

# Faculty Scholarship Collection

The faculty at Allegheny College has made this scholarly article openly available through the Faculty Scholarship Collection (FSC).

**HOW TO GET A COPY OF THIS ARTICLE:**
Students, faculty, and staff at Allegheny College may obtain a copy of this article at: https://www.eaglehill.us/SENAonline/articles/SENA-sp-11/25-Serfass.shtml.

| | |
|---|---|
| Article Title | River Crossings by Two Male Eastern Spotted Skunks in West Virginia |
| Author(s) | Hassler, Kendyl N., Waggy, Charles D., Oxenrider, Kevin J., Rogers, Rich E., Pearce, Kelly J., Serfass, Thomas L. |
| Journal Title | *Southeastern Naturalist* |
| Citation | Kendyl N. Hassler, Charles D. Waggy, Kevin J. Oxenrider, Rich E. Rogers, Kelly J. Pearce, Thomas L. Serfass "River Crossings by Two Male Eastern Spotted Skunks in West Virginia," Southeastern Naturalist, 20(sp11), 199-208, (13 August 2021) |
| Link to article on publisher's website | https://www.eaglehill.us/SENAonline/articles/SENA-sp-11/25-Serfass.shtml |
| Version of article in FSC | Published Article |
| Link to this article through FSC | https://dspace.allegheny.edu/handle/10456/52769 |
| Date article added to FSC | August 27, 2021 |
| Terms of Use | The publisher, Eagle Hill Institute reserves the copyright to all its publications. Any reproduction, other than for an individual's own personal and private use, or distribution of journal content is prohibited without written permission from Eagle Hill Institute. |

Information about Allegheny's Open Access Policy is available at http://sites.allegheny.edu/scholarlycommunication/
For additional articles from this collection, visit https://dspace.allegheny.edu/handle/10456/34250

# River Crossings by Two Male Eastern Spotted Skunks in West Virginia

Kendyl N. Hassler[1,2], Charles D. Waggy[2], Kevin J. Oxenrider[2], Rich E. Rogers[2], Kelly J. Pearce[3], and Thomas L. Serfass[1,*]

**Abstract -** *Spilogale putorius* (Eastern Spotted Skunk) populations have declined throughout their range and may now be extirpated from the northeast in Pennsylvania and Maryland. Populations have persisted south of the Potomac River along shared mountain ranges in Virginia and West Virginia. Little is known about the dispersal capabilities of the species, including if large riverine systems inhibit their dispersal. During a radio-telemetry study of 8 Eastern Spotted Skunks in West Virginia, 2 males crossed the South Branch of the Potomac River (SBPR) on 9 occasions. Crossings may have been motivated by breeding movements, as 7 occurred during the breeding season. Stretches of the Potomac River similar in size to the SBPR might not inhibit the natural recolonization of the northeastern range.

## Introduction

*Spilogale putorius* (L.) (Eastern Spotted Skunk) populations have been declining since the early 1940s, resulting in extirpations in many areas of their historical range (Gompper and Hackett 2005, Gompper and Jachowski 2016). The range of the Eastern Spotted Skunk once included much of the midwestern and southeastern United States, with populations in the east extending northward along the Appalachian Mountains into southwestern Pennsylvania (PA; Kinlaw 1995). Although historical records indicate Eastern Spotted Skunks were always relatively uncommon in the central Appalachian Mountains (Gifford and Whitebread 1951, Paradiso 1969), populations in PA and Maryland (MD) may now be extirpated. Despite camera-trapping efforts in both PA and MD to detect Eastern Spotted Skunks, there has only been 1 detection of an Eastern Spotted Skunk in either state since the 1960s (Gifford and Whitebread 1951, Larson 1968, Pearce et al. 2021 [this issue], PGC 2012). In 2012, an Eastern Spotted Skunk was live-trapped during a survey for *Neotoma magister* Baird (Allegheny Woodrat) in southwestern PA, and an individual was documented by camera-trap shortly after (PGC 2012). This detection is thought to be an isolated event, as the 2012 detection remains the only recent evidence of the species' occurrence in PA. The most northern populations known to have persisted in this region are located in portions of West Virginia (WV) and Virginia (VA) along the Appalachian Mountains, which extend through MD and PA (Hassler 2020, Thorne et al. 2017). The accrual of information regarding landscape conditions as impediments to expansion of Eastern Spotted Skunk populations is

[1]Department of Biology, Frostburg State University, 101 Braddock Road, Frostburg, MD 21532. [2]West Virginia Division of Natural Resources, 1 Depot Street, Romney, WV 26757. [3]Department of Environmental Science and Sustainability, Allegheny College, 520 N. Main Street, Meadville, PA 16335. *Corresponding author - Tserfass@Frostburg.edu.

