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Multi-Species Occupancy, Detection, and Habitat Selection of Mesocarnivores in Eastern Oklahoma with a Focus on Eastern Spotted Skunks

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By
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Multi-Species Occupancy, Detection, and Habitat Selection of Mesocarnivores in Eastern Oklahoma with a Focus on Eastern Spotted Skunks

A THESIS

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ABSTRACT OF THESIS

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TITLE OF THESIS: Multi-Species Occupancy, Detection, and Habitat Selection of Mesocarnivores In Eastern Oklahoma With A Focus on Eastern Spotted Skunks

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ABSTRACT:

The eastern spotted skunk (*Spilogale putorius*) was once a commonly occurring species and was regularly harvested for fur. In the mid-20th century, this species experienced a drastic and sudden decline which prompted conservation agencies to designate it as a species of conservation concern throughout its range. Range-wide studies have been occurring with the goal of gathering accurate distribution data on the species in order to understand more about the decline and determine reliable conservation strategies. In an effort to contribute data regarding their distribution and habitat presence in Oklahoma, I used camera traps to survey the Ouachita National Forest and Cookson Wildlife Management Area in eastern Oklahoma. Although my observations of the species were limited, I was successful at recording the presence of eastern spotted skunks in Oklahoma along with many other fur-bearing mesocarnivore species including coyotes (*Canis latrans*), gray foxes (*Urocyon cinereoargenteus*), bobcats (*Lynx rufus*), northern raccoons (*Procyon lotor*), Virginia opossums (*Didelphis virginiana*), and striped skunks (*Mephitis mephitis*). I discovered that most of the additional species were

underrepresented in population studies and conservation reports. Being that they are subject to legal harvest, it is important to emphasize the significance of achieving a more accurate understanding of population demographics for legally harvested furbearers in Oklahoma. It is also important to provide a basis for conducting regular species detection efforts for the state using camera traps and occupancy modeling. In addition, I conducted a human dimensions survey to understand public perception and attitudes toward mesocarnivores from residents living in eastern Oklahoma, and I used that opportunity to gather additional eastern spotted skunk location data that may be important for future distribution studies.

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I want to thank Matthew Fullerton, the Fish and Wildlife Biologist for Threatened and Endangered, of the U.S. Fish and Wildlife Service (previously the Threatened and Endangered Species Wildlife Biologist for the Oklahoma Department of Wildlife Conservation) and Jerrod Davis the Furbearer Wildlife Biologist for the Oklahoma Department of Wildlife Conservation, for providing insights on the eastern spotted skunks including locations and continuous updates within Oklahoma. I am also grateful for the advisement and cooperation of Robert Bastarache, the District Wildlife Biologist for the Ouachita National Forest (U.S. Forestry Service), and Curt Allen, Wildlife Biologist for the Cookson Wildlife Management Area (Oklahoma Department of Wildlife Conservation). I would also like to thank all of the private land-owners who allowed me to conduct my survey on their property.

I would not have been able to design and conduct the human dimensions aspect of my project without the advisement of Betsey York, Human Dimensions Specialist for the Oklahoma Department of Wildlife Conservation. I want to thank her for her direction, guidance, and ability to help us navigate through this study.

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Thesis Introduction

Over the last several years, eastern spotted skunks (*Spilogale putorius*) have been the focal point of several research efforts intended on gathering data that supports the petition to list them as a threatened or endangered species under the Endangered Species Act (United States 1983). Eastern spotted skunks were once understood to be a relatively abundant species, and were regularly trapped and sold as a furbearing species until the mid-20th century (Wilson et al. 2016). Unfortunately, the available information necessary for understanding population dynamics of eastern spotted skunks is limited to trapping records and anecdotal documentation. Evidence suggests that there was a dramatic population decline during the 1940s and 1950s, a period that also shows a noteworthy decrease in the prices and demand for eastern spotted skunk fur (Sasse 2021). Nevertheless, it is understood that the species now has an extremely fragmented distribution in the United States, especially compared to known occurrences and sightings in the past that suggest that the species once occurred statewide across Oklahoma and throughout the eastern United States from the Canadian border into northern Mexico (Gompper and Jachowski 2016; Lesmeister et al. 2009). There is no obvious explanation for their declining population, but leading arguments suggest that it is due to changes in land use and a decrease in food resource availability (Cheeseman et al. 2021). Other possibilities include disease, over-harvest, changing agricultural practices, loss of old forests, and shifting predator dynamics (Eng and Jachowski 2019, Gompper and Hackett 2005, Lesmeister et al. 2009, Perry et al. 2018, Nilz and Finck 2008).

Due to the severe population decline of eastern spotted skunks, conservation agencies across their historic range have classified the species as either a species of conservation concern, threatened, or endangered. According to search results on NatureServe Explorer (https://explorer.natureserve.org/), the authoritative source for North America's biodiversity data, eastern spotted skunks are listed as "critically imperiled" in seven U.S. states. NatureServe Explorer lists eastern spotted skunks as "imperiled" in Oklahoma. The state of Oklahoma describes eastern spotted skunks as a Tier III species of greatest concern which places a high priority on their conservation success in the state (ODWC 2016). In addition to the scarcity of the species, their small size and elusive behavior makes conducting studies very difficult and time consuming, often resulting in limited information (Benson et al. 2019, Eng and Jachowski 2019, Hackett et al. 2007, Lesmeister et al. 2009, Reed and Kennedy 2000). As with the rest of the species, information on eastern spotted skunks in Oklahoma is limited. In an effort to help bridge knowledge gaps on the species current distribution as well as facilitate future intensive studies in Oklahoma, we conducted a camera-trap survey in eastern Oklahoma specifically designed to search for evidence of a persisting population in the state (Branham and Jackson 2021).

As was mentioned before, studies focused on gathering eastern spotted skunk data often end with a limited amount of observations. Therefore, I expanded by study to include all additional mesocarnivores detected during my camera trapping survey. Mesocarnivores are essential components in a healthy ecosystem and are responsible for a variety of services. They are defined as small to mid-sized carnivores weighing less than 15 kg that consume between 50% and 70% meat in addition to fungi, fruits, and other plant material (Roemer et al. 2009, Van Valkenburgh 2007). During my study, I recorded the presence of six mesocarnivore species: coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), bobcat (*Lynx rufus*), northern raccoon (*Procyon lotor*), Virginia opossum (*Didelphis virginiana*), and striped skunk (*Mephitis mephitis*) (Branham and Jackson 2021). Each of these animals are considered furbearers, subjecting them to legal harvest during trapping season(s) in Oklahoma. Eastern spotted skunks have a year-round closed-season in Oklahoma, gray foxes and bobcats have daily and/or seasonal bag limits, but coyotes, northern raccoons, Virginia opossums, and striped skunks have no daily seasonal, or possession limits (https://www.eregulations.com/oklahoma/hunting/furbearer-regulations).

After learning of the drastic population decline of eastern spotted skunks and the lack of scientific reporting that may have alleviated the issues, I began researching population studies for each of the additional detected mesocarnivores in my study. A majority of the research regarding these species dealt directly with the mitigation of human-wildlife conflicts or potential disease spread. It seems that these species have largely understudied populations most likely because of their perceived abundance. As the mesocarnivores in my study tend to be considered "pest" or "nuisance" species, many states, including Oklahoma, have responded to this by open hunting and trapping seasons for a majority of these animals (Warren-Bryant 2017). Since there are so few limits on harvest and an absence in available population data, I conducted a search on NatureServe Explorer (https://explorer.natureserve.org/), an authoritative source for North America's biodiversity data, to determine the global, national, and state conservation status of these additional mesocarnivore species. Coyotes, bobcats, northern raccoons, Virginia opossums, and striped skunks (5 of the 7 species) were ranked as "SNR (Status Not Ranked)" for the state of Oklahoma. Furthermore, there is no mention of coyotes, gray foxes, bobcats, northern raccoons, Virginia opossums, or striped skunks within the most recent Oklahoma Comprehensive Wildlife Conservation Strategy published in 2016 (ODWC 2016).

In order to set successful and efficient harvest limits, it is important to understand whether or not trapping serves as an additive or compensatory mortality factor for each of these species. I used the data that I recorded from my camera trapping surveys to conduct occupancy models that will be useful for determining geographical distributions that are important for initiating future successful studies on each of these mesocarnivore species. Achieving a more accurate understanding of population demographics for legally harvested furbearers in Oklahoma should be a priority, and I expect that this study will have the potential to provide a basis for conducting regular population monitoring efforts for the state using camera traps and occupancy modeling.

The final component of my study was a human dimensions survey created to combat the challenges of conducting a survey approximately 400 km from the University of Central Oklahoma in Edmond, Oklahoma. The survey was initially designed to gather additional eastern spotted skunk location data, but I added a mesocarnivore perceptions component to maximize the opportunity to gather data on the additional mesocarnivore species of the area. The study of human dimensions is an important tool that uses citizen involvement and societal input to better understand wildlife inhabiting an area and the best ways to manage that wildlife by gauging why humans value natural resources, how humans want resources managed, and how humans affect or are affected by natural resources management decisions (Decker et al. 2001). Rather than use this survey to initiate specific management strategies or to survey responses for future wildlife management or population changes, I used this method to ascertain current perspectives of harvested furbearing mesocarnivore species by local community members and gather additional data to assess the potential distribution of eastern spotted skunks in eastern Oklahoma. I also expect that the results from this survey will provide valuable information regarding the general public's perceptions on mesocarnivores that may close knowledge gaps about each of these species and contribute to making more informed and efficient wildlife management decisions in Oklahoma.

Chapter one of this thesis has been published in the Southeastern Naturalist Eastern Spotted Skunk Special Issue, and was formatted and written following those specific journal guidelines. Chapters two and three are formatted and written in preparation for publication. Plural possessive pronouns are used rather than singular possessive pronouns because each chapter has been and/or will be published with a co-author.

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Chapter 1: Camera-trapping Survey for Plains Spotted Skunk (*Spilogale putorius interrupta*) in Eastern Oklahoma

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ABSTRACT

Once known as a regularly harvested furbearer, *Spilogale putorius* (Eastern Spotted Skunk) has experienced drastic population decline and is now considered a species of conservation concern throughout much of its range. In an effort to contribute to distribution and habitat presence data in Oklahoma, we surveyed 95 locations using camera traps during the months of October and April (2018–2019 and 2019–2020) attempting to detect the *S. p. interrupta* (Plains Spotted Skunk) subspecies. We began surveying the Ouachita National Forest in eastern Oklahoma and broadened our survey to include areas of recently confirmed sightings. We only detected Eastern Spotted Skunks in 5 of the 95 locations that were surveyed, during 12 of the 5287 trap nights, and 13 of the 2085 mammal detections. Although we had low trap success, we believe our results are useful in supporting the rarity of, or difficulty detecting, this species. Additionally, the information resulting from this study should be useful in establishing a basis for continued sampling in Oklahoma and providing information to improve sampling technique and design when researching this species.

INTRODUCTION

Spilogale putorius (Eastern Spotted Skunk) has experienced a significant decrease in population across its native range with no obvious explanation for the decline. Historically, the species occurred statewide across Oklahoma and throughout the eastern United States from the Canadian border into northern Mexico (Gompper and Jachowski 2016). Today, the population is fragmented, and accurate distribution data is lacking. The geographical distribution of the *S. p. interrupta* (Rafinesque) (Plains Spotted Skunk) subspecies includes the Great Plains ecoregion from the Canadian border to northeast Mexico (Shaffer et al. 2018). The exact cause(s) of the Eastern Spotted Skunk population decline is a debated subject, but those most likely to be major factors include disease, over-harvest, changing agricultural practices, loss of old forests, and shifting predator dynamics (Eng and Jachowski 2019, Gompper and Hackett 2005, Lesmeister et al. 2009, Perry et al. 2018, Nilz and Finck 2008). It is believed that the species now has an extremely fragmented distribution in the United States, especially compared to past known localities and sightings, due to habitat availability (Lesmeister et al. 2009). As a result, the species is classified as either a species of conservation concern, threatened, or endangered by conservation agencies throughout most of its historic range. In Oklahoma, Eastern Spotted Skunks are currently described as a Tier III species of greatest conservation urgency (ODWC 2016), making their conservation success a priority in this state.

Obtaining information about Eastern Spotted Skunks tends to be very time consuming, often resulting in limited information collected (Benson et al. 2019, Eng and Jachowski 2019, Hackett et al. 2007, Reed and Kennedy 2000) due to the reduced density, small size, and elusive behavior of these animals (Lesmeister et al. 2009). Along with considerable gaps in knowledge about their life-history characteristics, only historic records and anecdotal evidence of Eastern Spotted Skunks currently exist for Oklahoma. In a cooperative effort to bridge those knowledge gaps, reporting all observations and detection data is necessary. Here, we are reporting our findings of Eastern Spotted Skunk detections through our camera-trapping effort in eastern Oklahoma. These observations are an important contribution to improving our current understanding of range-wide distribution data for the species, and specifically the presence of Eastern Spotted Skunks in Oklahoma.

METHODS

We conducted our survey between the months of October and April (2018–2019 and 2019–2020). Initially, our study area was limited to the Ouachita National Forest in LeFlore and McCurtain counties based on previously recorded locations of Eastern Spotted Skunks (Fig. 1; Hardy 2013; Lesmeister et al. 2007, 2008, 2010a, 2010b, 2013). These locations were within the Oklahoma Ouachitas Level III Ecoregion (EPA) in southeast Oklahoma. This area is laced with small ephemeral and perennial streams carving the rugged terrain. The ecoregion is dominated by *Pinus* (pine)–deciduous forests with varying levels of vegetation densities in the understory (Bales et al. 2005). Annually, rainfall averages ~134.6 cm (51.3 in) and temperature averages 16.1 °C (61.0 °F) in the region (Laney 2017c, d).

During the fall of 2019, we discovered 2 confirmed observations of Eastern Spotted Skunks in Sequoyah and Adair counties. Upon learning of these observations, we decided to expand our survey northward for the remainder of the study (January–April 2020). Both of these confirmed observations were the result of these animals occupying residential structures, and were both removed and relocated to the Cookson Wildlife Management Area (Curt Allen, Oklahoma Department of Wildlife Conservation, Cookson WMA, OK, pers. comm.). This area is located in the Boston Mountains Level III Ecoregion (EPA) in northeastern Oklahoma, and is characterized by sharp changes in elevations and rolling hollows with rocky outcrops. The Boston Mountains are dominated by *Quercus* (oak)–*Carya* (hickory) forests with *Pinus echinata* Mill. (Shortleaf Pine) occurring at higher elevations (Lustig et al. 2021). Annually, average rainfall is ~123.8 cm (48.7 in) and average temperature is 17.7 °C (63.9 °F) in this part of the state (Laney 2017a, b, e).

We surveyed 95 locations (24 north and 71 south) (Fig. 1) with camera traps using an adaptive sampling method where we specifically selected sites with a close proximity to streams, dense canopy cover, and understory vegetation based on habitat selection by Plains Spotted Skunks on the Arkansas side of the Ouachita National Forest (Leismeister et al. 2010b). We utilized 25 Reconyx Hyperfire cameras (Reconyx, Holmen, WI) that we relocated to different locations no closer than 500 m from sites that had previously, or were currently being surveyed to determine home-range attributes and dynamics for the species (Leismeister et al. 2010b). We secured each camera to a tree about 60 cm (1.97 ft) off of the ground depending on the terrain and set it to focus on a tree baited with WCS™ Rosebud Skunk Paste Bait and On-Target™ Liquid Grub Lure for Skunk (Wildlife Control Supplies, East Granby, CT) 1–2 m (3.28–6.56 ft) away. The bait and lure were applied throughout a zone between about 20 cm to 1 m (7.92 in to 3.28 ft) from the ground. We deployed cameras for ~1 month before relocating them. The exception to this occurred when a Spotted Skunk was detected. In these cases, we left the camera out and continued monitoring the site for the duration of the field season and the following field season, reapplying bait on a monthly basis. Additionally, for the locations we detected Spotted Skunks, we adopted an adaptive-cluster sampling method where we targeted the immediate area around the detection site using the before-mentioned habitat parameters while maintaining our 500-m (0.31-mi) survey distance.

For each location, we measured canopy cover, average tree height, and average visual obstruction. We calculated average tree height using the mean of 4 clinometer readings taken from the location of the camera immediately north, south, east, and west. We measured the distance to these trees using a Simmons 801600 Volt 600 Laser Rangefinder (Bushnell, Overland Park, KS). We recorded canopy cover as the average of 16 densitometer readings taken from 4 locations 20 m (65.62 ft) from the camera in each cardinal direction. We calculated average visual obstruction measurements in the same locations as the densitometer measurements using the mean of 16 Robel pole readings at 4 locations 20 m from the camera in each cardinal direction. Each photograph recorded the time, temperature, and estimated moon phase as defined by the camera settings. Following the categorization method of moon illumination by Benson et al. (2019), we divided moon illumination into 2 categories: low (less than 50% illumination) and high (greater than 50% illumination). Our estimates did not consider cloud cover. We obtained climatic and elevation data for each of the locations from the PRISM Climate Group's PRISM Time Series Data (https://prism.oregonstate.edu/explorer/). Our study area is about 402 km (250 mi) away from the University of Central Oklahoma, where we are based, which prevented us from surveying more sites for shorter periods of time. We attempted to survey as large of an area as possible throughout our study which spanned an estimated total of 1357.15 km2 (524.0 mi2), and wanted to monitor the extent of the area during the entire field season to account for potential seasonality effects on detection.

RESULTS

We collected roughly 2085 mammal detections during a total of 5287 trap nights from 95 locations. Sites were surveyed between 28 and 253 days, depending on Eastern Spotted skunk detection and site accessibility in response to spring flooding (Table 1).

Eastern Spotted Skunks represented only 12 (0.576%) detections and were only detected at 5 survey locations (5.265%) during 11 trap nights (0.208%). Of these 5 locations, only 1 location had >1 Eastern Spotted Skunk detection. Latency to detection varied from less than 8 hours to 13 days after the camera was deployed, with all but 1 occurring within 4 days of setting the camera (Table 2). All of the detections were during the night between 20:36 and 5:37, and occurred at temperatures between 0 °C (32 °F) and 20 °C (68 °F).

Spotted Skunks were detected at 5 locations within the Ouachita Mountains Level III Ecoregion in southeast Oklahoma that represented slightly different physical habitat characteristics (Table 3, Fig. 2). The elevation varied from 185.01 m to 416.79 m (958 ft to 1367 ft), average canopy cover was 88.5–96.6%, average tree height varied from 11.2 m to 20.2 m (36.75 ft to 67.27 ft), and average visual obstruction was 6.33–45.63 cm (2.49–17.96 in) (Table 3).

