastern Spotted Skunks in the southern Appalachian Mountains. *Journal of Mammalogy* 99:242–251.
- Thorne, E.D. 2020. Spatial ecology of a vulnerable species: Home-range dynamics, resource use, and genetic differentiation of Eastern Spotted Skunks in central Appalachia. Ph.D. Dissertation. Virginia Tech, Blacksburg, VA. 230 pp.
- Thorne, E.D., C. Waggy, D.S. Jachowski, M.J. Kelly, and W.M. Ford. 2017. Winter habitat associations of Eastern Spotted Skunks in Virginia. *Journal of Wildlife Management* 81:1042–1050.
- US Fish and Wildlife Service. 2012. Endangered and threatened wildlife and plants; 90-day finding on a petition to list the Prairie Gray Fox, the Plains Spotted Skunk, and a distinct population segment of the Mearns's Eastern Cottontail in east-central Illinois and western Indiana as endangered or threatened species. *Federal Register* 77:71159–71771.