Manuscript Editor: David Jachowski

vital in assessing the potential for extant populations to recolonize areas where extirpations have occurred—e.g., expansion of populations from WV and VA into PA and MD.

Eastern Spotted Skunks in PA and MD were associated with dry, rocky forests at higher elevations of the Ridge and Valley physiographic province and the Allegheny Front (Gifford and Whitebread 1951, Larson 1968). Similar associations have been observed in extant populations in eastern WV and western VA (Hassler 2020, Hassler et al. 2021 [this issue], Thorne et al. 2017). Forested ridges possessing habitat conditions apparently suitable for Eastern Spotted Skunks are relatively continuous from WV and VA to the MD/WV border and likely represent a potential corridor for northward expansion (Larson 1968). However, the Potomac River flows along the MD/WV border (Strahler stream order: ≥6 [USGS 2018]; 10.4–278.5 m wide), bisecting the mountain corridor and potentially serving as a barrier to northward expansion. Although *Mephitis mephitis* (Schreber) (Striped Skunk) (Barton et al. 2010) has been reported to cross large riverine systems (Strahler order 7–9; Barton et al. 2010, USGS 2018), the lack of detections of Eastern Spotted Skunks north of the Potomac River led us to question the likelihood of Eastern Spotted Skunks crossing large riverine systems. We are unaware of any information pertaining to dispersal limitations imposed on Eastern Spotted Skunks by riverine systems of various stream orders and flow conditions.

Over a 5-year period, we used radio-telemetry to monitor 8 Eastern Spotted Skunks in the North Fork Mountain (NFM) region of eastern WV. Herein, we report the home ranges of monitored Eastern Spotted Skunks, the proximity (i.e., distance and elevation) of each home range to the South Branch of the Potomac River (SBPR; the largest riverine system [4$^{th}$ order; USGS 2018] in proximity to the overall study area), and evidence of 2 male individuals crossing the river.

## Field-Site Description

Our study took place between February 2015 and March 2020 and covered ~5316 ha on the Monongahela National Forest (MNF; 59%) and private land (41%) in the NFM region of Pendleton County, WV (38°49'13.80"N, 79°16'36.48"W). The study area was defined by the composite 100% minimum convex polygon based on telemetry locations of the 8 Eastern Spotted Skunks monitored (Fig. 1). Mountain ridges were northeast–southwest ranging and dominated by deciduous forest stands (primarily mixed *Quercus* spp. [oak] and mixed oak–*Carya* spp. [hickory]), with coniferous (primarily *Pinus* spp. [pine]) and mixed forest stands on ridge tops and dry slopes (Stihler 2011). Elevations in the study area varied from 358 m in valleys to 860 m on ridge tops. There were 54.6 km of 1$^{st}$–3$^{rd}$ order intermittent streams in the study area, most of which were associated with ridges and narrow valleys and drained into the 4$^{th}$-order SBPR (USGS 2018). The lowest elevations occurred along the 15.2 km of the SBPR flowing through the study area (elevation average = 420 m ± 34 SD, min–max = 358–500 m). The SBPR joins with the North Branch of the Potomac River ~137 km to the northeast at the MD/WV border, forming the Potomac River.