In addition to detecting Eastern Spotted Skunks, we also detected 20 other mammal species (Table 4). The most frequently detected species included *Sciurus carolinensis* (Eastern Grey Squirrel)*, Procyon lotor* (Northern Raccoon), *Odocoileus virginianus* (White-tailed Deer), and *Urocyon cinereoargenteus* (Gray Fox). Species detected least frequently, but at least once, were *Bos taurus* (Domestic Cattle), *Cervus canadensis* (Elk), *Sylvilagus floridanus* (Eastern Cottontail), *Tamias striatus* (Eastern Chipmunk), *Ursus americanus* (Black Bear) and Eastern Spotted Skunk. Of these mammal detections, 761 were mesocarnivore detections. We found that the most detected mesocarnivore species was Raccoon with 345 detections (45.33%) followed by Gray Fox with 218 (28.65%), *Didelphis virginiana* (Virginia Opossum) with 102 (13.40%), *Canis latrans* (Coyote) with 41 (5.39%), *Lynx rufus* (Bobcat) with 24 (3.15%), *Mephitis mephitis* (Striped Skunk) with 19 (2.50%), and Eastern Spotted Skunk with 12 (1.58%) detections. Of the sites with Eastern Spotted Skunk detections (1LEF2, 1LEF3, 2LEF4, 3LEF1, and 6MCC3; Table 2), 13 of the 20 additional mammal species were also recorded in these locations.

DISCUSSION

It is difficult to establish many patterns or come to strong conclusions on habitat preference, activity patterns, behavioral adaptations, and other life-history characteristics of the Eastern Spotted Skunk based on the limited data that we have. Given the latency to detection we experienced, this study may have yielded better results if we were able to survey more sites for shorter periods of time. All detections occurred within 2 weeks of setting the camera, which is 2 weeks less than the average latency to initial detection according to Eng and Jachowski's (2019) camera-trapping survey on Plains Spotted Skunks. Appalachian Spotted Skunks in the camera-trapping study by Thorne et al. (2017) showed an average latency to detection of 7 days. Further information is needed to determine accurate trends with latency to detection in Eastern Spotted Skunks, especially for the Plains Spotted Skunk subspecies. We found no compelling evidence indicative of preference by Eastern Spotted Skunk for average canopy cover, tree height, or visual obstruction by understory vegetation within our survey (Table 3), and did not successfully capture enough data to perform statistical analyses to compare these variables.

We were hopeful that our survey would yield more Eastern Spotted Skunk detections due to adopting adaptive sampling methods. During our initial literature review, we did not come across any adaptive-sampling survey designs with an Eastern Spotted Skunk focus. However, we believed that selecting sites based on habitat features such as dense canopy cover, understory vegetation, and proximity to streams (Hardy 2013;

Lesmeister et al. 2007, 2008, 2009, 2010b, 2013) would increase our probability of detecting the species. Adaptive-cluster sampling allowed us to study sites surrounding detection locations more intensively, although we did not locate the presence of Eastern Spotted Skunks at any of these surrounding sites. Additionally, we expected to detect Eastern Spotted Skunks in the Cookson WMA due to their confirmed presence, but we were unsuccessful.

Our study provides the first concentrated effort to sample for Eastern Spotted Skunks in Oklahoma. Information on the Plains Spotted Skunk is limited, therefore, communicating research is a critical component in accurately defining the range and natural history of the subspecies. Our study should establish a basis for continued concentrated sampling in Oklahoma and should provide additional study-design information to improve sampling techniques when researching Eastern Spotted Skunks, specifically the Plains Spotted Skunk. Our low trap success is not surprising based on trap success of other recent studies focusing on this species. During a camera-trap survey consisting of over 8000 trap nights in the Ozark region of Arkansas, Higdon and Gompper (2020) only captured 6 Plains Spotted Sunk detections at 4 sites. In addition to their low trap success, the Plains Spotted Skunk were also among the least-detected species, similar to the results of our study.

Low detection rates may provide evidence of this species rarity and/or decline. It may also be evidence of an ineffective survey design or inability for game cameras to detect Eastern Spotted Skunks. A comparative study using our research while including the more-efficient track-plates may provide a clearer insight to the effectiveness of these camera-trapping methods (Hackett et al. 2007). Future camera-trap studies on the Plains Spotted Skunk in Oklahoma should include shorter survey lengths that last 1–2 weeks at more survey sites with the goal of defining species distribution in Oklahoma. Studies involving radio collars and frequent location monitoring with the goal of finding den sites and/or determining activity patterns would aid in more-effective comparison studies on the Ouachita Mountains population on both the Oklahoma side as well as in Arkansas. Continued camera trapping and other noninvasive efforts that contribute to distribution and detectability studies are still very important in the ongoing effort of defining their distribution. Reporting these observations are crucial to improving what we currently know about the distribution of Plains Spotted Skunks and the other Eastern Spotted Skunk subspecies.

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CHAPTER 1 TABLES

Table 1. Summary of the number of days deployed for cameras with Eastern Spotted Skunk (ESS) detections including the minimum, maximum, mean, range, and standard error for both categories. Site inaccessibility due to spring flooding contributed to survey periods longer than a month for locations with no Eastern Spotted Skunk detections.

	without ESS detection	with ESS detection
min	28	184
max	93	253
mean	47.0125	223.8
range	65	69
SE	1.8167749	14.0477756

Table 2. Details for each Eastern Spotted Skunk detection event including date, time, latency to detection, and average abiotic environmental variables such as temperature and moon phase. Survey conducted October–April in 2018–2019 and 2019–2020.

Location	Latency	Date	Time	Temperature (C°)	Moon illumination
1LEF3	<8 hrs	28-Jan-19	20:49	0	Low
1LEF2	3 days	31-Jan-19	20:28	7	Low
		1-Feb-19	22:27	11	Low
		2-Feb-19	20:36	12	Low
		4-Feb-19	2:20	17	Low (0%)
		4-Feb-19	5:37	17	Low (0%)
		5-Feb-19	23:24	20	Low
		10-Feb-19	1:55	1	Low
		10-Mar-19	21:11	7	Low
2LEF4	4 days	20-Mar-19	2:21	14	High (100%)
3LEF1	3 days	9-Oct-19	1:33	14	High
6MCC3	13 days	31-Oct-19	2:09	2	Low

Table 3. Habitat characteristics including elevation (m), average canopy cover (%), average tree height (m), and average visual obstruction (cm) for each location that resulted in an Eastern Spotted Skunk detection. The survey was conducted October–April in 2018–2019 and 2019–2020. See Table 1 for comparison of sites with no detections.

Location	Elevation (m)	Average canopy cover (%)	Average tree height (m)	Average visual obstruction (cm)	Physical characteristics
1LEF2	317.91	96.04	20.2	45.63	Understory thick with pine saplings; pine dominated forest
1LEF3	416.97	96.49	11.95	9.375	Next to stream in moderately sparse understory; pine dominate forest
2LEF4	219.15	91.75	19.95	6.333	On steep incline with small ephemeral streambed at the bottom; large pines, young hard woods
3LEF1	185.01	88.495	13.35	15	On a steep rocky incline; woody vines and little understory vegetation; oak/hickory dominate forest
6MCC3	292.1	96.62	11.2	22.75	Next to small stream in a young hardwood forest

Table 4. Mammal species detected and number of detections in Cookson Wildlife Management Area (and nearby private land) and Ouachita Mountains National Forest. Species detected at locations where Eastern Spotted Skunks were detected are denoted by an asterisk. Survey conducted October–April 2018–2019 and 2019–2020.

Mammal	**# detections Ouachita Mountains NF**	**# detections Cookson WMA**	**Total**
Sciurus carolinensis Gmelin (Eastern Grey Squirrel)*	450	10	460
Procyon lotor (L.) (Raccoon)*	330	15	345
Odocoileus virginianus (Zimmermann) (White-tailed Deer)*	263	23	286
Urocyon cinereoargenteus (Schreber) (Gray Fox)*	204	14	218
Sus scrofa L. (Feral Pig)*	132	18	150
Peromyscus spp. (deer mice)*	112	6	118
Didelphis virginiana Kerr (Virginia Opossum)*	100	2	102
Dasypus novemcinctus L. (Nine-banded Armadillo)*	70		70
Sciurus niger L. (Eastern Fox Squirrel)	52	2	54
Neotoma spp.(woodrats)*	46		46
Canis latrans Say (Coyote)*	39	2	41
Glaucomys volans (L.) (Southern Flying Squirrel)*	28		28
Lynx rufus (Schreber) (Bobcat)*	20	4	24
Canis familiaris L. (Domestic Dog)	18	5	23
Mephitis mephitis (Schreber) (Striped Skunk)*	18	1	19

Spilogale putorius (L.) (Eastern Spotted Skunk)	**12**		**12**
Ursus americanus Pallas (Black Bear)	9	1	10
Tamias striatus (L.) (Eastern Chipmunk)		6	6
Sylvilagus floridanus (J.A. Allen) (Eastern Cottontail)	6		6
Cervus canadensis Erxleben (Elk)		5	5
Bos Taurus L. (Domestic Cattle)		1	1
unknown	49	12	61

CHAPTER 1 FIGURES

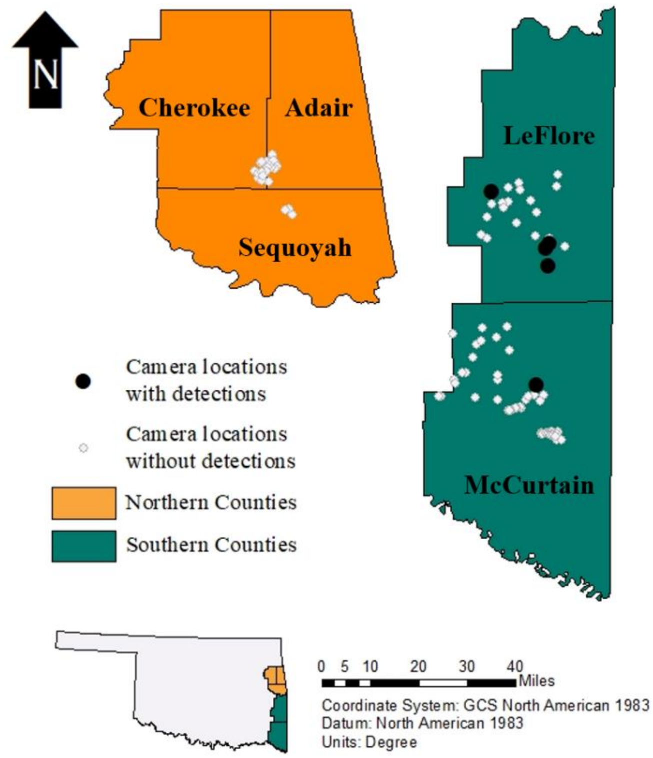

Figure 1. Map of study area showing camera-trap locations (those with Eastern Spotted Skunk detections shown as black filled circles and those without as white dots) in the 3 more northern counties (orange) and 2 more southern counties (green).

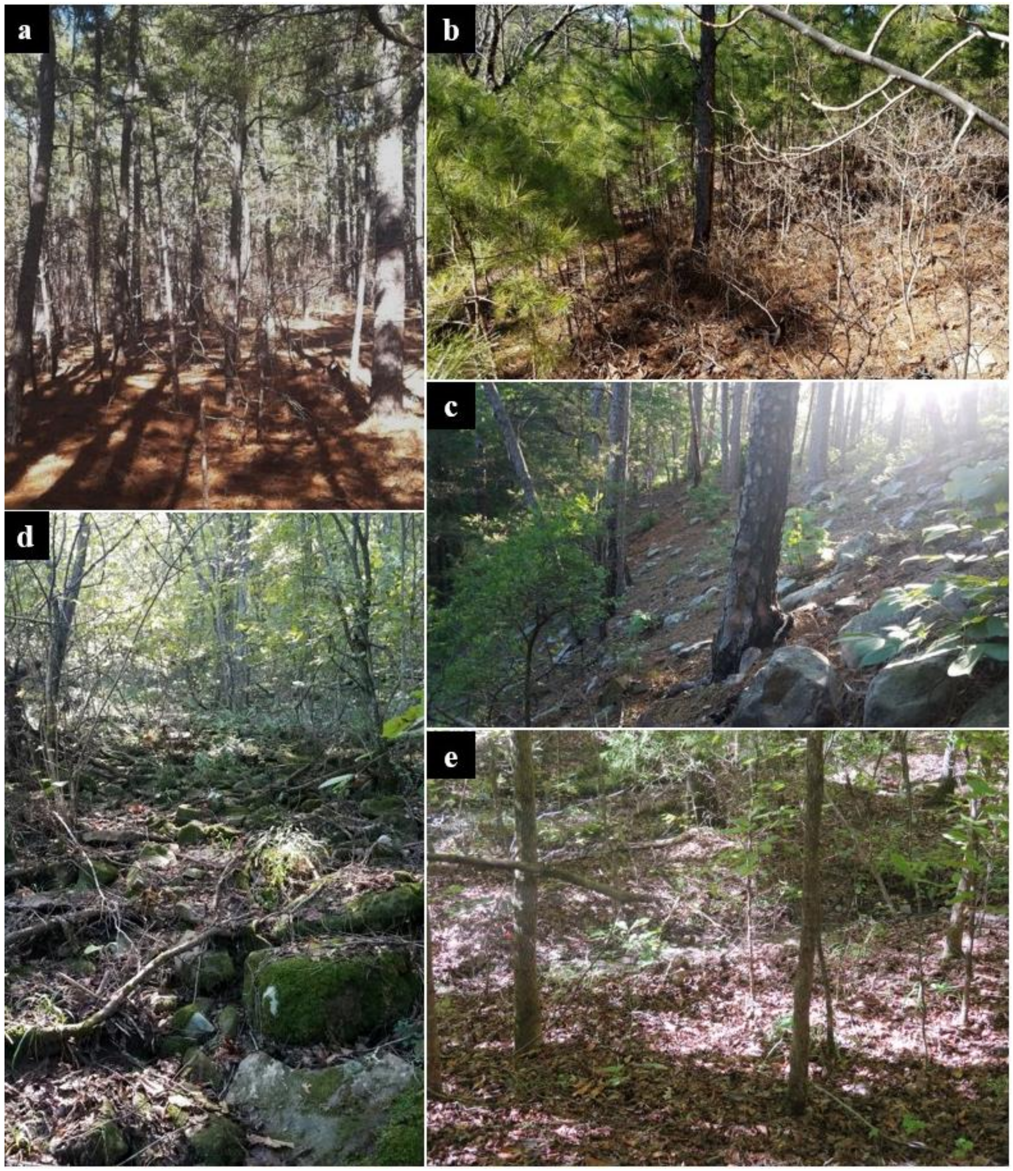

Figure 2. Photos of habitat characteristics representing 5 locations with Eastern Spotted Skunk detections: (a) 1LEF2, (b) 1LEF3, (c) 2LEF4,(d) 3LEF1, and (e) 6MCC3.

Chapter 2: Conservation Status of FurBearing Mesocarnivores in Eastern Oklahoma

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ABSTRACT

Mesocarnivores are an important ecological group of species that can act as apex predators in some communities, providing many significant ecological roles in their habitats. In an effort to gather data providing evidence that eastern spotted skunks still occur in Oklahoma, we conducted a camera trapping study in eastern Oklahoma between the months of October and April (2018–2019 and 2019–2020) and successfully recorded eastern spotted skunk presence along with 6 other mesocarnivore species: coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), bobcat (*Lynx rufus*), northern raccoon (*Procyon lotor*), Virginia opossum (Didelphis virginiana), and striped skunk (*Mephitis mephitis*). These additional species are all subject to legal harvest in Oklahoma with limited reporting on mostly open hunting seasons. We surveyed 95 sites resulting in 761 mesocarnivore observations and estimated probability of occupancy (Ψ) and probability of detection (p) for each species using program PRESENCE 12.32 (USGS Patuxent Wildlife Research Center). As harvested species, it is important to understand shifting population dynamics to accurately determine trapping limits prior to drastic population declines, as seen in eastern spotted skunks. This chapter highlights the significance of achieving a more accurate understanding of population demographics for legally harvested furbearers in Oklahoma, and provides a basis for

conducting regular species detection efforts for the state using camera traps and occupancy modeling.

KEY WORDS furbearers, harvest, mesocarnivores, occupancy modeling

INTRODUCTION

Mesocarnivores are an important group of mammalian species that provide many significant ecological roles in their habitats both directly and indirectly. They are defined as small to mid-sized carnivores weighing less than 15 kg that consume in their diet between 50% and 70% meat in addition to fungi, fruits, and other plant material (Roemer et al. 2009, Van Valkenburgh 2007). Mesocarnivores do not normally serve as apex predators but can act as apex predators in some communities, potentially influencing community-level cascades. In Oklahoma, there are many species of mesocarnivores including coyote (*Canis latrans*), red fox (*Vulpes vulpes*), gray fox (*Urocyon cinereoargenteus*), swift fox (*Vulpes velox*), bobcat (*Lynx rufus*), northern raccoon (*Procyon lotor*), ringtail (*Bassariscus astutus*), American badger (*Taxidea taxus*), Virginia opossum (*Didelphis virginiana*), striped skunk (*Mephitis mephitis*), American hog-nosed skunk (*Conepatus leuconotus*), western spotted skunk (*Spilogale gracilis*), and eastern spotted skunk (*Spilogale putorius*) (Shaughnessy Jr. and Cifelli, 2016). These animals, are also denoted as "furbearers," and are therefore subject to legal harvest during trapping season(s), except for eastern and western spotted skunks which have a year-round closed season in Oklahoma.

In an effort to gather data providing evidence that eastern spotted skunks continue to occur in Oklahoma, we conducted a camera trapping study in eastern Oklahoma in the Ouachita National Forest. We successfully recorded the continued presence of eastern spotted skunks in Oklahoma along with 6 other mesocarnivore species during this study:

coyote, gray fox, bobcat, northern raccoon, Virginia opossum, and striped skunk (Branham and Jackson 2021). These additional species are all subject to legal harvest in Oklahoma with no daily, season, or possession limits on coyote, northern raccoon, Virginia opossum, or striped skunk (https://www.eregulations.com/oklahoma/hunting/furbearer-regulations). Gray fox harvest is limited to 2 per day with no more than 6 per season, and bobcat harvest is limited to a season/possession limit of 20 with no daily limit.

We conducted our study based on the rapid decline of a species that was previously considered relatively abundant. Before the 1940s and 1950s, eastern spotted skunks were a regularly-trapped game animal and were quite popular with fur trappers throughout their range (Wilson et al. 2016). During the 1940s, a slight decrease in annual harvest was shown to be about 1% compared to previous trapping seasons. However, after the 1950s, conservationists determined that the species had undergone a 90% decline in abundance (Wilson et al. 2016). Currently, information on eastern spotted skunks and their decline is limited to trapping records and anecdotal evidence, and they are now believed to have an extremely limited population and geographic distribution. As a result, they are classified as an imperiled species in Oklahoma and are ranked as a Tier III species of greatest conservation need within Oklahoma's Comprehensive Wildlife Conservation Strategy (OCWCS) (ODWC 2016). The additional mesocarnivore species detected in our study have largely understudied populations likely due to their perceived abundance. Since they are harvested species, it is important to understand shifting population dynamics to accurately determine trapping limits and record potential population declines before an issue, similar to eastern spotted skunks, occurs.