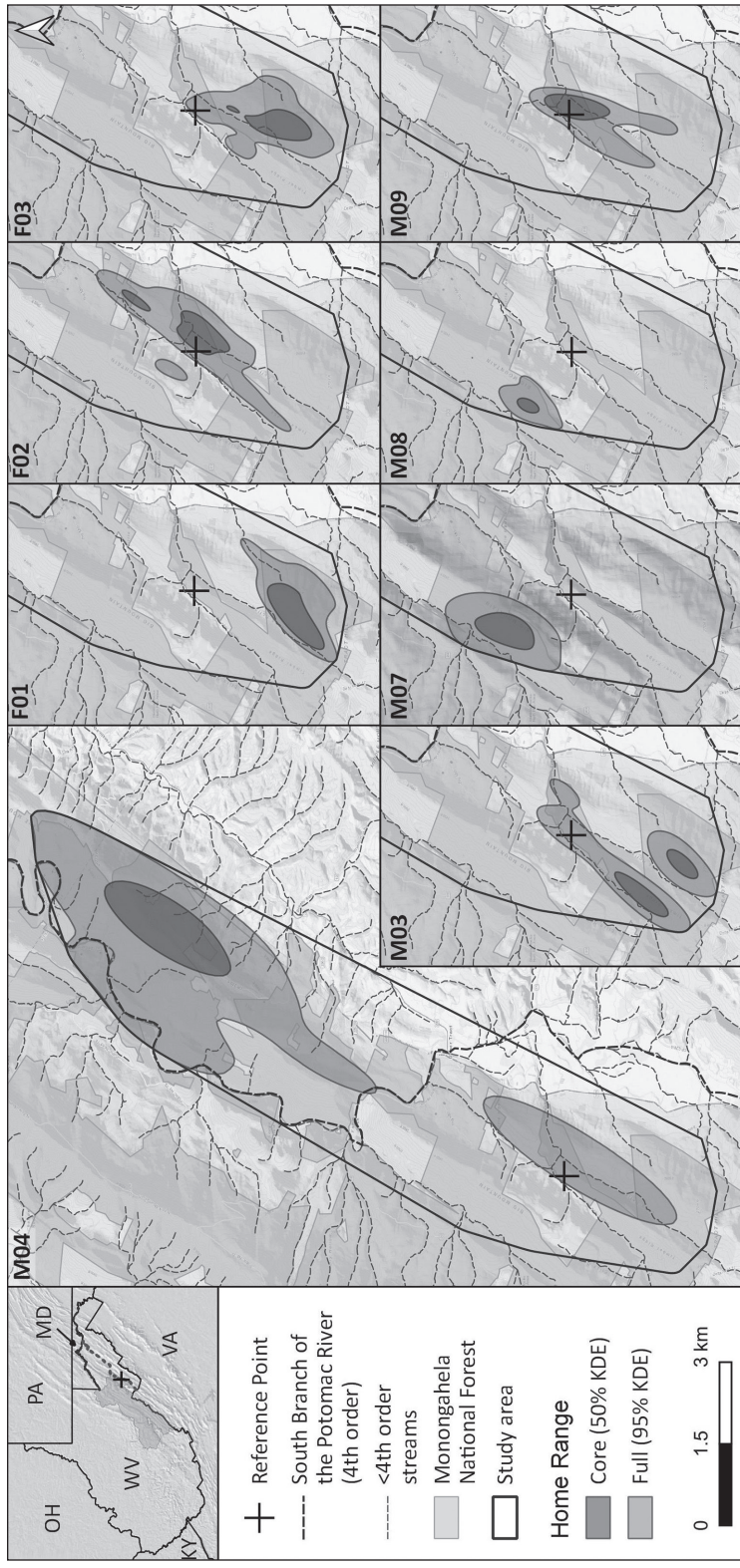



Figure 1. Home ranges of 8 Eastern Spotted Skunks (5M:3F) monitored on the Monongahela National Forest and private land in Pendleton County, WV, between March 2015 and March 2020. The 5316-ha study area was defined as the composite 100% minimum convex polygon of telemetry locations and is bisected by the South Branch of the Potomac River.

During the study period, the height and discharge (i.e., volume of water flow per second at gaging station) of the SBPR at the nearest United States Geological Survey gaging station (USGS Streamgage 01605500; 38°38'8.00"N, 79°20'17.00"W) varied from 0.49 to 2.77 m and 0.64 to 265.61 $m^3$/s, respectively (USGS 2020). Stream heights >2.31 m exceed the flood stage (i.e., the stage at which overflow of the natural banks of a stream begins to cause damage in the local area from inundation) for the gaging station, indicating a flooding event. Average gage height and flow varied seasonally, with highest values occurring in the spring (0.83 m ± 0.16 SD and 8.78 $m^3$/s ± 9.76 SD, respectively). The river varies in width from 7.6 to 44.9 m wide (average = 22.1 m ± 9.1 SD). There are several islands and 3 paved bridges that could facilitate river crossings by wildlife (Fig 2). Two of the bridges