These mesocarnivores tend to be considered "pest" or "nuisance" species, therefore a majority of the research within the state of Oklahoma deals directly with the mitigation of human-wildlife conflicts or potential disease spread. Many states, including Oklahoma, have responded to this by open hunting and trapping seasons for a majority of these animals (Warren-Bryant 2017). Human perceptions of these animals tend to lead to the assumption that they are abundant or overabundant, and therefore accurate population research is lacking which contributes to a lack of reporting for these species. We conducted a search on NatureServe Explorer (https://explorer.natureserve.org/), an authoritative source for North America's biodiversity data, to determine the global, national, and state conservation status of these additional mesocarnivore species. Upon searching each species, we discovered that coyote, bobcat, northern raccoon, Virginia opossum, and striped skunk (5 of the 7 species) were ranked as "SNR (Status Not Ranked)" for the state of Oklahoma (Table 1). When comparing these status ranks to other states, we noticed that Oklahoma represents one of only a few states that do not provide a conservation status for these species (Table 2).

The Oklahoma Department of Wildlife Conservation (ODWC) organizes all species of conservation concern or species of greatest conservation need into a three Tier (priority ranking) system within the OCWCS every 10 years to designate species requiring the most attention (ODWC 2016). ODWC uses NatureServe's Natural Heritage Global Rank as one of the 5 criteria for designation as a species of greatest conservation need. There is no mention of coyote, gray fox, bobcat, northern raccoon, Virginia opossum, or striped skunk within the most recent OCWCS published in 2016. In order to set successful and efficient harvest limits, it is important to understand whether or not trapping serves as an additive or compensatory mortality factor for each of these species. Along with trapper data, regular and repeated population monitoring methods should be utilized for these harvested species.

Using occupancy monitoring techniques provides insights useful for determining geographical distributions that are important for initiating future successful studies. This chapter highlights the significance of achieving a more accurate understanding of population demographics for legally harvested furbearers in Oklahoma, and provides a basis for conducting regular population monitoring efforts for the state using camera traps and occupancy modeling.

STUDY AREA

This study is part of a larger study assessing the status of eastern spotted skunks in Oklahoma. We conducted this survey between the months of October and April (2018–2019 and 2019–2020). Initially, our study area was limited to the Ouachita National Forest in LeFlore and McCurtain counties based on previously recorded locations of eastern spotted skunks on the Arkansas side of the Forest (Fig. 1; Hardy 2013; Lesmeister et al. 2008, 2010a, 2010b, 2013). These locations were within the Oklahoma Ouachitas Level III Ecoregion (EPA) in southeast Oklahoma (U.S. Enviornmental Protection Agency 2013). The ecoregion is dominated by *Pinus* (pine)–deciduous forests with varying levels of vegetation densities in the understory and is laced with small ephemeral and perennial streams carving the rugged terrain (Bales et al. 2005). Annual precipitation averages about 134.6 cm and annual temperature averages 16.1 °C in this region (Laney 2017c, d).

During Fall 2019, we learned of two new confirmed observations of eastern spotted skunks in Sequoyah and Adair counties, Oklahoma provided by ODWC. Upon learning of these observations, we expanded our survey northward to the Cookson Wildlife Management Area (CWMA) for the remainder of the study (January–April 2020). This area is located in the Boston Mountains Level III Ecoregion (EPA) in northeastern Oklahoma and is characterized by sharp changes in elevations and rolling hollows with rocky outcrops (U.S. Environmental Protection Agency 2013). The Boston Mountains are dominated by *Quercus* (oak)–*Carya* (hickory) forests with *Pinus echinata* (shortleaf pine) occurring at higher elevations (Lustig et al. 2021). Average annual precipitation is about 123.8 cm and average annual temperature is 17.7 °C in this part of Oklahoma (Laney 2017a, b, e). We attempted to survey as large of an area as possible throughout our study which spanned an estimated total of 135,715 ha.

METHODS

Camera trapping

We surveyed 95 locations (24 in the northern counties and 71 in the southern counties) (Fig. 1) with camera traps using an adaptive sampling method where we specifically selected sites with a close proximity to streams, dense canopy cover, and understory vegetation based on known habitat selection by plains spotted skunks on the Arkansas side of the Forest (Lesmeister et al. 2010b). We utilized 25 Reconyx Hyperfire cameras (Reconyx, Holmen, WI) that we relocated to different locations no closer than 500 m from sites that had previously or were currently being surveyed (Lesmeister et al. 2010b). We secured each camera to a tree about 60 cm off the ground depending on terrain and set it to focus on a tree baited with WCS™ Rosebud Skunk Paste Bait and On-Target™ Liquid Grub Lure for Skunk (Wildlife Control Supplies, East Granby, CT) 1–2 m away. The bait and lure were applied throughout a zone between about 20 cm to 1 m from the ground. We deployed cameras for about one month before relocating them. The exception to this occurred when a spotted skunk was detected. In these cases, we left the camera out and continued monitoring the site for the duration of the field season and the following field season, reapplying bait monthly. Additionally, for the locations where we detected spotted skunks, we adopted an adaptive-cluster sampling method and targeted the immediate area around the detection site using the aforementioned habitat parameters while maintaining our 500 m survey distance.

Habitat Measurements

For each location, we measured average tree height, canopy cover, and average visual obstruction. We calculated average tree height using the mean of 4 Suunto PM-5/360 PC Clinometer (Suunto Oy, Vantaa, Finland) readings recorded from the closest tree immediately north, south, east, and west of the camera location (Figure 2). To accurately calculate tree height, we measured the distance between the location of the camera and each tree using a Simmons 801600 Volt 600 Laser Rangefinder (Bushnell, Overland Park, KS). We recorded canopy cover as the average of 16 spherical crown densiometer (Forestry Suppliers, Jackson, MS) readings taken from 4 locations 20 m from the camera in each cardinal direction (4 readings per direction) (Figure 3). We calculated average visual obstruction measurements in the same locations as the densiometer measurements using the mean of 16 Robel pole readings at 4 locations 20 m from the camera in each cardinal direction (Figure 4).

Data Analysis

We downloaded the photos from every SD card each month prior to relocating or rebaiting cameras. These images were immediately examined for the presence of eastern spotted skunks and were subsequently processed to record data for each mesocarnivore detection. In an attempt to decrease multiple detection records from a single visitation, detections that occurred within 30 minutes were combined as a single observation event. Data recorded from each observation event included the location, species, date, time, temperature, and estimated moon phase. Each photograph recorded the time, temperature, and estimated moon phase as defined by the camera settings. We combined the observations for each species to establish the total number of detections during our 2019-2020 and 2021-2021 survey seasons. To compare the amount of detections to the amount of trap nights surveyed, we calculated the number of nights each camera was deployed and combined them to determine the total sum of trap nights. Average latency to detection was calculated for each species by taking the average of the sum of trap nights from the date the camera was deployed to the date when the first observation occurred.

Occupancy models

We estimated probability of occupancy (Ψ) and probability of detection (p) for the separate survey seasons based on detection/non-detection data using program PRESENCE 12.32 (USGS Patuxent Wildlife Research Center) (Hines 2006; MacKenzie 2010; MacKenzie et al. 2002, 2005). Detection data for each species was entered independently and models were run as separate survey-specific single species-single season models. The input for these models relied on a binary detection history for each survey site during each sampling period where "1" indicated that the species was detected and "0" indicated that it was not. Site occupancy does not deliver accurate population density, but instead determines the probability that a site is occupied by a species given imperfect detection. The model outputs provided us with naïve detection estimates which represents the proportion of sites with confirmed detections compared to the total number of sites surveyed (MacKenzie et al. 2002). Each survey period lasted for 3 days, meaning that for each 3-day period all observations counted as 1 detection, if an animal was not observed in this 3-day period it was counted as 0, not detected. Although our sites occurred in areas with similar habitat characteristics, we incorporated 2 site-specific covariates into our models that we believed to be biologically relevant to mesocarnivore detection probabilities within these environments:

canopy cover (<79%, 80-89%, and >90%) and visual obstruction (<15 cm, 15-30 cm, and >30 cm). Understanding how occupancy can be affected by these covariates will help us manage the species by focusing on research in areas with similar characteristics.

We did not collect enough detection data for bobcat, eastern spotted skunk, or striped skunk, and were, therefore, unable to run occupancy models on the species. However, for the remaining 4 species, we tested each covariate independently, combined both covariates to observe potential correlations, and ran a model with constant site occupancy (Ψ) and detection probability (p) (Table 3). We could not determine any factors that would influence detection of the species we surveyed, so p remained constant throughout all of our models (e.g. Ψ(cov) + p(constant)). We ran 4 models for each species during each survey period resulting in a total of 8 models per species. We then ranked our models based on delta Akaike's Information Criterion (ΔAIC). Models with lower ΔAIC values were ranked higher because they have more support. Strong support is given to models with a relative difference of less than 2 between the AIC values of the respective model compared to the top-ranked model, reasonable support is given to models with $4 < \Delta\text{AIC} < 7$, and no support is given to models with $\Delta\text{AIC} > 10$ (Burnham and Anderson, 2002; MacKenzie et al., 2006). The highest ranked models helped us identify the covariates that may influence Ψ for each species during the two separate survey seasons.

RESULTS

Camera trapping

We collected 2,085 mammal observations during a total of 5,287 trap nights from 95 locations. Sites were surveyed between 28 and 253 days, depending on eastern spotted skunk detection and site accessibility in response to spring flooding (Table 4). Furbearing mesocarnivores (including eastern spotted skunk) represented 761 observations (Table 5). Of the mesocarnivore observations, northern raccoon was the most frequently observed species with 345 (45.34%) separate observations followed by gray fox with 218 (28.65%) visitations, Virginia opossum with 102 (13.40%) visitations, coyote with 41 (5.39%) visitations, bobcat with 24 (3.15%) visitations, striped skunk with 19 (2.50%) visitations, and plains spotted skunk with 12 (1.58%) visitations (Figure 5). Detections rates were lower in the northern counties, but we attribute that to the shorter survey period.

In addition to being the most frequently detected species, northern raccoons were also detected at more survey sites compared to the other mesocarnivore species with striped skunk being detected in the lowest number of survey sites (Table 6). Eastern spotted skunks had the smallest average latency to detection (LTD), while bobcat detections had a larger LTD. Specifically, bobcats were detected at 17 (naïve site occupancy estimate of 17.89%) locations with 20 detections (83.33% of total observations) and an average LTD of 21 days. Coyotes were detected at 28 (naïve site occupancy estimate of 29.47%) locations with 39 detections (95.12% of total observations) and an average LTD of 18 days. Eastern spotted skunks were detected at 5 (naïve site occupancy estimate of 5.26%) locations with 9 detections (75.00% of total observations) and an average LTD of 18 days. Gray foxes were detected at 45 (naïve site occupancy estimate of 47.37%) locations with 111 detections (50.92% of total observations) and an average LTD of 12 days. Northern raccoons were detected at 74 (naïve site occupancy estimate of 77.89%) survey locations with 206 detections (59.71% of total observations) and an average LTD of 12 days. Striped skunks were detected at 8 (naïve site occupancy estimate of 8.42%) locations with 12 detections (63.16% of total observations) and an average LTD of 16 days. Virginia opossum were detected at 27 (naïve site occupancy estimate of 28.42%) locations with 70 detections (68.63% of total observations) and an average LTD of 9 days.

Habitat Measurements

Canopy cover for all survey sites consisted of a minimum of 66.72% closed, a median of 91.16%, a maximum of 100%, and an average of 88.74% (Table 7). Each species, except for eastern spotted skunk and striped skunk, was detected in areas with a canopy cover of equal or less than 70.88%. For maximum canopy cover detections, all species were detected in areas within about 3.5% of a 100% closed canopy habitat. Average canopy cover occurring at survey sites for each detected species ranged from 87.72% to 93.88%. Figure 6 illustrates a slight shift in the occurrence of each species to a denser canopy compared to all sites surveyed.

Visual obstruction for all survey sites consisted of a minimum of 3.50 cm understory density, a median of 21.00 cm, a maximum of 48 cm, and an average of 22.06 cm (Table 8). Aside from bobcat, eastern spotted skunk, and striped skunk, each species was detected in survey sites with an understory visual obstruction of equal or less than 4.40 cm. For maximum visual obstruction detections, all species were detected in areas between 45.63 cm and 48.00 cm visual obstruction. Average visual obstruction occurring at survey sites for each detected species ranged from 19.82 cm to 26.18 cm. Figure 7 illustrates a slight shift in the occurrence of bobcat and striped skunk to a denser understory vegetation density compared to all sites surveyed. Gray fox and Virginia opossum seem to have a slightly lower rate of occurrence in areas with higher understory vegetation density. Northern raccoon occurrence remained relatively uninfluenced by visual obstruction along with coyote which seems to occur in slightly denser areas than northern raccoon.

Occupancy and detection

We ran models for 47 survey sites representing the October-April 2018-2019 survey season and 51 survey sights for the October-April 2019-2020 survey season. The 4-site overlap was the result of eastern spotted skunk detections in the 2018-2019 survey season leading us to resample those 4 sites for the duration of the 2019-2020 survey season. A summary of our supported models with a ΔAIC value of less than 2 are shown in Table 9. Holding occupancy constant was supported for coyote (2018-2019), gray fox (both seasons), northern raccoon (2019-2020), and Virginia opossum (both seasons). Canopy cover was supported for all species during both seasons. Visual obstruction was supported for all of the species during both survey seasons. The correlation between canopy cover and visual obstruction was supported for coyote (both seasons), northern raccoon (2018-2019), and Virginia opossum (both seasons).

The model with highest reasonable support for coyote occupancy probabilities in eastern Oklahoma during the 2018-2019 survey season consisted of constant site occupancy and detection probabilities (Table 9) where occupancy estimates across all sites equaled 0.44 (±0.26) (Table 10). Models including canopy cover illustrate a higher occupancy probability (0.99 ±0.05) in areas with high canopy cover during the 2018-2019 survey season, however, that estimate shifted to indicate similar occupancy probabilities (0.54—0.59) for areas with each canopy type in the 2019-2020 season. Models including visual obstruction covariates suggest a higher probability (0.54 ±0.33) for areas with high visual obstruction for the 2018-2019 survey season, with similar occupancy probabilities (0.60—0.55) for areas with each visual obstruction category in the 2019-2020 season. However, models combining canopy cover and visual obstruction indicate that coyote occupancy is indicated by low to medium canopy cover and lower levels of visual obstruction.

The models with the highest reasonable support for gray fox occupancy in eastern Oklahoma for both the 2018-2019 and 2019-2020 referred to constant site occupancy and detection probabilities (Table 9) where occupancy estimates across all sites equaled 0.68 (±0.09) for the 2018-2019 survey season and 0.49 (±0.10) for the 2019-2020 survey season (Table 11). Models for gray fox indicate that the highest occupancy predictor for this species includes areas with medium to high canopy cover and low visual obstruction, which may indicate a potential preference for open understory with a dense overstory.

Canopy cover was the covariate with the highest support for northern raccoon occupancy (Table 9) in eastern Oklahoma during the 2018-2019 survey season. In this model, high canopy was the greatest indicator of northern raccoon occupancy probability (Table 12). Models including visual obstruction covariates illustrate a higher occupancy probability in areas with lower visual obstruction, however probabilities were relatively high (between 0.81 and 0.91) for each visual obstruction category. The model assessing both canopy cover and visual obstruction covariates indicates a higher occupancy probability in areas with high canopy cover and varying levels of visual obstruction. Based on canopy cover and visual obstruction covariates observed independently and together, the models for northern raccoon suggest that the highest occupancy indicator for this species includes areas with medium to high canopy cover with no preference for visual obstruction densities.

The model with the highest reasonable support for Virginia opossum occupancy probability during the 2018-2019 survey season included canopy cover (Table 9), while the model with constant parameters had the highest support during the 2019-2020 survey season. Occupancy probabilities in relation to canopy cover indicate a higher occupancy probability (0.66 ±0.25) in areas with high canopy cover during the 2018-2019 survey season

(Table 13), however, that estimate shifted to indicate a higher occupancy probability (0.53 ±0.15) in areas with low canopy cover in the 2019-2020 season. Models including visual obstruction covariates illustrate relatively low occupancy probabilities (<0.57) for each category of visual obstruction. Models combining both canopy cover and visual obstruction suggest that predictors for Virginia opossum occupancy include habitats with lower levels of canopy cover as well as lower levels of visual obstruction.

DISCUSSION

According to a study conducted in two areas of Tennessee, the average density for northern raccoon tends to be 1 individual per 70.4 ha (in western Tennessee) and 34.5 ha (in central Tennessee) (Kissell and Kennedy 1992). This could explain the high rate of observations, as there was only a 500 m^2 (0.05 ha) distance between many of our survey sites. It could be that different survey locations were visited by the same individual. Gray fox home-range can vary from 142 ha to 185 ha during the months of our survey seasons (Fuller 1978), which may explain higher observation rates for this species as well. Virginia opossum densities in suitable habitats average about 1 individual per 4 ha in the U.S. (Hunsaker 1977), but individuals normally only occupy an area for 6 months to a year (Hunsaker and Shup 1997). All of the other mesocarnivore detection rates were less than 70 which could be explained by larger home-ranges. For example, coyotes have a density of about 1 per km^2 (Knowlton 1972), bobcats have a 4-5 per 100 km^2 density (Kitchener 1991), and striped skunks have an average home-range of around 5 km^2 (Frey and Conover 2007). Interestingly, the WCS™ Rosebud Skunk Paste Bait and On-Target™ Liquid Grub Lure is specifically marketed toward attracting skunks, however, striped skunks represented the second smallest number of observations in this study compared to the other mesocarnivores discussed in this chapter.

We intentionally selected survey sites with dense canopy cover and the presence of understory vegetation. Therefore, our survey sites were biased to only include habitats with these specific variables. All species included in this study were observed in survey sites with high canopy cover. However, all mesocarnivores except striped skunks were recorded in survey sites with the lowest levels of canopy cover. Striped skunks are notable habitat generalists, but evidence supports that they are likely found in higher densities in areas with deciduous and mixed forests in a patch mosaic type landscape (Amspacher et al. 2021). However, they were also found in areas close to human structures or in lawn-type habitats near habitat corridors. Amspacher et al. (2021) suggest that this is likely due to the presence of den sites and foraging opportunities. A majority of our survey locations occurred in a pine-dominated forest, which may have contributed to the low trap success of striped skunks. Winton (1998) suggested that striped skunk populations were relatively low in northeastern Oklahoma in a study comparing furbearer trap success during 1984-1985 and 1994-1995, which could also explain our low trap success.

Due to our low detection rates of bobcat, eastern spotted skunk, and striped skunk, all generalizations that we can conclude lack significant support. Eastern spotted skunks have experienced a drastic decline over the past several decades due to multiple environmental stressors including disease, over-harvest, changing agricultural practices, loss of old forests, and shifting predator dynamics (Eng and Jachowski 2019, Gompper and Hackett 2005, Lesmeister et al. 2009, Nilz and Finck 2008, Perry et al. 2018), which is potentially the reason for the lack of observations for this species in this study. Bobcats tend to prefer wooded habitats but are less likely to be found in deeper forests (Whitaker and Hamilton 1998). This may help explain our low trap success for the species. We were able to determine naïve estimates for these species, but these estimates often underestimate the

Proportion of Area Occupied (POA) or occupancy probability because the data only represents recorded detection events. For the additional 4 species, our models suggest that canopy cover and visual obstruction were good predictors of mesocarnivore presence. Coyote occupancy seems to depend more on canopy cover, as this was the covariate measured in the model with the highest reasonable support for both seasons. The first season showed a high probability that this species would occur in areas with either low or medium canopy cover and a low probability that they would occur in sites with high canopy cover. The second season showed very similar probabilities (54-59%) that coyotes would be found across all levels of canopy cover. This could potentially be because we began adding locations from the Boston Mountains to our survey during the 2019-2020 survey season, whereas all locations surveyed in the 2018-2019 were within the Ouachita Mountains. These results are consistent with known coyote habitat preference for grasslands and edge habitats (Gier 1974). Northern raccoon also seemed to show preference for specific canopy cover levels, especially during the first survey season where there was a 92% probability that they would occur in sites with high canopy cover followed by a 10-point decrease to an 80% probability that they would occur in medium canopy cover followed by a 22-point decrease for low canopy cover site occupancy. Similar to the coyote site occupancy probabilities for the 2019-2020 survey season, northern raccoon occupancy probabilities showed probabilities (83-89%) of this species occurring in areas represented by each level of canopy cover. Northern raccoons are habitat generalists that thrive in woody habitats with hollow trees, rock crevices, or other structures that they can use as den sites (Chamberlain et al. 2002), all of which were present throughout our survey area. The highest supported models for gray fox during both seasons resulted from models with constant site parameters, however, visual obstruction was the highest rated covariate model for gray fox. For both seasons, occupancy probabilities increased as visual obstruction decreased with the 2018-2019 survey season having slightly higher occupancy estimates than 2019-2020. Gray foxes tend to prefer forested areas (Sullivan 1996) which may account for the high rate of detections in this study. Conversely, Virginia opossum occupancy probabilities seem to be influenced by a different covariate for each season with canopy cover being the most supported predictor for the 2018-2019 season and visual obstruction being the covariate with the greatest reasonable support (following the constant site parameters model) for the 2019-2020 season. During the first season, our models suggest that Virginia opossum would have a greater probability (65%) of occurring in areas with low canopy cover followed by a 21-point drop in occupancy probability for medium canopy cover (44%) and an additional 19-point drop for high canopy cover (25%). The 2019-2020 survey season showed a higher probability (57%) for areas with lower visual obstruction, and probability decreased as vegetation density increased. Virginia opossums are known as habitat generalists, however Beatty et al. (2016) suggest that they tend to avoid open grasslands and prefer forested areas with shrubby understory.

These occupancy models are important for providing a baseline understanding of habitat preference for each of these furbearers that may be useful in conducting population studies in the future. Our study does not provide accurate density measures for the species included in our analysis, but it does show patterns of occupancy that contribute to distribution data for eastern Oklahoma. Our results also provide a basis for more intensive mesocarnivore studies in eastern Oklahoma forests and in varying habitats across the state. These future studies will be invaluable in supplying ODWC and other state natural resource with more accurate distribution and population information necessary for maintaining precise conservation status information. Oklahoma's contribution to reporting authorities like NatureServe is crucial in maintaining records that can be used to monitor populations for potential conservation crises. Future studies should focus on understanding and reporting occupancy, distribution, and population density for each of these harvested furbearing mesocarnivore species across Oklahoma. It is also important for these studies to be conducted in other states that are not reporting conservation statuses for these animals. Maintaining accurate and up-to-date databases will help promote persistence of our wildlife populations by ensuring access to data and trends that may indicate a decreasing population before the decline is irreparable: a situation that was not available for eastern spotted skunks.

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CHAPTER 2 TABLES

Table 1. NatureServe conservation status for each of the detected mesocarnivore species in eastern Oklahoma during this study. Ratings are represented as follows: 5 Secure; 4 Apparently Secure; 3 Vulnerable; 2 Imperiled; 1 Critically Imperiled; and NR or No Status Rank. (Data accessed from NatureServe Explorer (https://explorer.natureserve.org/) on August 2020).

Species	Last Assessed	Global	National (U.S.)	State (Okla.)
Bobcat	2016	G5	N5	SNR
Coyote	2016	G5	N5	SNR
Eastern Spotted Skunk	2014	G4	N4	S2
Gray Fox	2016	G5	N5	S3
Northern Raccoon	2016	G5	N5	SNR
Striped Skunk	2016	G5	N5	SNR
Virginia Opossum	2016	G5	N5	SNR

Table 2. Comparison of species conservation status reported by U.S. states and Tribal Nations within the geographical area of each species. Ratings are represented as follows: 5 Secure; 4 Apparently Secure; 3 Vulnerable; 2 Imperiled; 1 Critically Imperiled; NR or No Status Rank; H or Possibly Extirpated; and X or Presumed Extirpated. (Data accessed from NatureServe Explorer (https://explorer.natureserve.org/) on August 2020).

Species	S1	S2	S3	S4	S5	SNR	SH	SX	Total
Bobcat	2.0%	4.0%	8.0%	32.0%	38.0%	14.0%	2.0%		50
Coyote				6.0%	80.0%	14.0%			50
Eastern Spotted Skunk	18.2%	18.2%	18.2%			3.8%		11.1%	26
Gray Fox	2.2%		10.9%	21.7%	54.3%	10.9%			46
Northern Raccoon				6.0%	84.0%	10.0%			50
Striped Skunk				12.0%	76.0%	12.0%			50
Virginia Opossum	4.3%		2.1%	6.4%	70.2%	17.0%			47

Table 3. Covariates used in PRESENCE 12.32 (USGS Patuxent Wildlife Research Center) models to determine mesocarnivore occupancy probabilities and a summary of what they represent.

Covariate	Definition
Ψ(.), p(.)	constant site occupancy and detection probabilities
Ψ(Canopy_Cover), p(.)	covariate assessing canopy cover
Ψ(Visual_Obstruction), p(.)	covariate assessing visual obstruction
Ψ(Canopy_Cover+Visual_Obstruction), p(.)	covariate assessing potential correlations between canopy cover and visual obstruction

Table 4. Summary of the number of days deployed for cameras with eastern spotted skunk detections including the minimum, maximum, mean, range, and standard deviation for both categories. Site inaccessibility due to spring flooding contributed to survey periods longer than a month for locations with no eastern spotted skunk detections.

	without detection	**with detection**
min	28	184
max	93	253
mean	47.013	223.8
range	65	69
SD	23.281	31.412

Table 5. Comparison of furbearing mesocarnivore detections between the northern survey counties and southern counties in eastern Oklahoma during October-April (2018-2019 and 2019-2020) within camera trapping survey. Lower rates of northern detections can be attributed to a shorter survey period (January-April 2020).

Species	Southern detections	Northern detections	Total
Bobcat	20	4	24
Coyote	39	2	41
Gray Fox	204	14	218
Northern Raccoon	330	15	345
Eastern Spotted Skunk	12	0	12
Striped Skunk	18	1	19
Virginia Opossum	100	2	102
Total	**723**	**38**	**761**

Table 6. Summary of furbearing mesocarnivore detections in eastern Oklahoma during October-April (2018-2019 and 2019-2020) within camera trapping survey. Northern and southern county detections combined. Includes the number of locations detected, total observations, total detections (in 3-day detection period), average latency to detection (LTD), and naïve occupancy estimates.

Species	**# locations detected**	**Total observations**	**# detections**	**Avg. LTD (days)**	**Naïve estimates**
Bobcat	17	24	20	21	0.1789
Coyote	28	41	39	18	0.2947
Gray Fox	45	218	111	12	0.4737
Northern Raccoon	74	345	206	12	0.7789
Eastern Spotted Skunk	5	12	9	7	0.0526
Striped Skunk	8	19	12	16	0.0842
Virginia Opossum	27	102	70	9	0.2842

Table 7. Percent canopy cover at sites with species detections compared to canopy cover across all survey sites in eastern Oklahoma during the 2018-2019 and 2019-2020 survey seasons. Includes minimum, median, maximum, and average % canopy cover.

	Canopy cover			
	Minimum	**Median**	**Maximum**	**Average**
All Locations	66.72%	91.16%	100.00%	88.74%
Bobcat	70.88%	93.76%	97.60%	89.60%
Coyote	70.88%	89.21%	98.57%	87.72%
Eastern Spotted Skunk	88.50%	96.04%	96.62%	93.88%
Gray Fox	66.72%	93.11%	97.66%	89.63%
Northern Raccoon	66.72%	91.16%	98.96%	88.77%
Striped Skunk	81.93%	92.01%	96.49%	90.74%
Virginia Opossum	66.72%	88.89%	98.96%	88.88%

Table 8. Visual obstruction (cm) in relation to understory density at sites with species detections compared to visual obstruction across all survey sites. Includes minimum, median, maximum, and average (cm) visual obstruction.

	Visual obstruction			
	Minimum (cm)	**Median (cm)**	**Maximum (cm)**	**Average (cm)**
All Locations	3.50	21.00	48.00	22.06
Bobcat	8.00	25.00	45.63	26.18
Coyote	4.40	21.22	48.00	22.84
Eastern Spotted Skunk	6.33	15.00	45.63	19.82
Gray Fox	3.50	19.38	48.00	19.83
Northern Raccoon	3.50	20.38	48.00	21.51
Opossum	3.50	19.00	45.63	19.95
Striped Skunk	8.50	23.50	45.63	22.68

Table 9. PRESENCE occupancy model selection ranks for furbearing mesocarnivores detected in eastern Oklahoma during October-April (2018-2019 and 2019-2020). Akaike Information Criteria (AIC), difference between the AIC values of the respective model compared to the top-ranked model (ΔAIC), AIC weight (wi), and number of model parameters (k).

	2018-2019 Survey Season					*2019-2020 Survey Season*				
Species	**Model**	**AIC**	**ΔAIC**	***wi***	**k.**	**Model**	**AIC**	**ΔAIC**	***wi***	**k.**
Coyote	Ψ(Canopy_Cover), p(.)	108.66	0.00	0.3381	3	Ψ(Canopy_Cover), p(.)	260.42	0.00	0.4163	3
	Ψ(.), p(.)	108.77	0.11	0.3200	2	Ψ(Visual_Obstruction), p(.)	260.43	0.01	0.4142	3
	Ψ(Canopy_Cover+Visual_Obstruction), p(.)	109.66	1.00	0.2051	4	Ψ(Canopy_Cover+Visual_Obstruction), p(.)	262.40	1.98	0.1547	4
	Ψ(Visual_Obstruction), p(.)	110.47	1.81	0.1368	3					
Gray Fox	Ψ(.), p(.)	446.49	0.00	0.4629	2	Ψ(.), p(.)	333.61	0.00	0.4015	2
	Ψ(Visual_Obstruction), p(.)	447.08	0.59	0.3446	3	Ψ(Visual_Obstruction), p(.)	334.18	0.57	0.3020	3
	Ψ(Canopy_Cover), p(.)	448.25	1.76	0.1920	3	Ψ(Canopy_Cover), p(.)	335.30	1.69	0.1725	3
Northern Raccoon	Ψ(Canopy_Cover), p(.)	610.82	0.00	0.5110	3	Ψ(.), p(.)	596.22	0.00	0.5214	2
	Ψ(Visual_Obstruction), p(.)	612.33	1.51	0.2402	3	Ψ(Canopy_Cover), p(.)	598.07	1.85	0.2067	3
	Ψ(Canopy_Cover+Visual_Obstruction), p(.)	612.33	1.51	0.0240	4	Ψ(Visual_Obstruction), p(.)	598.19	1.97	0.1947	3
Virginia Opossum	Ψ(Canopy_Cover), p(.)	266.31	0.00	0.3512	3	Ψ(.), p(.)	264.24	0.00	0.3255	2
	Ψ(.), p(.)	266.51	0.20	0.3178	2	Ψ(Visual_Obstruction), p(.)	264.75	0.51	0.2523	3
	Ψ(Canopy_Cover+Visual_Obstruction), p(.)	267.69	1.38	0.1761	4	Ψ(Canopy_Cover), p(.)	264.99	0.75	0.2237	3
	Ψ(Visual_Obstruction), p(.)	268.02	1.71	0.1494	3	Ψ(Canopy_Cover+Visual_Obstruction), p(.)	265.23	0.99	0.1984	4

Table 10. PRESENCE occupancy model outputs with reasonable support for coyote detected in eastern Oklahoma during October-April (2018-2019 and 2019-2020). Includes seasons occupancy probability estimates ($\hat{\Psi}$), detection probability estimates ($\hat{p}$), and standard error (SE) for models with constant parameters (Ψ(.), p(.)), canopy cover covariates Ψ(Canopy_Cover), p(.), visual obstruction covariates (Ψ(Visual_Obstruction), p(.)), and canopy cover + visual obstruction covariates (Ψ(Canopy_Cover+Visual_Obstruction), p(.)).Blank fields indicate models that lacked reasonable support.

	Coyote	*2018-2019 Survey Season*				*2019-2020 Survey Season*			
	Covariate Values	$\hat{\Psi}$	**±1SE**	$\hat{p}$	**±1SE**	$\hat{\Psi}$	**±1SE**	$\hat{p}$	**±1SE**
Constant Parameters		0.4432	0.2587	0.0307	0.0199				
Canopy Cover	Low	0.9908	0.0467	0.0304	0.0147	0.5436	0.1854	0.0553	0.0132
	Medium	0.8824	0.2811	0.0304	0.0147	0.5680	0.1217	0.0553	0.0132
	High	0.3431	0.1937	0.0304	0.0147	0.5921	0.1634	0.0553	0.0132
Visual Obstruction	Low	0.3578	0.2595	0.0314	0.0201	0.5969	0.1986	0.0552	0.0132
	Medium	0.4456	0.2578	0.0314	0.0201	0.5732	0.1223	0.0552	0.0132
	High	0.5369	0.3377	0.0314	0.0201	0.5491	0.1787	0.0552	0.0132
Canopy Cover + Visual Obstruction	Low; Low	1.0000	0.0000	0.0287	0.0126	0.5691	0.2504	0.0553	0.0132
	Low; Medium	1.0000	0.0000	0.0287	0.0126	0.5470	0.1871	0.0553	0.0132
	Low; high	1.0000	0.0000	0.0287	0.0126	0.5247	0.2222	0.0553	0.0132
	Medium; Low	1.0000	0.0000	0.0287	0.0126	0.5918	0.1988	0.0553	0.0132
	Medium; Medium	1.0000	0.0000	0.0287	0.0126	0.570	0.1227	0.0553	0.0132
	Medium; High	1.0000	0.0000	0.0287	0.0126	0.5479	0.1786	0.0553	0.0132
	High; Low	0.1985	0.1730	0.0287	0.0126	0.6141	0.2165	0.0553	0.0132
	High; Medium	0.3686	0.2162	0.0287	0.0126	0.5927	0.1626	0.0553	0.0132
	High; High	0.5791	0.3308	0.0287	0.0126	0.5708	0.2147	0.0553	0.0132

Table 11. PRESENCE occupancy model outputs with reasonable support for gray fox detected in eastern Oklahoma during October-April (2018-2019 and 2019-2020). Includes seasons occupancy probability estimates ($\widehat{\Psi}$), detection probability estimates ($\hat{p}$), and standard error (SE) for models with constant parameters (Ψ(.), p(.)), canopy cover covariates Ψ(Canopy_Cover), p(.), and visual obstruction covariates (Ψ(Visual_Obstruction), p(.)).

	Gray Fox	*2018-2019 Survey Season*				*2019-2020 Survey Season*			
	Covariate Values	$\widehat{\Psi}$	**±1SE**	$\hat{p}$	**±1SE**	$\widehat{\Psi}$	**±1SE**	$\hat{p}$	**±1SE**
Constant Parameters		0.6766	0.0886	0.1299	0.0171	0.4869	0.0981	0.0882	0.0153
Canopy Cover	Low	0.5432	0.2887	0.1299	0.0171	0.4149	0.1556	0.0884	0.0154
	Medium	0.6223	0.1413	0.1299	0.0171	0.4796	0.0985	0.0884	0.0154
	High	0.6954	0.0961	0.1299	0.0171	0.5450	0.1451	0.0884	0.0154
Visual Obstruction	Low	0.7770	0.1147	0.1296	0.0171	0.6444	0.1668	0.0886	0.0152
	Medium	0.6622	0.0935	0.1296	0.0171	0.4932	0.1013	0.0886	0.0152
	High	0.5245	0.1596	0.1296	0.0171	0.3433	0.1392	0.0886	0.0152

Table 12. PRESENCE occupancy model outputs with reasonable support for northern raccoon detected in eastern Oklahoma during October-April (2018-2019 and 2019-2020). Includes seasons occupancy probability estimates ($\hat{\Psi}$), detection probability estimates ($\hat{p}$), and standard error (SE) for models with constant parameters (Ψ(.), p(.)), canopy cover covariates Ψ(Canopy_Cover), p(.), visual obstruction covariates (Ψ(Visual_Obstruction), p(.)), and canopy cover + visual obstruction covariates (Ψ(Canopy_Cover+Visual_Obstruction), p(.)). Blank fields indicate models that lacked reasonable support.