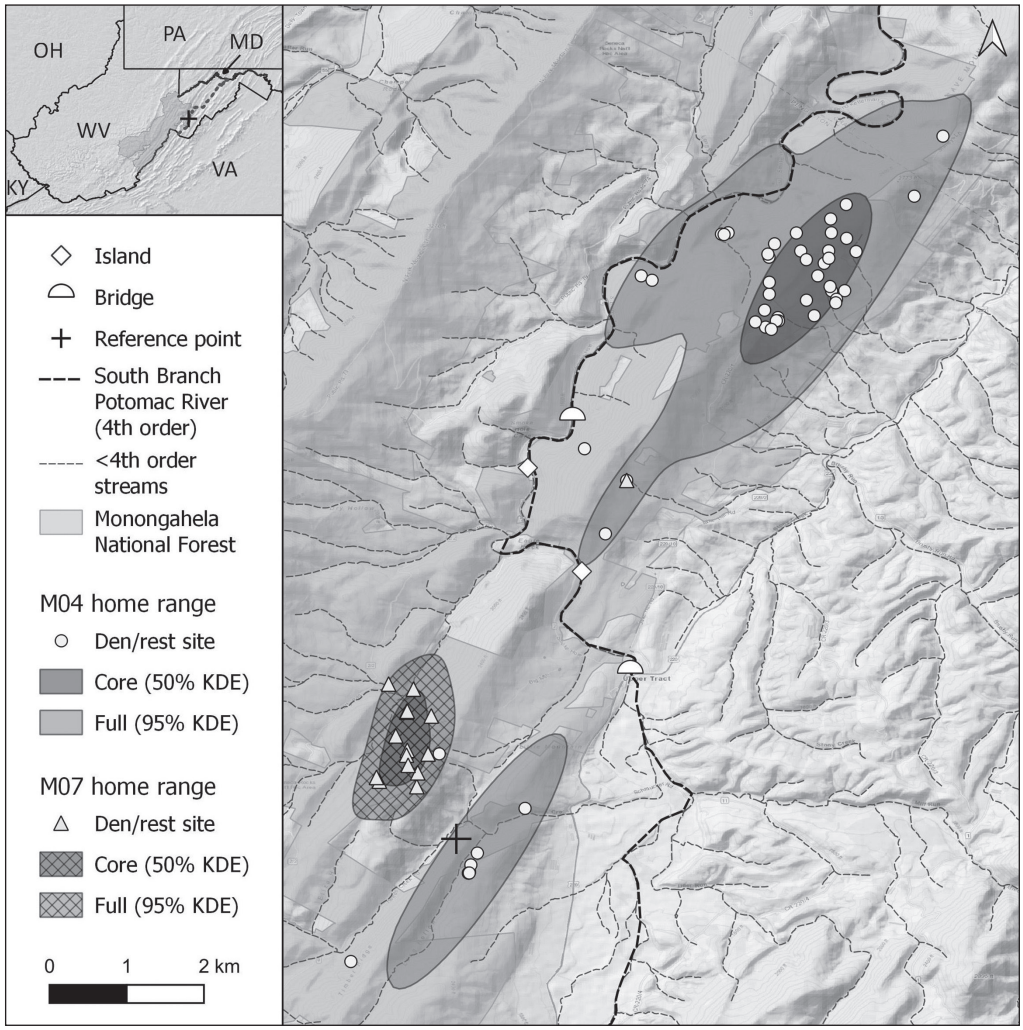



Figure 2. The 95% isopleth home ranges of the 2 male Eastern Spotted Skunks (M04 and M07) that crossed the South Branch of the Potomac River (SBPR) during a telemetry monitoring study of 8 Eastern Spotted Skunks between March 2015 and March 2020. (Note: There are 2 adjacent bridges at the southernmost bridge location depicted on the map.)

are adjacent (~12–65 m apart) and occur in the valley. One of these bridges is crossed by a 2-lane primary road (approximately 9.5 m wide by 107 m long) and the other (approximately. 6 m wide by 63 m long) is decommissioned (i.e., closed to foot and vehicle traffic). The third bridge (approximately 4.5 m wide by 40 m long) is located nearly 7 km downstream from the other 2 bridges and is closed to vehicular use.

## Methods

We live-trapped and radio-collared 8 Eastern Spotted Skunks (5M:3F) during the study. Trap sites were located 2.0–2.5 km from the SBPR and at elevations between 625–705 m. Protocols for live-trapping and radio-collaring followed guidelines of the American Society of Mammalogists (Sikes et al. 2016) and were approved by the Frostburg State University Institutional Animal Care and Use Committee (Approval number A2018-004) and the West Virginia Division of Natural Resources.