Northern Raccoon		2018-2019				2019-2020			
Covariate Variables		$\hat{\Psi}$	**±1SE**	$\hat{p}$	**±1SE**	$\hat{\Psi}$	**±1SE**	$\hat{p}$	**±1SE**
Constant Parameters						0.8656	0.0596	0.1159	0.0123
Canopy Cover	Low	0.5780	0.2717	0.1595	0.0158	0.8314	0.1145	0.0351	0.0282
	Medium	0.8000	0.1011	0.1595	0.0158	0.8635	0.0601	0.0351	0.0282
	High	0.9212	0.0645	0.1595	0.0158	0.8904	0.0804	0.0351	0.0282
Visual Obstruction	Low	0.9059	0.0723	0.1618	0.0156	0.8783	0.0964	0.0344	0.0279
	Medium	0.8635	0.0631	0.1618	0.0156	0.8659	0.0596	0.0344	0.0279
	High	0.8061	0.1381	0.1618	0.0156	0.8524	0.1056	0.0344	0.0279
Canopy Cover + Visual Obstruction	Low; Low	0.6799	0.2777	0.1600	0.0157				
	Low; Medium	0.5572	0.2743	0.1600	0.0157				
	Low; high	0.4271	0.3427	0.1600	0.0157				
	Medium; Low	0.8612	0.1158	0.1600	0.0157				
	Medium; Medium	0.7862	0.1050	0.1600	0.0157				
	Medium; High	0.6854	0.2109	0.1600	0.0157				
	High; Low	0.9477	0.0591	0.1600	0.0157				
	High; Medium	0.9149	0.0660	0.1600	0.0157				
	High; High	0.8642	0.1245	0.1600	0.0157				

Table 13. PRESENCE occupancy model outputs with reasonable support for Virginia opossum detected in eastern Oklahoma during October-April (2018-2019 and 2019-2020). Includes seasons occupancy probability estimates ($\hat{\Psi}$), detection probability estimates ($\hat{p}$), and standard error (SE) for models with constant parameters (Ψ(.), p(.)), canopy cover covariates Ψ(Canopy_Cover), p(.), visual obstruction covariates (Ψ(Visual_Obstruction), p(.)), and canopy cover + visual obstruction covariates (Ψ(Canopy_Cover+Visual_Obstruction), p(.)).

Virginia Opossum		*2018-2019*				*2019-2020*			
	Covariate Variables	$\hat{\Psi}$	**±1SE**	$\hat{p}$	**±1SE**	$\hat{\Psi}$	**±1SE**	$\hat{p}$	**±1SE**
Constant Parameters		0.3047	0.0727	0.1581	0.0257	0.4110	0.1011	0.0693	0.0148
Canopy Cover	Low	0.6555	0.2479	0.1580	0.0257	0.2587	0.1408	0.0703	0.0147
	Medium	0.4465	0.1388	0.1580	0.0257	0.3875	0.1007	0.0703	0.0147
	High	0.2548	0.0747	0.1580	0.0257	0.5342	0.1586	0.0703	0.0147
Visual Obstruction	Low	0.3588	0.1115	0.1579	0.0258	0.5724	0.1748	0.0703	0.0147
	Medium	0.2908	0.0749	0.1579	0.0258	0.4131	0.1032	0.0703	0.0147
	High	0.2311	0.1169	0.1579	0.0258	0.2701	0.1308	0.0703	0.0147
Canopy Cover; Visual Obstruction	Low; Low	0.7344	0.2432	0.1573	0.0258	0.3911	0.2126	0.0707	0.0147
	Low; Medium	0.6576	0.2558	0.1573	0.0258	0.2394	0.1425	0.0707	0.0147
	Low; high	0.5715	0.2970	0.1573	0.0258	0.1336	0.1188	0.0707	0.0147
	Medium; Low	0.5272	0.1790	0.1573	0.0258	0.5610	0.1758	0.0707	0.0147
	Medium; Medium	0.4365	0.1430	0.1573	0.0258	0.3851	0.1035	0.0707	0.0147
	Medium; High	0.3498	0.1769	0.1573	0.0258	0.2348	0.1269	0.0707	0.0147
	High; Low	0.3103	0.1110	0.1573	0.0258	0.7178	0.1912	0.0707	0.0147

CHAPTER 2 FIGURES

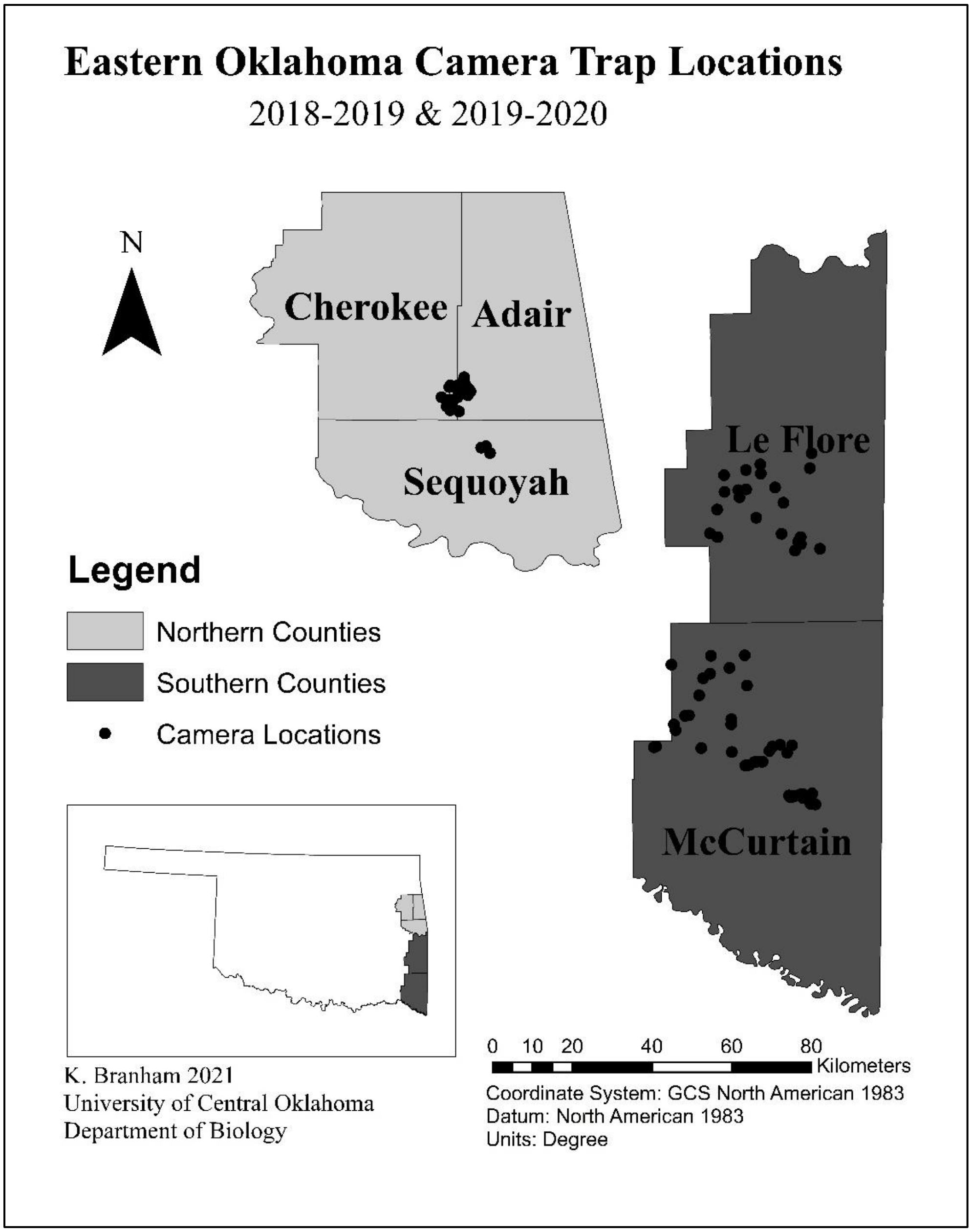

Figure 1. Study area for mesocarnivore camera trapping survey in eastern Oklahoma indicating camera-trap locations in the 3 more northern counties (light gray) and 2 southern counties (dark gray).

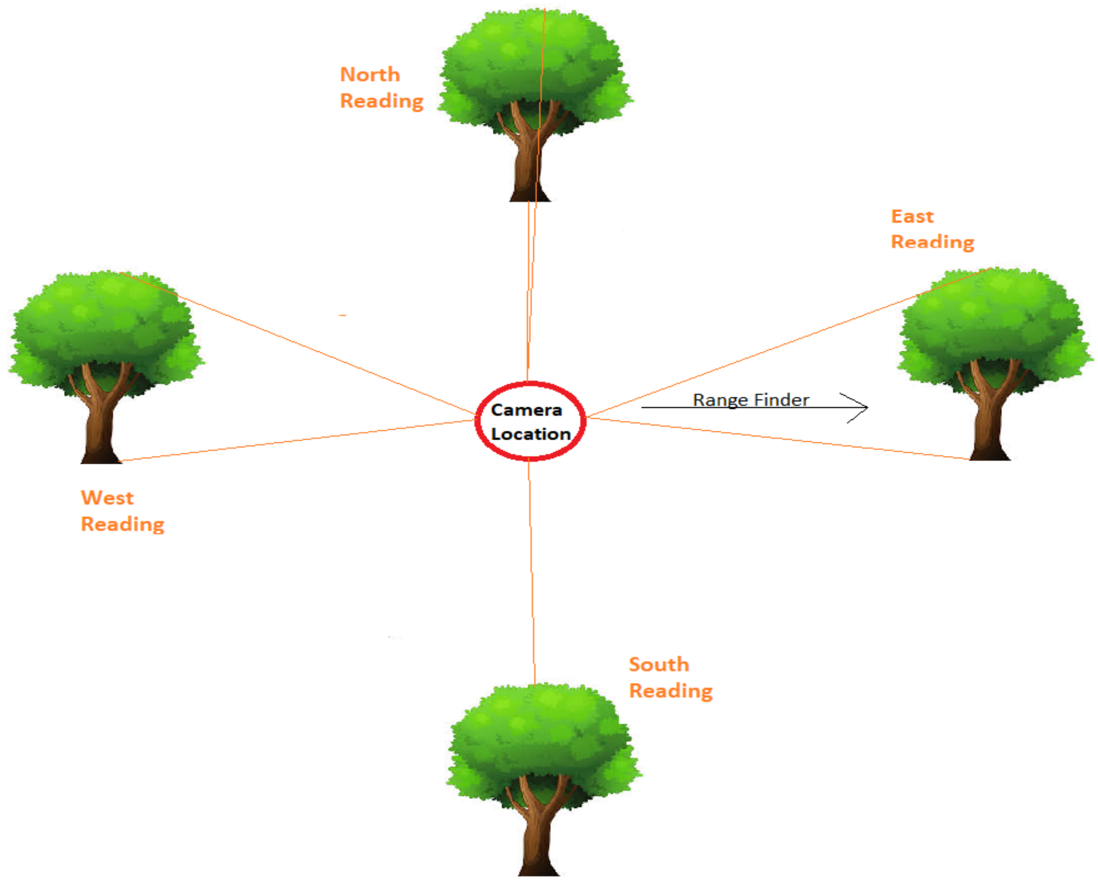

Figure 2. Illustration of tree height measurements using a Clinometer (Suunto Oy, Vantaa, Finland) to record angle and a Simmons 801600 Volt 600 Laser Rangefinder (Bushnell, Overland Park, KS) to record distance.

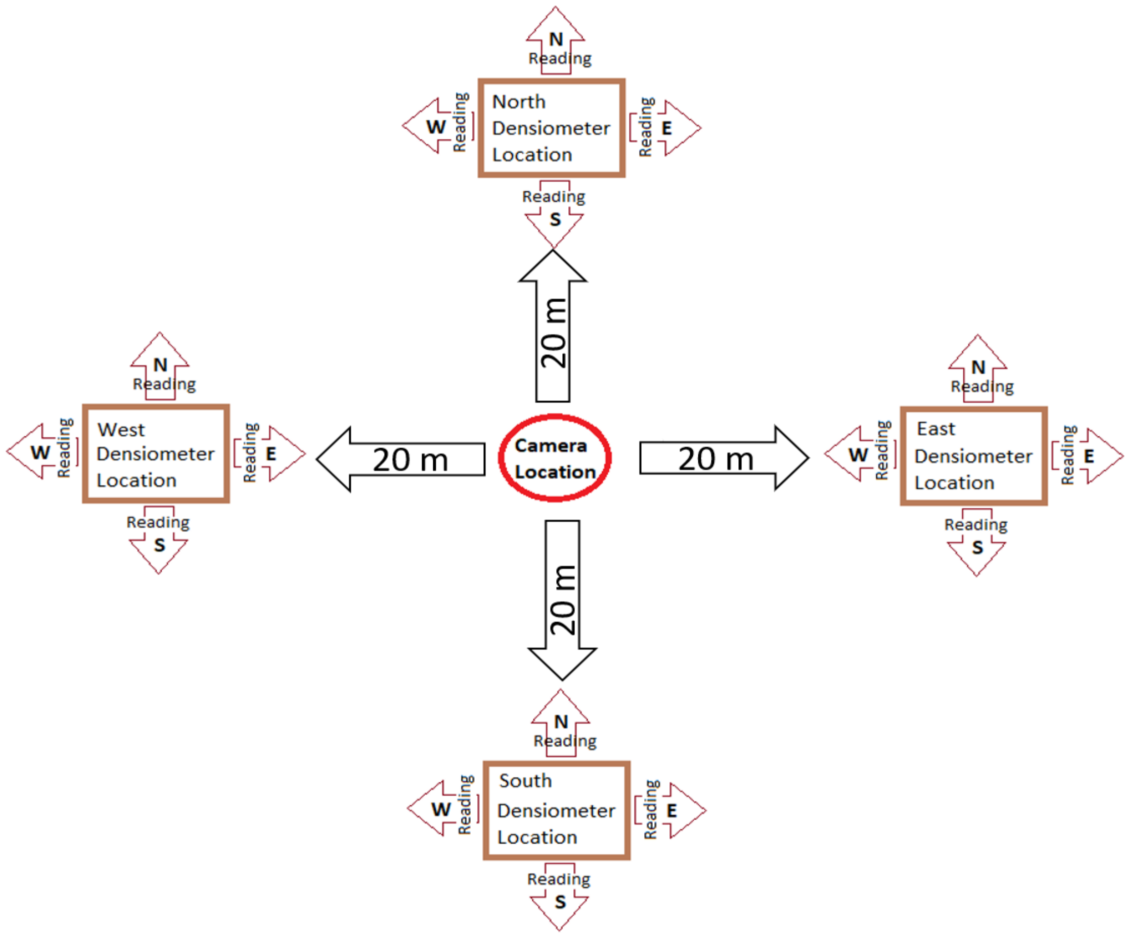

Figure 3. Illustration of the 16 crown densitometer (Forestry Suppliers, Jackson, MS) readings used to determine average canopy cover.

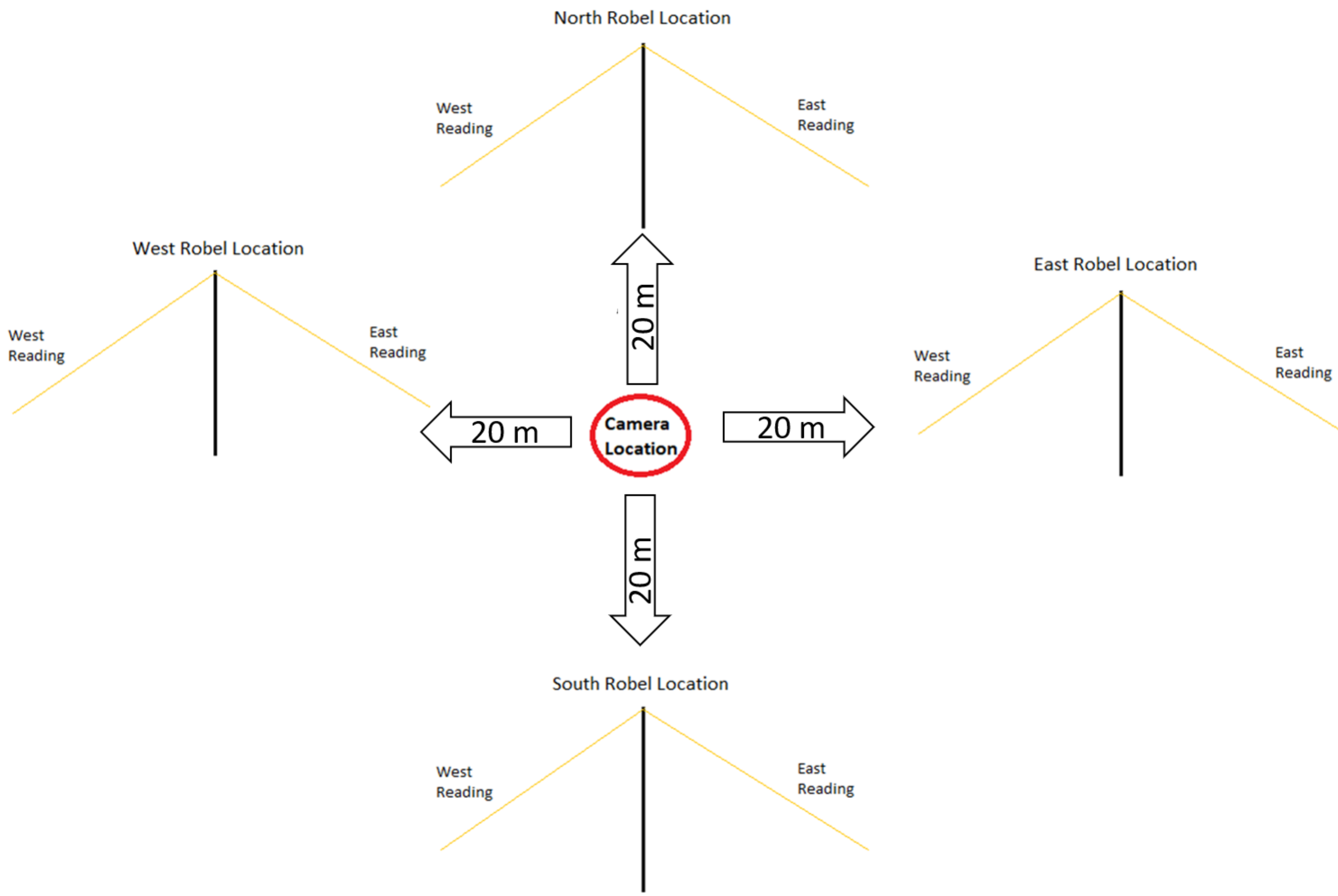

Figure 4. Illustration of the 16 Robel pole readings used to determine average visual obstruction or understory density.