We used radio-collars (Model M1740 [16 g]; Advanced Telemetry Systems, Inc., Isanti, MN) with set frequencies varying from 150 to 151 MHz or 164 to 165 MHz. We located Eastern Spotted Skunks by homing (i.e., following VHF signals to the den/resting site) or by triangulation (≥2 bearings and ≤1 km observer-to-animal distance [≥3 bearings for all triangulations associated with river crossings]) using either a Wildlife Materials model TRX-2000S receiver (Wildlife Materials International, Inc., Murphysboro, IL) or a Telonics TR-4 163/167 receiver (Telonics, Inc., Mesa, AZ) and a 3-element Yagi antenna. We took all locations during the day when Eastern Spotted Skunks were assumed to be in a den/resting site (i.e., not moving between locations; Crabb 1948).

We calculated 95% isopleth polygon home ranges for each Eastern Spotted Skunk using the plug-in method in the 'ks' package in Program R version 3.6.1 (Duong 2020, R Core Team 2019, RStudio Team 2019) following guidelines by Walter and Fischer (2016). We took radio-telemetry locations ≥24 hrs apart (average = 8.30 days ± 5.93 SD) for the period each Eastern Spotted Skunk was monitored (Table 1).

We mapped the home ranges using QGIS version București 3.12 (QGIS Development Team 2020). To assess distance to the SBPR, we created a series of points along the perimeter of each home range and along the length of the SBPR using the plugin 'QChainage 3.0.1' (Macho 2018). We then used the 'Distance Matrix' tool to locate the nearest point on the SBPR to each point along the home range boundary. We extracted elevation values for each point and home range from the USGS National Elevation Dataset in QGIS. For home ranges overlapping the SBPR, we calculated the proportion of the home range on the respective sides of the river.

If 2 sequential telemetry locations of an Eastern Spotted Skunk were on opposite sides of the SBPR, then we assumed the individual crossed the river. Each river-crossing event represented a one-way crossing. We collected height and discharge conditions of the SBPR during the study and during river-crossing events from USGS Streamgage 01605500 (USGS 2020).

We used descriptive statistics (average, standard deviation, and/or min–max) to portray outcomes of the study.

## Results

Average home-range sizes for males and females were 600 ha ± 1036 SD (min–max = 82–2082 ha) and 296 ha ± 145 SD (min–max = 299–353 ha), respectively (Table 1). Average elevation within home ranges for males and females were 645 m ± 45 SD (min–max = 358–855 m) and 649 m ± 51 SD (min–max = 481–829 m), respectively. Intermittent 1st–3rd-order streams were dispersed throughout the home ranges of all individuals. Shortest distance between male home-range boundaries and the SBPR varied from 0.00 to 1.95 km. Shortest distance between female home-range boundaries and the SBPR varied from 0.84 to 1.61 km. Of the 8 Eastern Spotted Skunks monitored, only 2 individuals crossed the river. Two males, M04 and M07, crossed the SBPR on a minimum of 7 and 2 occasions, respectively (Table 2). All telemetry locations associated with river crossings occurred between 17 February and 1 June of each year. Seven of these crossings occurred on or before 11 April, which is during the breeding season of Eastern Spotted Skunks (i.e., late winter to mid-spring).

The home range of M04 was considerably larger than other Eastern Spotted Skunks in this study and may be an outlier (Fig. 1). M04's home range was composed of 2 separate polygons on the eastern and western sides of the SBPR, with 1546 ha (74%, 47 telemetry locations) on the eastern side and 536 ha (26%, 10 telemetry locations) on the western side (Fig. 2). The distance from M04's

Table 1. The 95% isopleth home ranges (HR) from telemetry locations of 8 Eastern Spotted Skunks monitored along the South Branch of the Potomac River (SBPR) between March 2015 and March 2020, and average ± SD distance (and min–max distance) from the HR boundaries to the SBPR.

| ID | Period monitored | # of relocations (# of sites[A]) | Average ± SD time between relocations (days) | HR Size (ha) | Average ± SD distance (min–max) from HR boundary to SBPR (km) |
|---|---|---|---|---|---|
| M03 | Mar 2015–Nov 2015 | 31 (25) | 7.20 ± 4.51 | 353 | 2.51 ± 0.63 (1.29–3.83) |
| M04 | Mar 2017–Mar 2020 | 58 (47) | 15.02 ± 15.03 | 2082 | 1.31 ± 0.92 (0.00–3.15) |
| M07 | Mar 2018–Mar 2020 | 25 (10) | 18.26 ± 12.55 | 263 | 2.79 ± 0.63 (1.67–4.08)[B] |
| M08 | Mar 2018–Mar 2020 | 33 (19) | 12.53 ± 10.31 | 82 | 3.26 ± 0.35 (1.95–4.03) |
| M09 | Jan 2019–Mar 2020 | 23 (11) | 10.09 ± 8.98 | 220 | 2.42 ± 0.43 (1.73–3.36) |
| Male average | | | | 600 ± 1036 | 2.46 ± 0.72 |
| F01 | Mar 2015–Jul 2016 | 61 (35) | 7.85 ± 4.18 | 236 | 2.13 ± 0.54 (1.38–3.16) |
| F02 | Mar 2017–Mar 2020 | 121 (50) | 8.36 ± 4.73 | 353 | 2.24 ± 0.75 (0.84–3.36) |
| F03 | Mar 2018–Mar 2020 | 57 (32) | 11.46 ± 9.35 | 299 | 2.26 ± 0.47 (1.61–3.37) |
| Female average | | | | 296 ± 145 | 2.21 ± 0.07 |

[A]Eastern Spotted Skunks were sometimes detected at the same site on multiple occasions. Each site was used only once in home-range calculations.
[B]The 95% home range of M07 did not overlap the SBPR; however, one location for this individual was 1.06 km from the SBPR on the opposite side of the river.

home-range boundary to the SBPR varied from 0.00 to 3.15 km. M04 was recorded crossing the SBPR during the breeding season each year from 2017–2020 (Table 2), routinely travelling ~10 km between home-range polygons.

M07 was recorded crossing the SBPR on 2 occasions during the breeding season in 2018 but not in any subsequent years (Table 2). M07 was initially detected on the western side of the river, 2.02 km from the SBPR. The next telemetry location of M07 was on the eastern side of the SBPR, 1.06 km from the SBPR. M07 then crossed back to the western side of the SBPR and was located 2.47 km from the SBPR. The 95% isopleth home range for M07 occurred only on the western side (29 telemetry locations; Fig. 2). The distance from M07's home-range boundary to the SBPR varied from 1.67 to 4.08 km (Table 1).

During the span of time each river-crossing event could have occurred, the average stream flow and stream height readings at the USGS Streamgage varied from 4.01 to 14.12 $m^3/s$ and 0.68 to 0.99 m, respectively (Table 2). The maximum stream height during the time period of 1 river crossing event by M04 was 2.77 m, exceeding the flood stage.

## Discussion

We provide strong circumstantial evidence that male Eastern Spotted Skunks have the capability of crossing mid-sized rivers such as the SBPR. However, given we only documented 2 of the 8 Eastern Spotted Skunks crossing the SBPR, it is difficult to discern the regularity of such crossings. The home range of M04 was nearest to the SBPR and incorporated low-elevation sites. In contrast, several individuals that did not cross the SBPR had home ranges closer to the river than the home range of M07. Similarly, several individuals that did not cross the SBPR had home ranges that incorporated sites with lower elevations than the home range of

Table 2. Average ± SD river discharge and height for the periods when 2 male Eastern Spotted Skunks crossed the South Branch of the Potomac River (SBPR) during a telemetry monitoring study of 8 Eastern Spotted Skunks between March 2015 and March 2020.

| | | | Discharge of SBPR ($m^3/s$)[A] | | Height of SBPR (m)[A] | |
|---|---|---|---|---|---|---|
| ID | Year | Date range of river crossings | Average ± SD | Min–max | Average ± SD | Min–max |
| M04 | 2017 | 20 Apr–01 Jun | 10.52 ±9.89 | 2.72–76.17 | 0.89 ±0.19 | 0.69–1.80 |
| | 2018 | 17 Feb–25 Feb | 9.34 ±3.13 | 6.82–23.13 | 0.89 ±0.07 | 0.83–1.18 |
| | | 28 Mar–02 Apr | 13.57 ±3.69 | 9.20–20.59 | 0.99 ±0.08 | 0.89–1.13 |
| | 2019 | 19 Feb–16 Mar | 13.25 ±5.98 | 6.99–42.76 | 0.96 ±0.13 | 0.80–1.49 |
| | | 20 Mar–02 Apr | 4.79 ±0.96 | 3.51–6.46 | 0.72 ±0.04 | 0.66–0.78 |
| | 2020 | 24 Feb–25 Feb | 4.01 ±0.11 | 3.82–4.25 | 0.68 ±0.00 | 0.67–0.69 |
| | | 09 Mar–16 Mar | 4.66 ±1.64 | 3.11–7.79 | 0.70 ±0.06 | 0.63–0.81 |
| M07 | 2018 | 26 Mar–11 Apr | 9.38 ±3.98 | 4.45–20.59 | 0.89 ±0.09 | 0.76–1.13 |
| | | 11 Apr–20 May | 14.12 ±21.70 | 3.17–265.61 | 0.91 ±0.24 | 0.70–2.77[B] |