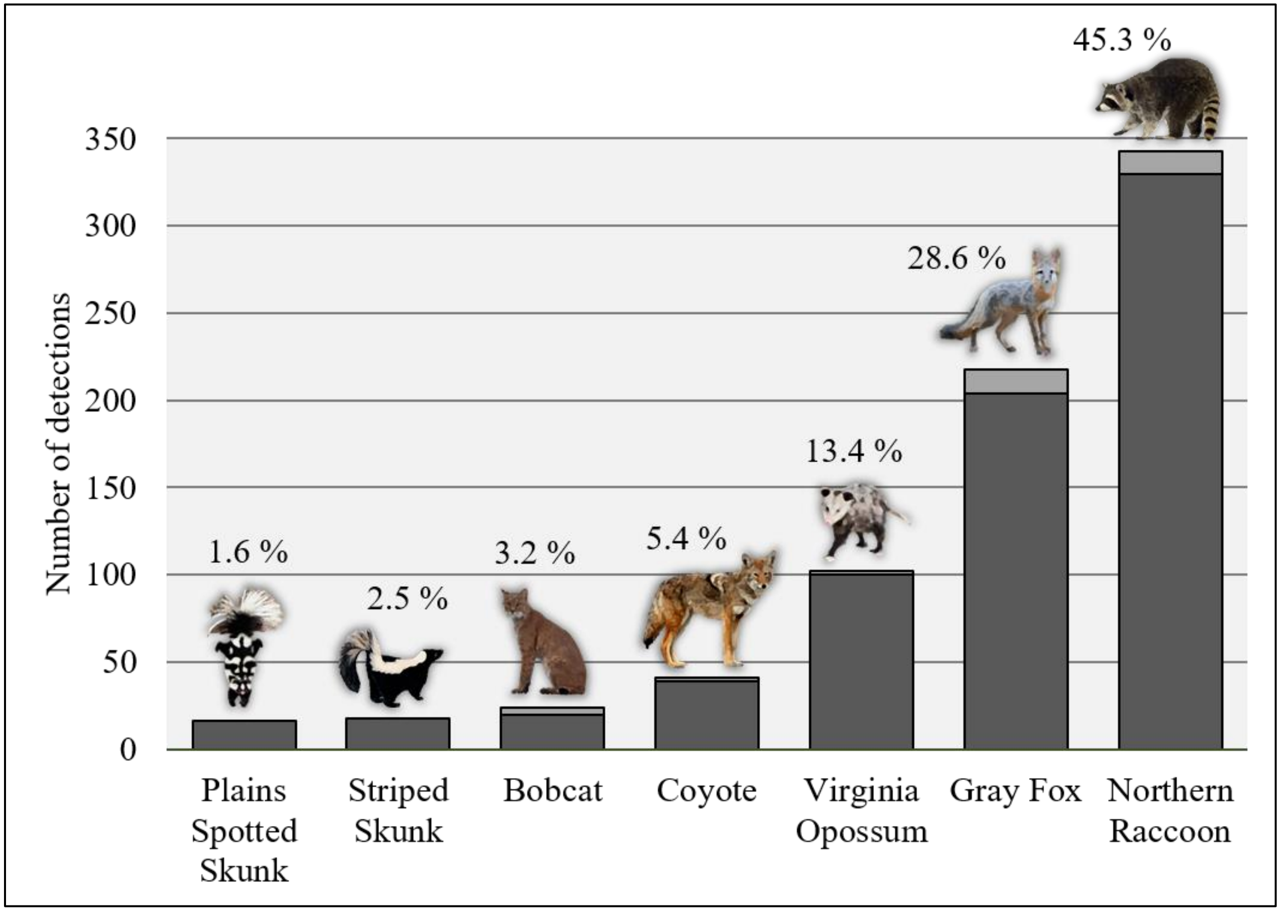

Figure 5. Comparison of furbearing mesocarnivore detections between the northern survey counties and southern survey counties in eastern Oklahoma during October-April (2018-2019 and 2019-2020) within camera trapping survey. Dark grey represents species detections in the southern survey counties. Light grey represents species detections in the northern survey counties.

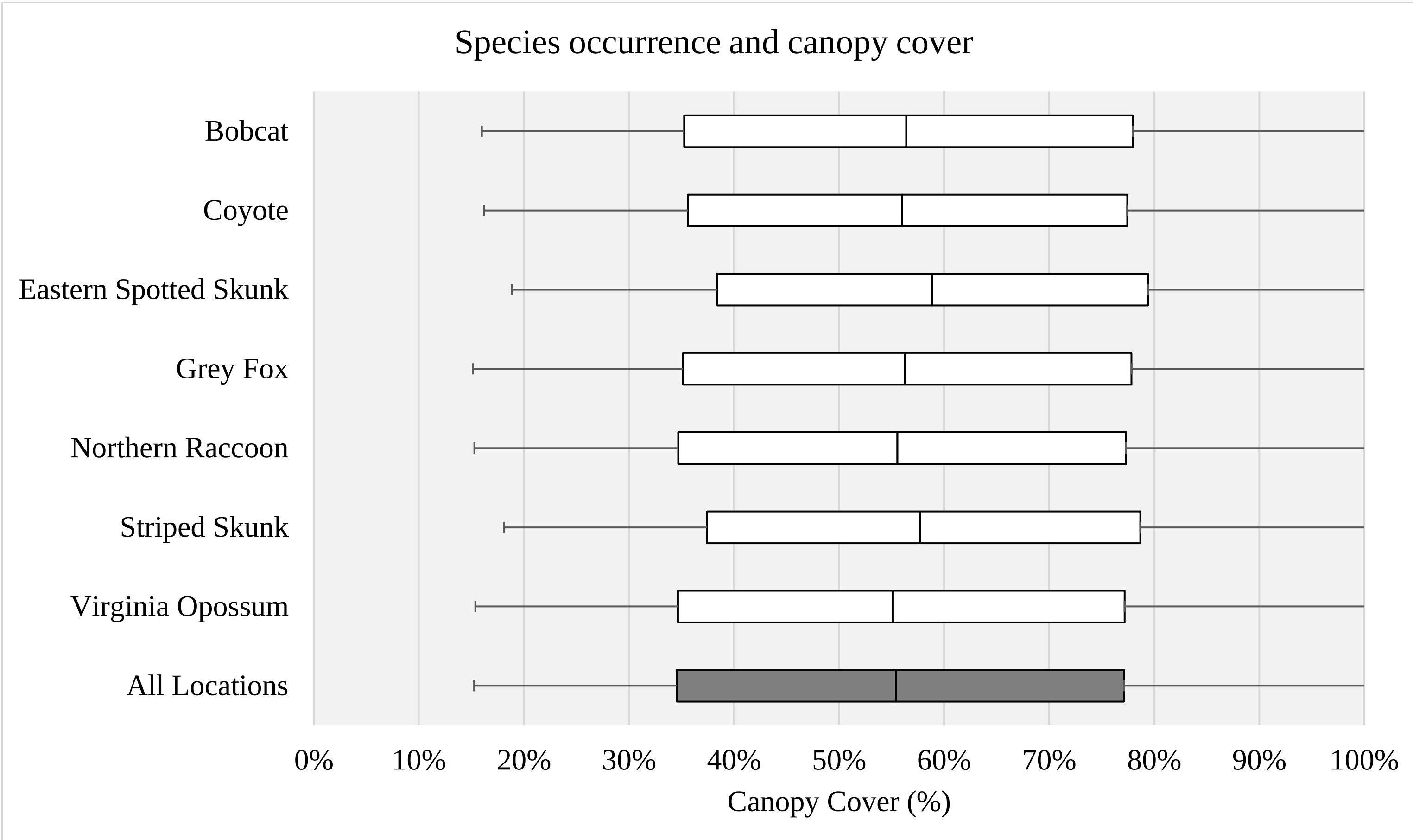

Figure 6. Graph comparing species detection in relation to percent canopy cover for all locations. Includes the first quartile, third quartile, median, minimum, and maximum values of canopy cover data collected at each survey sight.

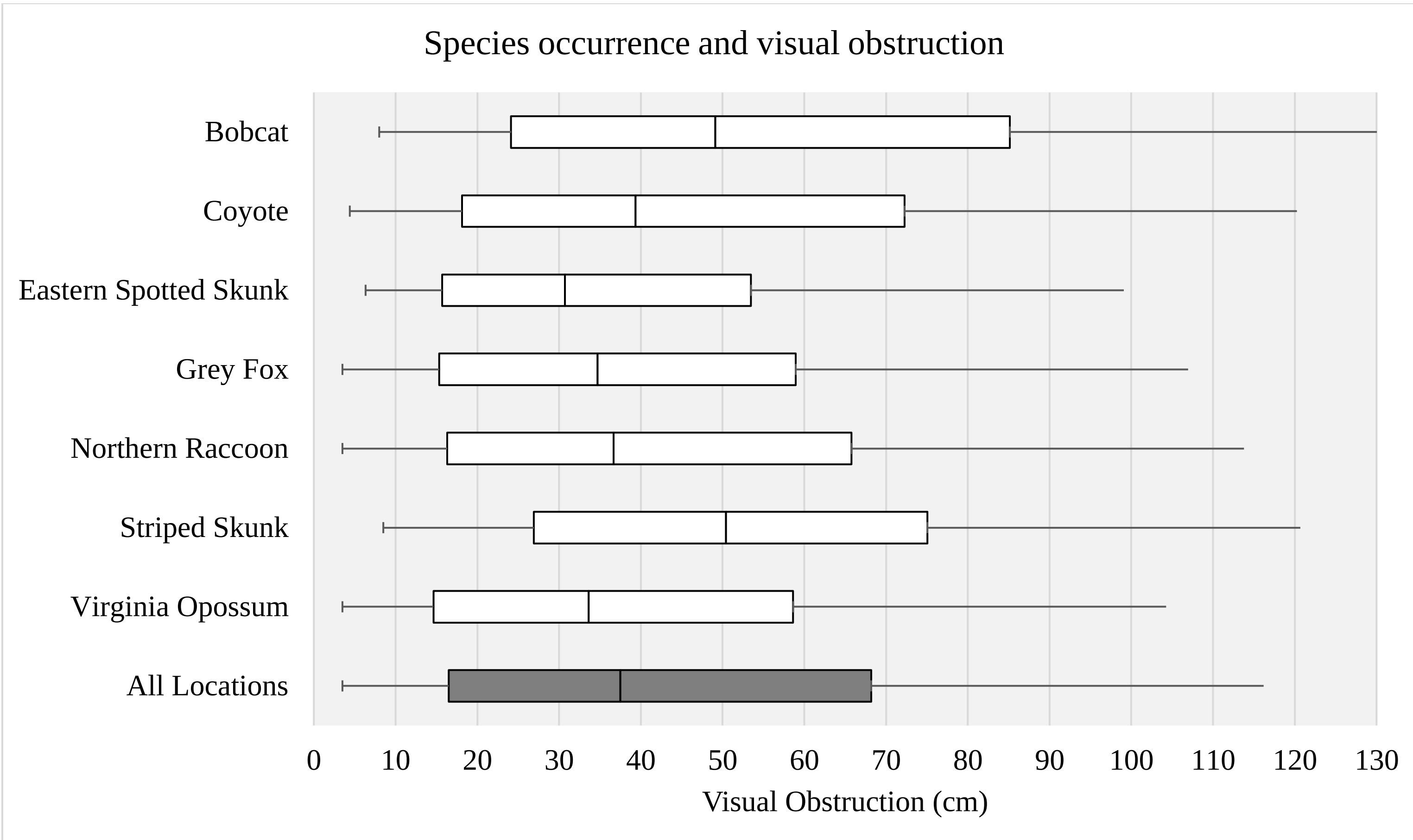

Figure 7. Species detection in relation to % canopy cover for all locations. Includes the first quartile, third quartile, median, minimum, and maximum values of canopy cover data collected at each survey sight.

Chapter 3: Integrating Human-Dimensions Survey to Understand Mesocarnivore Perceptions in Eastern Oklahoma

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ABSTRACT

Understanding human-dimensions and utilizing citizen science enhances our ability to manage wildlife by providing a basis for both citizen involvement and societal input that we can use to gauge a more accurate perspective on wildlife in eastern Oklahoma and best ways to manage that wildlife. We utilized a human dimensions survey to gather information that contributes to making better and more up to date management decisions for eastern spotted skunks (*Spilogale putorius*) and other harvested furbearing mesocarnivore species in the area, as well as identify various stakeholders and understanding recreational land use of the area. We conducted this research through mailing post cards to random addresses in Adair, Cherokee, LeFlore, McCurtain, and Sequoyah counties, Oklahoma. These post cards included information and a link to an online survey that was divided into four sections: pre-survey verification and informed consent, general perceptions of mesocarnivore species, eastern spotted skunk observations, and surveyor biases/demographic information. Results from our study will provide valuable information for a species of conservation concern while simultaneously gathering data for harvested species that are sometimes overlooked. We anticipate that this information will be useful in making more informed and efficient wildlife management decisions in eastern Oklahoma.

KEY WORDS citizen science, eastern spotted skunks, furbearers, human-dimensions, Oklahoma, stakeholders.

INTRODUCTION

The study of human dimensions is an important element that provides a basis for both citizen involvement and societal input to better understand wildlife inhabiting an area and the best ways to manage that wildlife. The term "human dimensions" refers to how and why humans value natural resources, how humans want resources managed, and how humans affect or are affected by natural resources management decisions (Decker et al. 2001). Citizen science is closely related to human dimensions and refers to the collection and analysis of data relating to the natural world by members of the general public, typically as part of a collaborative project with professional scientists (Parrish et al. 2018). Citizen science can provide an opportunity for researchers to gather data remotely from individuals who may be more familiar with certain study areas.

Stedman et al. (2004) successfully utilized human dimensions surveys to understand hunter behavior and use it as a tool to both manage wildlife and understand how hunters may react to potential management changes. Similarly, Cleary et al. (2021) used human-dimensions surveys to understand how public may respond to increases in black bear populations in eastern Oklahoma. These studies provide us with examples on what is possible by surveying human populations to gain insight necessary to manage wildlife with public responses in mind. Our focus was not to initiate any specific management strategy or to survey responses for future wildlife management or population changes, but rather to ascertain current perspectives by local community members. We decided to integrate this method to respond to challenges associated with our larger goal of assessing the potential distribution of eastern spotted skunks (*Spilogale putorius)* in eastern Oklahoma. Our study area is approximately 400 km from the University of Central Oklahoma in Edmond, Oklahoma. This distance restricted the amount of time we were able to spend in the study area. Limited access, in addition to the reduced population density and elusive behavior of the focal species, provided challenges that could be overcome by gaining information from the people living in eastern Oklahoma. We decided to use a human dimensions survey to combat challenges and potentially collect additional eastern spotted skunk location and observation data. We also used this opportunity to explore public opinions relating to the other harvested furbearing mesocarnivore species detected in the study area to determine if there are potential trends in perception that may assist in future management strategies. These species include coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), bobcat (*Lynx rufus*), raccoon (*Procyon lotor*), Virginia opossum (*Didelphis virginiana*), and striped skunk (*Mephitis mephitis*) (Branham and Jackson 2021).

Our goals for initiating this survey were to 1) provide data for a species of conservation concern while 2) simultaneously gathering data on harvested species that are largely understudied (see Chapter 2 of this thesis). We also hoped to identify various stakeholders of the area as well as popular recreational outdoor activities that may contribute to perception trends. Results from this study will provide insight on plains spotted skunk observation rates from residents in eastern Oklahoma. We anticipate that results from this study will also supply us with valuable information regarding the general public's perceptions on mesocarnivores that may open opportunities to close knowledge gaps on each of these species. We believe that the information from this survey will be useful in launching similar studies that will build a more complete picture necessary for making more informed and efficient wildlife management decisions in Oklahoma.

STUDY AREA

Between the months of March and October 2021, our human dimensions survey was sent to randomly selected recipients in the 5 counties included in our plains spotted skunk distribution study: Adair, Cherokee, LeFlore, McCurtain, and Sequoyah counties (Figure 1). These counties incorporated two Level III ecoregions (U.S. Environmental Protection Agency 2013) in eastern Oklahoma where eastern spotted skunks have recently been confirmed: the Ouachita Mountains in southeast Oklahoma and Boston Mountains in northeastern Oklahoma. The Ouachita Mountains are dominated by *Pinus* (pine)–deciduous forests with varying levels of vegetation densities in the understory and is laced with small ephemeral and perennial streams carving the rugged terrain (Bales et al. 2005). Annual rainfall averages approximately 134.6 cm and average annual temperature is 16.1 °C in this region (Laney 2017c, d). The Boston Mountains are characterized by sharp changes in elevations ranging from 200 m to 800 m (U. S. Department of Agriculture 1981). This ecoregion is dominated by *Quercus* (oak)–*Carya* (hickory) forests with *Pinus echinata* (shortleaf pine) occurring at higher elevations (Lustig et al. 2021). Average annual rainfall is about 123.8 cm and average annual temperature is 17.7 °C in this part of the state (Laney 2017a, b, e).

METHODS

Our study was determined to be exempt from IRB under 45 CFR 46.110, for research involving no more that minimal risk (December 14, 2020, Office of Research Integrity and Compliance, University of Central Oklahoma, Edmond, OK). Informed consent (and HIPAA authorization) was obtained from subjects and documented prior to research involvement. We distributed postcards to random addresses throughout five counties in eastern Oklahoma following a similar approach by Mullendore et al. 2014. Based on previous surveys, the average response rate for Oklahoma is about 20% (Betsey York, ODWC, Personal Communication). Our goal was to obtain 500 responses, so we purchased an address panel containing 3,500 addresses that are within the study area from Dynata (Shelton, CT, USA). We excluded addresses listed as vacant or seasonal residents. The list of addresses purchased were imported to an excel spreadsheet and were each paired with an individualized random code made up of 6 characters including letters and numerical values (ex. WR368D). This code was used to determine whether or not individuals at the corresponding address have participated in the survey. We designed our post-cards with information about the project and instructions to access the online survey, and attempted to make them visually appealing to increase participation (Figure 3) (Kaplowitz et al. 2011). We sent those designs and our address panel to R.K. Black Office (Edmond, OK 74034, United States). Our first round of 3,500 post-cards were printed and mailed on 25 March 2021. On 7 June 2021, we removed addresses with the corresponding codes that were entered into the survey, indicating respondent participation. We followed up with the 1,500 remaining postcards by sending them to 1,500 randomly selected addresses from our updated address list. Separately, we included our survey link in various social media posts to broaden our audience in an effort to potentially compare results from eastern Oklahoma to other areas.

The online survey was conducted through Qualtrics (Provo, Utah, USA), which provided us with results as they were submitted. Our survey was divided into four sections: pre-survey verification and informed consent form, general perceptions of mesocarnivore species, eastern spotted skunk observations, and demographic information. The pre-survey verification and informed consent form section included a space to record the individualized random code found on the post card or indicate where they received the survey link. Following, the respondent was provided with the informed consent form and were prompted to either consent or not consent. Those who consented were sent to the general perceptions section of the survey, and those who did not consent were sent to the end of the survey. The general perceptions section was comprised of 4 questions assessing each mesocarnivore species on a 5-point Likert scale with an additional "I don't know" option. Respondents were asked if they believed the species is a threat to their produce or livestock, is overabundant, is beneficial to its habitat, and if they have noticed an increase or decrease in species observations (Table 1).

The eastern spotted skunk observation section included one main question: Have you ever personally observed an eastern spotted skunk? Respondents who selected "Yes" were given an additional set of questions to provide additional information on their sighting (Table 1). Respondents who selected "No" were sent to the final section. The additional questions regarding the respondent's sighting included when the last observation occurred, where the last observation occurred, additional observation information, and whether or not the individual would like to discuss their sighting with a researcher. If the respondent was interested in speaking with us, they were given the option to provide contact information. The final section assessing demographics included questions aimed at understanding potential biases as well as demographics of the respondents. These questions included asking the respondent for their postal code, living situation, amount of time spent outdoors, species of live stock owned (if any), gender, age, ethnicity, and education level (Table 1).