[A]Data collected from United States Geological Survey Streamgage 01605500 South Branch Potomac River (SBPR) at Franklin, WV.
[B]Maximum height during this interval was 2.77 m, exceeding flood stage of 2.13 m

M07. Therefore, the proximity of an Eastern Spotted Skunk's home range to the SBPR did not appear to determine if an individual will cross the river. All Eastern Spotted Skunks in this study were adults and may have had less motivation to cross the river, as compared to a dispersing juvenile. However, the possibility remains that some individuals may have crossed the SBPR and we did not detect the events.

We are uncertain where and by what method the 2 male Eastern Spotted Skunks crossed the river. Potential modes of crossing could have been swimming, crossing when the river was frozen, rafting, or using structures like bridges (Jones 1964). The SBPR was not frozen during the periods when river crossings occurred. Based on locations before and after river crossing events, we suspect M04 and M07 crossed the river in an area that includes a large island, rather than at any of the 3 bridge locations (Fig. 2).

The time period for most river crossings closely aligned with the breeding season for Eastern Spotted Skunks (Mead 1968). With the limited data available and small sample size, we cannot be certain of motivations for these movements. We speculate these observations could have been associated with movements related to breeding season, when male Eastern Spotted Skunks often expand their home range in search of reproductively receptive females (Crabb 1948, Lesmeister et al. 2009, McCullough and Fritzell 1984). These river crossings also overlapped with much of spring, when the SBPR height and flow are greatest. The height of the SBPR exceeded the flood stage during the time period of a river crossing by M07, further supporting the premise that $\leq 4^{th}$-order streams are not barriers for male Eastern Spotted Skunks.

Although to the best of our knowledge this report is the first documentation of a river crossing by an Eastern Spotted Skunk, crossings may not be unprecedented. In the central Great Plains, gene flow between Striped Skunk populations was not inhibited by large rivers (Strahler order 7–9; Barton et al. 2010, USGS 2018). We did not detect female Eastern Spotted Skunks crossing the SBPR and are unsure if females will cross $4^{th}$-order streams. In southern Québec, Canada, major rivers (water flow $\geq$0.6 m/s) inhibited the movement of female Striped Skunks, but not male Striped Skunks (Talbot et al. 2012).

By understanding what landscape features are permeable to Eastern Spotted Skunks, we can begin to understand how Eastern Spotted Skunks might recolonize their historical range. Although the Potomac River along the MD/WV border is considerably larger (average width = 75.3 m ± 7.1 SD, min–max = 10.4–278.5 m) than the SBPR, there are sections of the Potomac River similar in size to the SBPR. We do not know if larger riverine systems are a barrier to dispersal, but our study demonstrates male Eastern Spotted Skunks can cross up to $4^{th}$-order riverine systems.

## Acknowledgments

We thank C. Kimble for his assistance in monitoring river-crossing events. We appreciate the constructive criticism provided by 3 reviewers and assistance from the manuscript

editor. Funding for this project was provided through a Wildlife Restoration Program grant administered by the United States Fish and Wildlife Service's Wildlife and Sport Fish Restoration Program. Equipment and additional funding for this research was provided by Frostburg State University and the West Virginia Division of Natural Resources.

## Literature Cited

Barton, H.D., A.J. Gregory, R. Davis, C.A. Hanlon, and S.M. Wisely. 2010. Contrasting landscape epidemiology of two sympatric rabies virus strains. Molecular Ecology 19:2725–2738.

Crabb, W.D. 1948. The ecology and management of the Prairie Spotted Skunk in Iowa. Ecological Monographs 18:201–232.

Duong, T. 2020. ks: Kernel Smoothing. R package, version 1.11.7. Available online at https://cran.r-project.org/web/packages/ks/index.html.

Gifford, C.L., and R. Whitebread. 1951. Spotted Skunk *Spilogale putorius*. Mammal Survey of South Central Pennsylvania 1:39–40.