RESULTS

We obtained 123 total responses (24.6% of our goal) who agreed to participate after reading informed consent. Only 66 responses (13.2%) included the individualized random code in the pre-survey verification, however, 79 responses (15.8%) were within our survey area according to postal code answers (Figure 4). There were more responses from individuals located in the northern portion of our survey area.

All 79 individuals located in the study area answered each of the 4 questions assessing the general perceptions of each mesocarnivore species. When it came to perceived threats against livestock, responses for coyotes and bobcats seemed to indicate these two species are the most threatening while Virginia opossums and striped skunks are perceived to be the least threatening (Figure 5). Specifically, for coyotes, 11 individuals (13.9%) strongly disagreed that this species was a threat to produce or livestock, 11 (13.9%) somewhat disagreed, 5 (6.3%) neither agreed nor disagreed, 30 (38.0%) somewhat agreed, 21 (26.6%) strongly agreed, and 1 (1.3%) did not know. As for bobcats, 16 (20.3%) strongly disagreed, 12 (15.2%) somewhat disagreed, 13 (16.5%) neither agreed nor disagreed, 27 (34.2%) somewhat agreed, 10 (12.7%) strongly agreed, and 1 (1.3%) did not know. On the other hand, 32 (40.5%) strongly disagreed that Virginia opossums were a threat to produce or livestock, 18 (22.8%) somewhat disagreed, 9 (11.4%) neither agreed nor disagreed, 15 (19.0%) somewhat agreed, 4 (5.1%) strongly agreed, and 1 (1.3%) did not know. For striped skunks, 29 (36.7%) strongly disagreed, 18 (22.8%) somewhat disagreed, 18 (22.8%) neither agreed nor disagreed, 10 (12.7%) somewhat agreed, 0 strongly agreed, and 4 (5.1%) did not know.

The second question assessing general perceptions indicated that respondents disagreed more than agreed that each of the species (except Virginia opossums) were overabundant in the area (Figure 6). Virginia opossums were the only species where the sum of responses agreeing to the statement were greater than the sum of the responses in disagreement. For this species, 15 (19.0%) strongly disagreed that this species was overabundant, 12 (15.2%) somewhat disagreed, 19 (24.1%) neither agreed nor disagreed, 13 (16.5%) somewhat agreed, 20 (25.3%) strongly agreed, and 0 did not know. On the other hand, gray fox and bobcat had the highest rates of disagreement. For gray fox, 39 (49.4%) strongly disagreed that this species was overabundant, 18 (19.0%) somewhat disagreed, 16 (21.5%) neither agreed nor disagreed, 2 (2.5%) somewhat agreed, 1 (1.3%) strongly agreed, and 3 (3.8%) did not know. As for bobcats, 35 (44.3%) strongly disagreed, 17 (21.5%) somewhat disagreed, 15 (19.0%) neither agreed nor disagreed, 3 (3.8%) somewhat agreed, 5 (6.3%) strongly agreed, and 4 (5.1%) did not know. For eastern spotted skunks, a large proportion indicated that they didn't know compared to the other 6 species. Specifically, 34 (43.0%) strongly disagreed, 11 (13.9%) somewhat disagreed, 14 (17.7%) neither agreed nor disagreed, 4 (5.1%) somewhat agreed, 1 (1.3%) strongly agreed, and 15 (19.0%) did not know.

When it comes to whether or not each species is beneficial to the habitat it occupies, at least 50% of all respondents indicated that all species are beneficial (Figure 7). Less than 12 respondents (15.2%) indicated that they did not believe that some animals were beneficial to the habitat they occupy. Of these species, gray fox and bobcat seem to have the highest rates of respondents that agreed that they were beneficial to their habitat. For gray fox, 2 (2.5%) strongly disagreed that this species was beneficial, 1 (1.3%) somewhat disagreed, 9 (11.4%) neither agreed nor disagreed, 27 (34.2%) somewhat agreed, 21 (44.3%) strongly agreed, and 5 (6.3%) did not know. As for bobcat, 2 (2.5%) strongly disagreed, 0 somewhat disagreed, 9 (11.4%) neither agreed nor disagreed, 32 (40.5%) somewhat agreed, 31 (39.2%) strongly agreed, and 5 (6.3%) did not know. Conversely, 6 (7.6%) strongly disagreed that striped skunks were beneficial, 6 (7.6%) somewhat disagreed, 13 (16.5%) neither agreed nor disagreed, 26 (32.9%) somewhat agreed, 23 (29.1%) strongly agreed, and 5 (6.3%) did not know. Similar to the previous question, a large proportion indicated that they didn't know whether eastern spotted skunks were beneficial compared to the other species. Specifically, 5 (6.3%) strongly disagreed, 6 (7.6%) somewhat disagreed, 13 (16.5%) neither agreed nor disagreed, 19 (24.1%) somewhat agreed, 21 (26.6%) strongly agreed, and 15 (19.0%) did not know.

The last question in this section was intended to determine whether or not respondents have noticed changes in observation rates for each species. Most responses indicated that the rate of gray fox observations decreased the most, that detections did not change for striped skunk observations, that the rate of coyote observations increased the most, and that many respondents did not know for eastern spotted skunks (Figure 8). For gray fox, 15 (19.0%) indicated a notable decrease in observation rates, 14 (17.7%) indicated a slight decrease, 31 (39.2%) indicated no change, 9 (11.4%) indicated a slight increase, 0 indicated a notable increase, and 4 (12.7%) indicated that they did not know. For striped skunks, 3 (3.8%) indicated a notable decrease, 6 (7.6%) indicated a slight decrease, 44 (55.7%) indicated no change, 10 (12.7%) indicated a slight increase, 10 (12.7%) indicated a notable increase, and 6 (7.6%) indicated that they did not know. For coyotes, 5 (6.3%) indicated a notable decrease, 8 (10.1%) indicated a slight decrease, 36 (45.6%) indicated no change, 18 (22.8%) indicated a slight increase, 8 (10.1%) indicated a notable increase, and 4 (5.1%) indicated that they did not know. For eastern spotted skunks, 11 (13.9%) indicated a notable decrease, 7 (8.9%) indicated a slight decrease, 24 (30.4%) indicated no change, 1 (1.3%) indicated a slight increase, 1 (1.3%) indicated a notable increase, and 35 (44.3%) indicated that they did not know.

All 79 individuals located in the study area answered the main question in the section attempting to gather eastern spotted skunk observation data. Of these respondents, 13 (16.5%) indicated that they had personally observed an eastern spotted skunk (locations shown in Figure 4). Of those 13 respondents, 3 (23.1%) indicated that their last observation occurred within the last year, 3 (23.1%) indicated that their last observation occurred between last year and 5 years ago, 1 (8.0%) indicated that their last observation occurred between 5 and 10 years ago, 3 (23.1%) responses were vague or unclear, and 3 (23.1%) declined to indicate when their last observation occurred. Only 3 individuals included additional observation information, however 2 of these responses lacked information for further elucidation of the observation. Of the 13, 4 individuals stated that they would be interested in speaking with a researcher about their observation, and all 4 provided contact information. Of these 4 individuals, 2 had observed an eastern spotted skunk within the last year, 1 had observed an eastern spotted skunk between 5 and 10 years ago, and 1 provided an unclear answer as to when their last observation occurred.

The last section was aimed at assessing surveyor biases and demographic information. In this section, 73 continued with the survey and included their postal code. Of these 73 respondents, 59 (80.8%) described their living situation as rural, 10 (13.7%) described living in a suburban setting, and 4 (5.5%) indicated that they lived in an urban setting (Figure 9). For the question assessing time spent outdoors (Figure 10), 47 (64.4%) of respondents indicated that they spent more than 60% of their time outdoors, 19 (26.0%) indicated that they spend between 30% and 59% of their time outdoors, 11 (15.1%) indicated that they spend between 10% and 29% of their time outdoors, and no one indicated that they spent less than 10% of their time outdoors.

When asked if the respondent own(ed) livestock, 42 (57.5%) indicated that they do/did own livestock (Figure 11). Of these livestock owners, 15 (35.7%) indicated that they owned poultry, 12 (28.6%) indicated that they owned cattle, 8 (19.0%) indicated that they owned an unlisted "other" species, 3 (7.1%) indicated that they owned goats, 2 (4.8%) indicated that they owned pigs, 2 (4.8%) indicated that they own sheep.

The next question asked respondents to "check off" outdoor activities that they participate in. Gardening and exercise were the most reported outdoor activities, while mountain biking and trapping were the least reported (Figure 12). Of the 73 respondents who answered this question, 56 (76.7%) participated in gardening, 50 (68.5%) walking/running/jogging, 41 (56.2%) camping, 40 (54.8%) fishing, 36 (49.3%) hiking, 30 (41.1%) bird watching, 27 (37.0%) hunting, 26 (35.6%) canoeing/kayaking, 25 (34.2%) photography, 17 (23.3%) "other," 8 (11.0%) climbing, 4 (5.5%) mountain biking, and 3 (4.1%) trapping.

The following questions were intended to gather basic demographic information from the respondents. Of the 73 respondents, 26 (35.6%) described themselves as male, and 47 (64.4%) described themselves as female (Figure 13). Of these respondents, 1 (1.4%) was under 18, 5 (6.8%) were between the ages of 18 and 24, 7 (9.6%) were between the ages of 25 and 34, 16 (21.9%) were between the ages of 35 and 44, 18 (24.7%) were between the ages of 45 and 54, 17 (23.3%) were between the ages of 55 and 64, 8 (11.0%) were between the ages of 65 and 74, 0 were between the ages of 75 to 84, and 1 (1.4%) was 85 or older (Figure 14). For the question attempting to gauge ethnicity of the respondents, 49 (67.1%) of respondents described themselves as White, 21 (28.8%) described themselves as American Indian or Alaskan Native, 2 (2.7%) described themselves as Hispanic, 1 (1.3%) described themselves as someone other than the ethnicities listed, and none of the respondents described themselves as either Asian or Black or African American (Figure 15). Most respondents indicated that the highest degree or level of school completed was a “4-year degree” followed by “some college”, while the education level indicated least was “less than high school” (Figure 16). Two (2.7%) respondents selected that the highest education level was “less than high school”, 10 (13.7%) selected “high school graduate”, 17 (23.3%) selected “some college”, 7 (9.6%) selected “2-year degree”, 20 (27.4%) selected “4-year degree”, 10 (13.7%) selected “professional degree”, and 7 (9.6%) selected “doctorate”.

DISCUSSION

We were unsuccessful in reaching our goal of 500 responses, however, we were able to collect responses from all areas of our survey site. Therefore, we assume that all our post cards were delivered around our survey area. Two locations in Sequoyah and Cherokee counties had noticeably higher response rates. One of these locations is near the city of Sallisaw in Sequoyah County and the other is near the city of Tahlequah in Cherokee County. Sallisaw is the hometown of the surveyors, so higher rates may be due to name recognition. Tahlequah is the capitol of the Cherokee Nation and location of Northeastern State University, which may have also contributed to higher response rates. Our limited sample size prevents us from assuming public perceptions across Oklahoma, however it does give us a glimpse into how residents in rural eastern Oklahoma may perceive these animals. Coyotes and bobcats were perceived to be the most threatening to livestock whereas Virginia opossums and striped skunks were perceived to be the least threatening to livestock. A majority of the respondents own livestock, with poultry making up the highest percentage of livestock ownership, immediately followed by cattle. Therefore, we can infer that general livestock ownership, as well as the type(s) of livestock owned, may have influenced this answer. Conversely, respondents tend to believe that each of the species listed in the survey were beneficial to their respective habitat, even if they were perceived to be a threat to livestock and produce. When it came to perceived abundance, respondents indicated that they felt that all of the species, with the exception of Virginia opossums, are overabundant in the survey area. Observation rates for gray fox decreased the most while observation rates for coyotes increased. For eastern spotted skunks specifically, most respondents disagreed that this species was a threat to livestock, that they either did not know or believed that this species was not abundant, and they either did not know or noticed a decrease in observations.

Much of the land in eastern Oklahoma is rural, so it is not surprising that a majority of the respondents indicated that they lived in a rural situation. Furthermore, the majority of respondents spend more than half of their time outdoors with gardening and exercise being the highest reported outdoor activities. These particular factors may have had an impact on the survey respondents' perceptions of the species in the survey, as they may increase the chances for humans to come in contact with wildlife and/or increase the possibility of wildlife damage to livestock and produce. Additionally, more than 60% of the respondents identified as female, more than 60% were between the age of 25 and 64, ethnicity was made up of mostly "White" individuals followed by "American Indian or Alaskan Native," and a majority indicated that their education level was at least "some college." Understanding how demographics influence perceptions of wildlife may help with natural resource education and outreach planning along with promoting wildlife conservation in ways that appeal to stakeholders. In a survey examining the social context of wildlife management across the U.S., Manfredo et al. (2018) determined that wildlife value orientation types vary by ethnicity (orientation types defined in Table 2). For example, Whites had a larger proportion of

"Traditionalists" when compared to other ethnic groups, and actually doubled compared to Hispanic/Latino and Asian "Traditionalists". On the opposite side of the spectrum, Whites represented the lowest proportion of "Distanced" individuals, which were mostly represented within Black/African American, Asian, and American Indian/Alaska Native ethnic groups. "Mutualists" made up the largest proportions for Hispanic/Latinos and Asians, and American Indian/Alaska Natives had the highest proportion of Pluralists. Further, Manfredo et al. (2018) discovered different wildlife-related recreation activities in both past participation and future interest. Whites and Native Americans tended to have higher participation and interest in hunting and fishing compared to other ethnic groups. Additionally, Whites, Native Americans, and Hispanics had the highest participation and interest in wildlife viewing activities compared to Blacks and Asians. A majority of individuals who responded were rural White and Native Americans, therefore, we would expect a majority of our respondents to have Traditionalist and Pluralist wildlife value orientations as defined by Manfredo et al. (2018). Understanding these slight variations may be an important contributing factor in developing and maintaining conservation strategies in eastern Oklahoma while simultaneously providing insights necessary for strengthening communication between scientists and the public.

Our low return rate makes it difficult to determine perception trends based on the responses relating to the individual's demographics or assumed biases. In the future, we expect to explore potential differences in perceptions depending on the respondents' age, gender, and education level. We also look forward to understanding if the amount of time the respondent spends outdoors, the types of activities the respondent participates in, or the ownership of livestock influence the way respondents perceive these mesocarnivores within eastern Oklahoma, however, due to our small sample size, we do not believe that these outcomes will serve as a reliable indicator to the general perceptions of this area. Lastly, we hope to compare the perceptions of the respondents from eastern Oklahoma to the respondents located in the rest of Oklahoma and in other states. Our survey successfully made 4 connections with community members of the study area who are interested in discussing their recent eastern spotted skunk sightings. This may potentially create additional opportunities for future eastern spotted skunk distribution studies. Our survey also provided a glimpse into how the public views furbearing mesocarnivores located in eastern Oklahoma forests. Assessing these additional species is important, as they are largely underrepresented in population studies due to their perceived abundance.

In future human dimensions studies, we recommend a more intensive follow-up procedure to increase participation. Stedman et al. (2004) sent surveys to hunters in order to understand hunter behavior with a higher success rate. They attribute their higher response rate to informing camp owners of the surveys before the survey was sent out. Cleary et al. (2021) initiated a human-dimensions survey in eastern Oklahoma in 2018. They had a 15.6% response rate, even with the option of mailing surveys back and follow-up phone calls. It seems that participation and response rates for human-dimension surveys has been declining over the last few decades, especially when compared to higher response rates in the past. (Connelly et al. 2003, Stedman et al. 2019).

Due to the important data that human dimension surveys can contribute, a critical component to continued success is to understand how to increase public engagement with human dimensions work. Involving stakeholders is integral to planning and implementing wildlife management strategies and efficient conservation landscape design (Bartuszevige et al. 2016). This involvement will increase productivity for conserving species of conservation concern, but may also help manage species that may be detrimental to an ecosystem such as an overabundant or invasive species (Jonker et al. 2010). Results from our study, although limited, do successfully contribute additional insight on eastern spotted skunk observation rates from residents in eastern Oklahoma. We were also able to gain useful information on general public perceptions of furbearing mesocarnivores of eastern Oklahoma that may aid in planning future studies aimed at closing knowledge gaps for each of these species. We hope that the information resulting from this survey will be applicable in designing similar studies intended on providing information to make more informed and efficient wildlife management decisions in Oklahoma.

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We thank B. York, Human Dimensions Specialist for the Oklahoma Department of Wildlife Conservation, for her direction, guidance, and ability to help us navigate through this study. Funding for this project was provided by the ODWC and USFWS through a Federal Assistance Grant funding from the State Wildlife Grant Program.

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CHAPTER 3 TABLES

Table 1. Questions and the associated response type included in each section of the human-dimensions survey conducted on Qualtrics (Provo, Utah, USA).

Section	Question	Response type
General perceptions	Statement: I believe that the following animal is a threat to produce or livestock.	5-point Likert scale
	Statement: I believe that the following animal is overabundant in my area.	5-point Likert scale
	Statement: I believe that the following animal is beneficial to the habitat that it currently occupies.	5-point Likert scale
	Statement. I have noticed the following changes in sightings of the following animal.	5-point Likert scale
Eastern spotted skunk observation	Have you ever personally observed an eastern spotted skunk?	Yes or no
	(*If "yes" on previous question*) Please indicate on the map where this observation occurred.	Heat map
	If you would like to contribute additional Eastern Spotted Skunk information, you may do so here.	Open answer
	Would you be interested in speaking with a researcher about your sighting?	Yes or no

	(*If "yes" on previous question*) Please provide details for your preferred method of contact. Includes name, phone number, email address, and mailing address.	Short answer
Surveyor biases and demographic information	What is your postal code?	Short answer
	How would you classify your living situation?	Multiple choice
	About how much time do you spend outdoors?	Sliding scale
	Which of the following outdoor activities do you participate in? Please select all that apply.	Checklist
	What is your gender?	Multiple choice
	How would you describe yourself? Please select all that apply.	Checklist
	What is the highest degree or level of school you have completed?	Multiple choice

Table 2. Explanations for each wildlife value orientation type from where Manfredo et al. (2018) analyzed responses from individuals across the U.S.to determine America's Wildlife Values.