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.E., and D.S. Jachowski. 2016. Eastern Spotted Skunk (*Spilogale putorius*). The IUCN Red List of Threatened Species. Version 2017.1. e.T41636A45211474. Available online at https://www.iucnredlist.org/species/41636/45211474.

Hassler, K.N. 2020. Monitoring and den-site habitat of Eastern Spotted Skunks in the Appalachian Mountains of West Virginia. M.Sc. Thesis. Frostburg State University, Frostburg, MD. 114 pp.

Hassler, K.N., C.D. Waggy, R.M. Spínola, K.J. Oxenrider, R.E. Rogers, K.J. Pearce, and T.L. Serfass. 2021 Den-site selection by Eastern Spotted Skunks in the central Appalachian Mountains of West Virginia. Southeastern Naturalist 20(Special Issue 11):209–224.

Jones, J.K.J. 1964. Distribution and taxonomy of mammals of Nebraska. University of Kansas Publications, Museum of Natural History, Lawrence, KS. Vol. 16(2):1–356.

Kinlaw, A. 1995. *Spilogale putorius*. Mammalian Species 511:1–7.

Larson, J.S. 1968. Notes on the Spotted Skunk in Maryland. Chesapeake Science 9:204–206.

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.

Macho, W. 2018. QChainage: Chainage Plugin for QGIS. QGIS plugin, version 3.0.1. Available online at https://plugins.qgis.org/plugins/qchainage/.

McCullough, C.R., and E.K. Fritzell. 1984. Ecological observations of Eastern Spotted Skunks on the Ozark Plateau. Transactions of the Missouri Academy of Science 18:25–32.

Mead, R.A. 1968. Reproduction in eastern forms of the Spotted Skunk (genus *Spilogale*). Journal of Zoology 156:119–136.

Paradiso, J.L. 1969. Eastern Spotted Skunk, *Spilogale putorius putorius* (Linnaeus). Mammals of Maryland 66:206.

Pearce, K.J., T.L. Serfass, J.M. McCann, and D.J. Feller. 2021. Status and distribution of the Eastern Spotted Skunk (*Spilogale putorius*) in Maryland: A historic review and recent assessment. Southeastern Naturalist 20(Special Issue 11):52–63.

Pennsylvania Game Commission (PGC). 2012. Wildlife Diversity Program report. Harrisburg, PA. 16 pp.

QGIS Development Team. 2020. QGIS Geographic Information System. Open Source Geospatial Foundation Project. Available online at https://www.qgis.org/en/site/.

R Core Team. 2019. R: A language and environment for statistical computing. Version 3.6.1. R Foundation for Statistical Computing, Vienna, Austria.

RStudio Team. 2019. RStudio: Integrated Development for R. RStudio, Inc., Boston, MA.

Sikes, R.S., and the Animal Care and Use Committee of the American Society of Mammalogists. 2016. 2016 Guidelines of the American Society of Mammalogists for the use of wild mammals in research and education. Journal of Mammalogy 97:663–688.

Stihler, C.W. 2011. Radiotelemetry studies of female Virginia Big-eared Bats (*Corynorhinus townsendii virginianus*) in Pendleton County, West Virginia. Pp. 139–146, *In* S.C. Loeb, M.J. Lacki, and D.A. Miller (Eds.). Conservation and management of Eastern Big-eared Bats: A symposium. General Technical Report SRS-145. US Department of Agriculture Forest Service, Southern Research Station, Asheville, NC. 157 pp.

Talbot, B., D. Garant, S.R. Paquette, J. Mainguy, and F. Pelletier. 2012. Lack of genetic structure and female-specific effect of dispersal barriers in a rabies vector, the Striped Skunk (*Mephitis mephitis*). PLoS ONE 7:e49736.

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.

United States Geological Survery (USGS). 2018. National Hydrography Dataset Plus High Resolution (NHDPlus HR) for 4-digit hydrologic unit - 0207 (published 20180813). Available online at https://www.usgs.gov/core-science-systems/ngp/national-hydrography/nhdplus-high-resolution. Accessed 30 July 2020.

USGS. 2020. National Water Information System data. Available online at https://waterdata.usgs.gov/nwis/uv?site_no=01605500. Accessed 19 August 2020.

Walter, W.D., and J.W. Fischer. 2016. 4.3 KDE with plug-in bandwidth selection (hplug-in). Pp. 77–83, *In* Manual of Applied Spatial Ecology. PennState College of Agricultural Sciences, University Park, PA. 190 pp.