Orientation type	**Explanation**
Traditionalists	"Score high (above the midpoint) on the dominion scale and low (at or below) the midpoint on the mutualism scale; i.e. they are the most extreme in beliefs that wildlife should be used and managed for the benefit of people"
Mutualists	"score high on the mutualism scale and low on the dominion scale; i.e., they are the most extreme in seeing wildlife as part of their extended social network"
Pluralists	Score high on both mutualism and dominion scales; i.e. different situations or contexts result in this group emphasizing one orientation over the other"
Distance	"Score low on both mutualism and dominion scales; i.e., they exhibit low levels of thought about and interest in wildlife"

CHAPTER 3 FIGURES

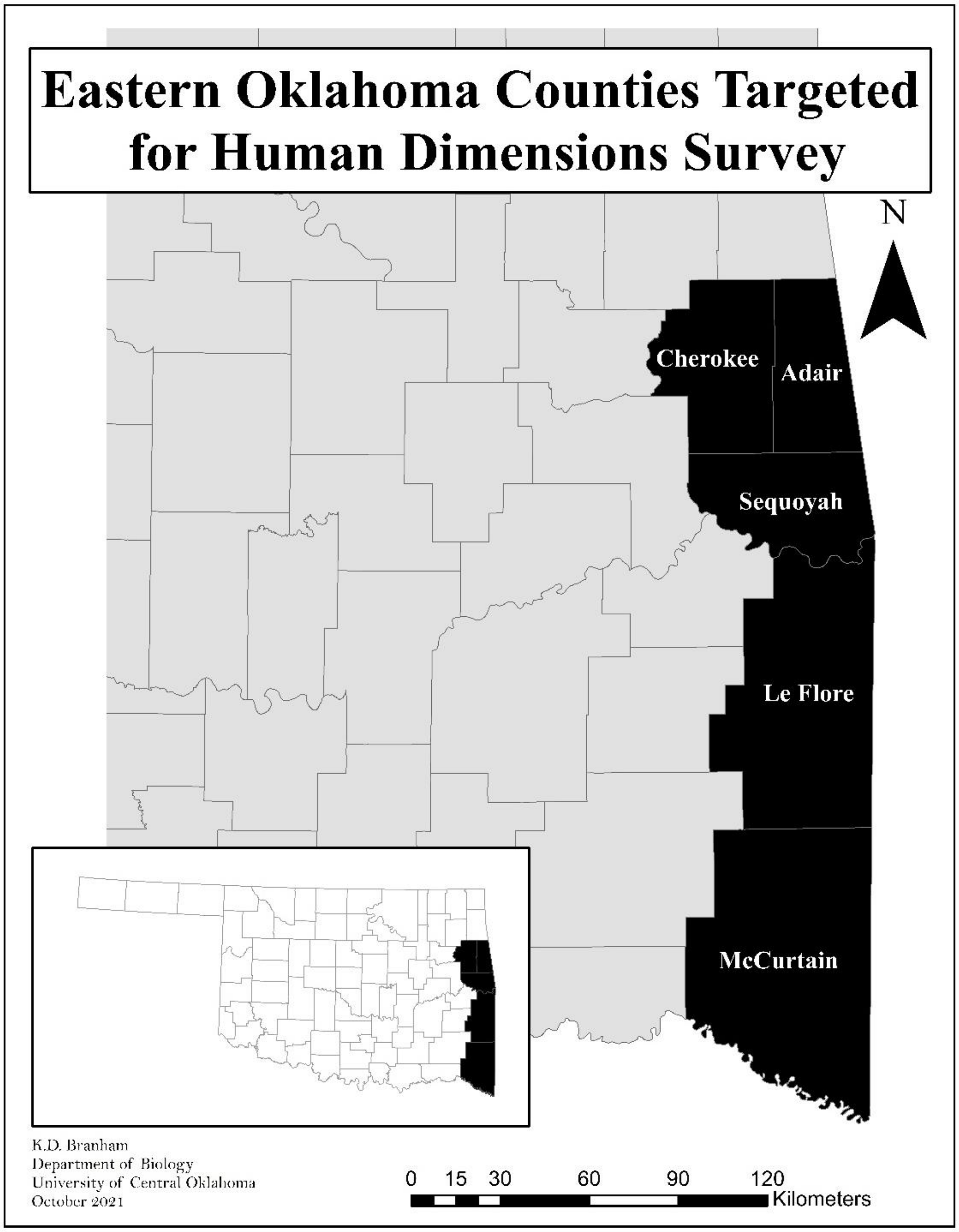

Figure 1. Map of eastern Oklahoma counties included in human-dimensions survey area in relation to the rest of Oklahoma.

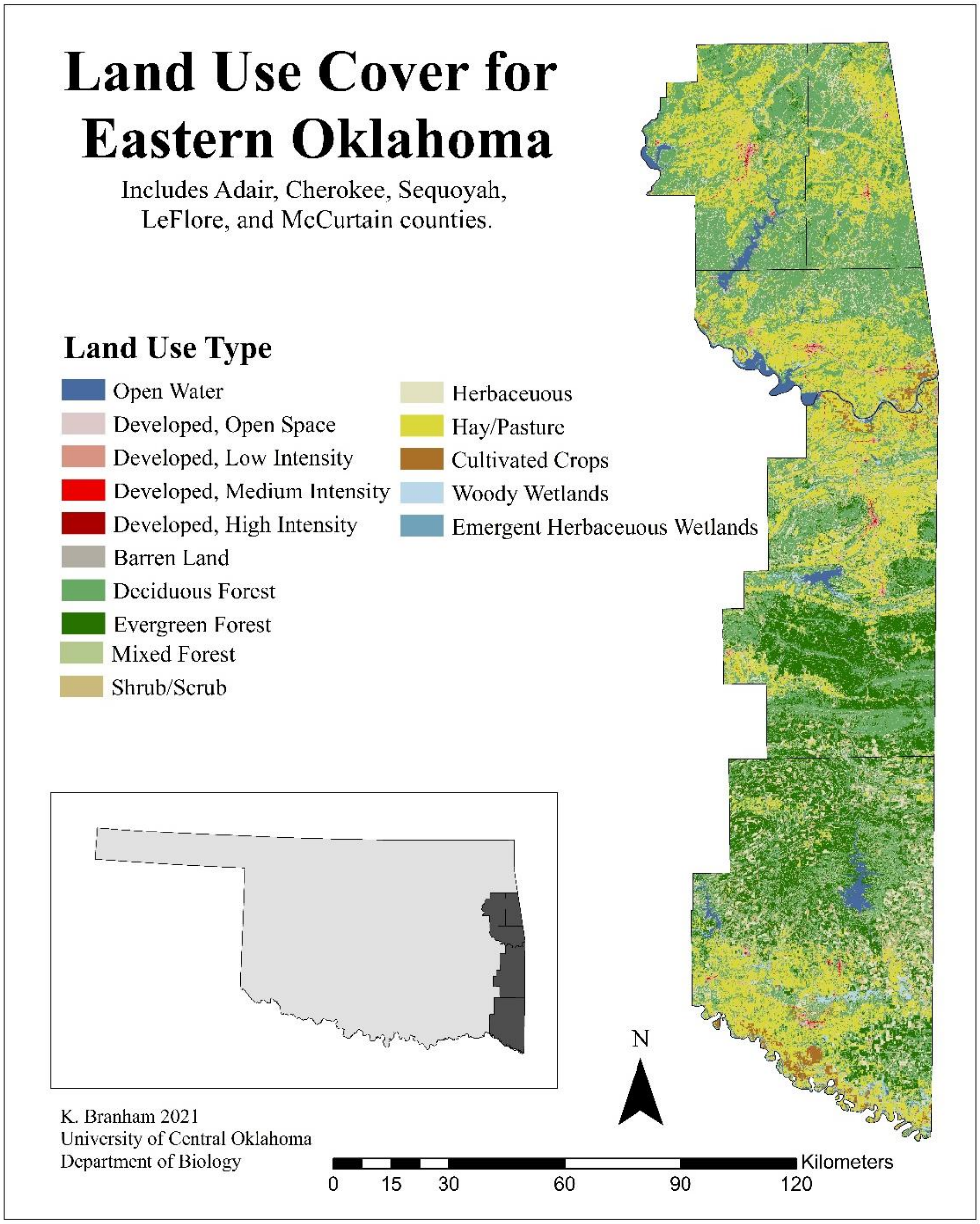

Figure 2: Map of land cover for eastern Oklahoma counties included in the human-dimensions survey. Cover type information downloaded from the U.S. Geological Survey (https://www.usgs.gov/core-science-systems/science-analytics-and-synthesis/gap/science/land-cover-data-download?qt-science_center_objects=0#qt-science_center_objects) accessed on 27 June 2019.

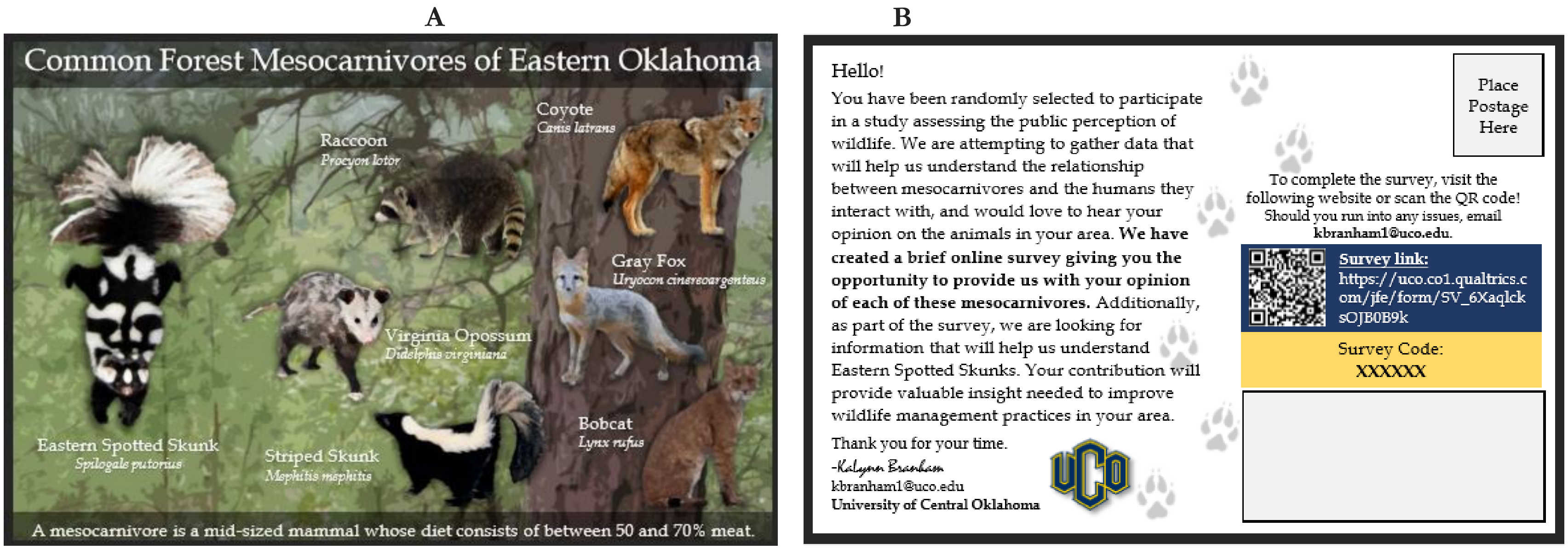

Figure 3. Post-card design distributed for human-dimensions survey including an artistic illustration on the front side (A), and information about the project including instructions to access the online survey on the back (B).

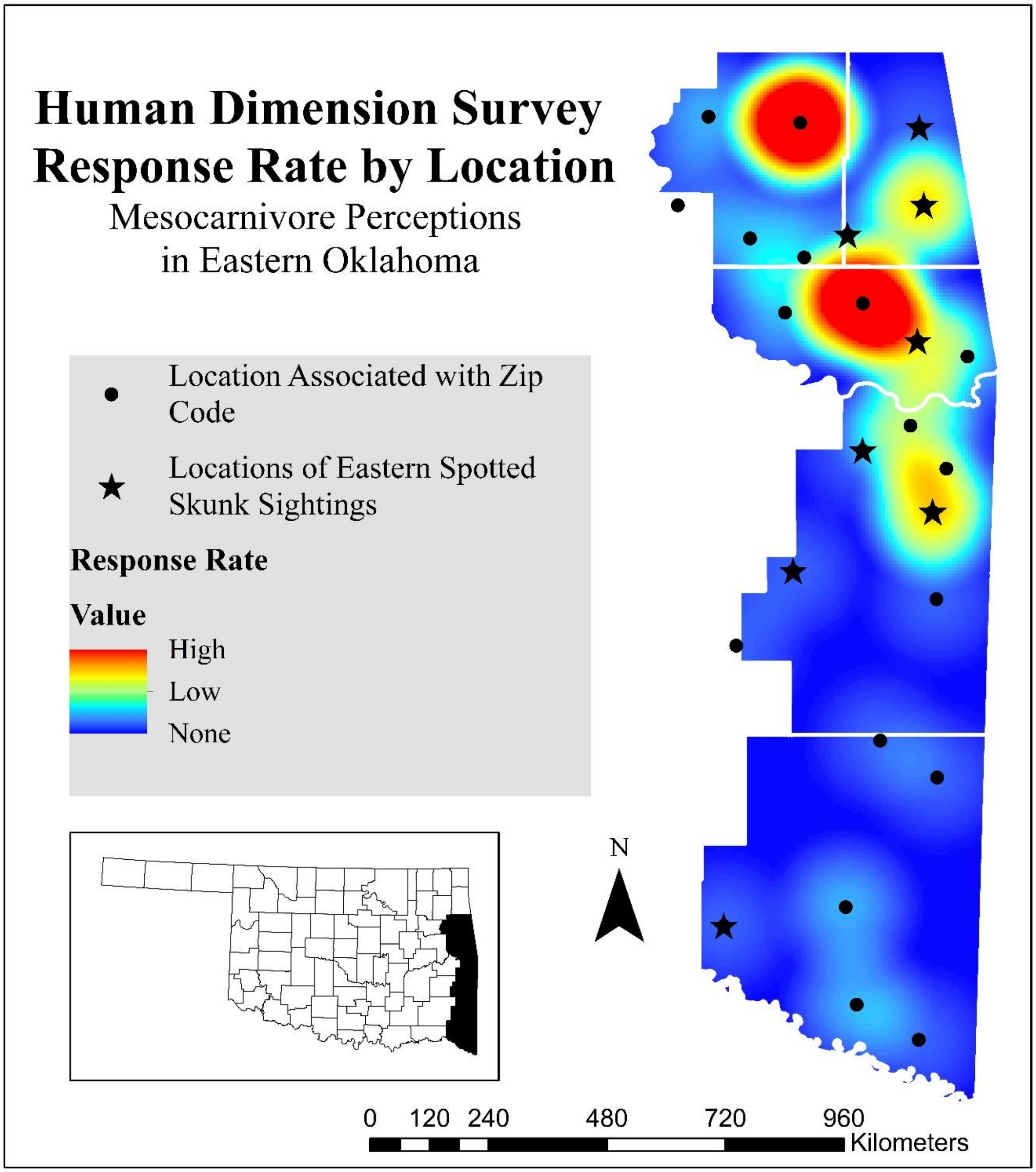

Figure 4. Map of survey area including the locations associated with each respondent's zip code. Higher rates of responses per location are indicated by red on the heatmap, while low response rates are highlighted in blue. Black stars represent the relative location of respondents with eastern spotted skunk sightings.

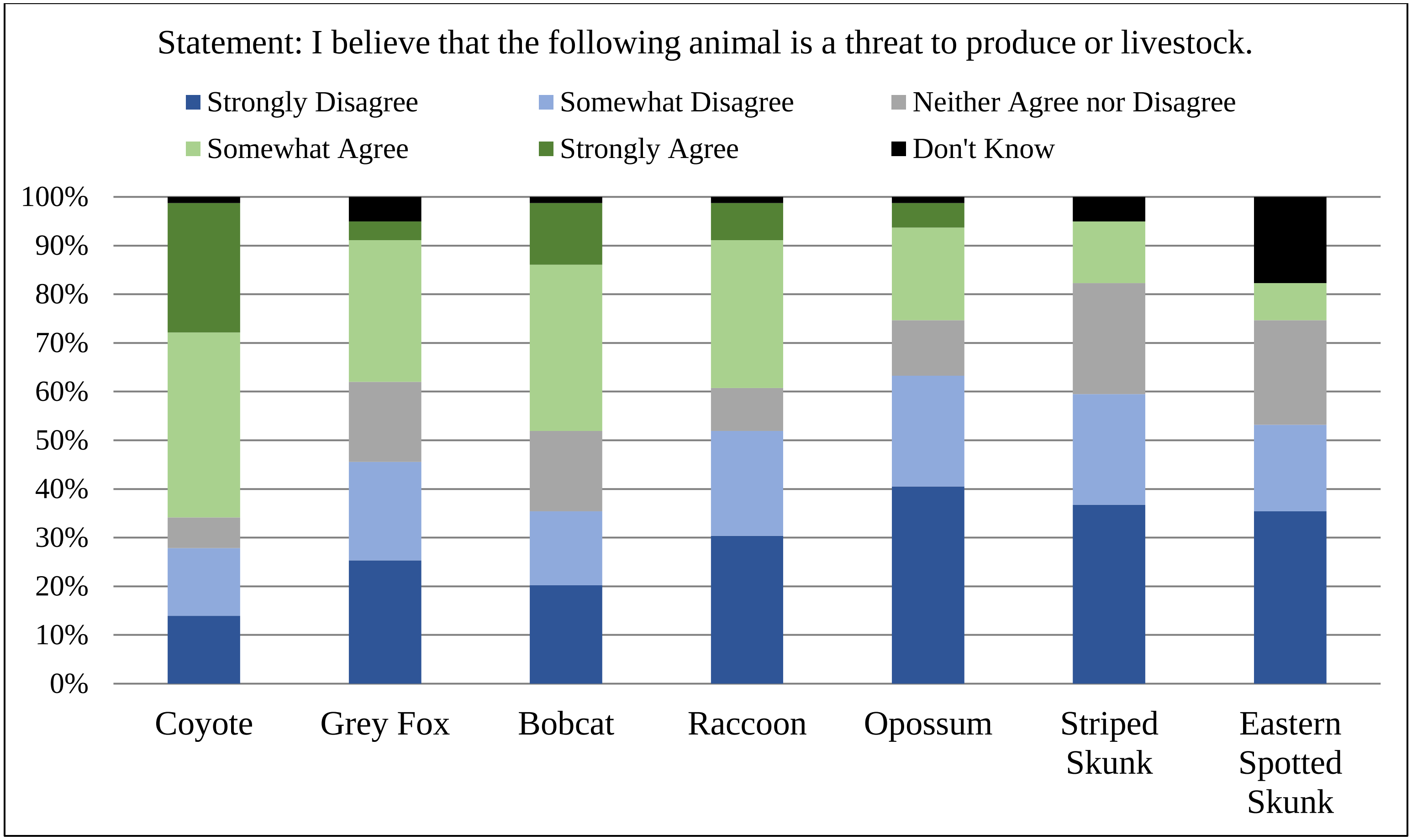

Figure 5. Bar graph illustrating the opinions regarding threats to produce and livestock for each mesocarnivore species included in survey. Only includes 79 respondents within the study area.

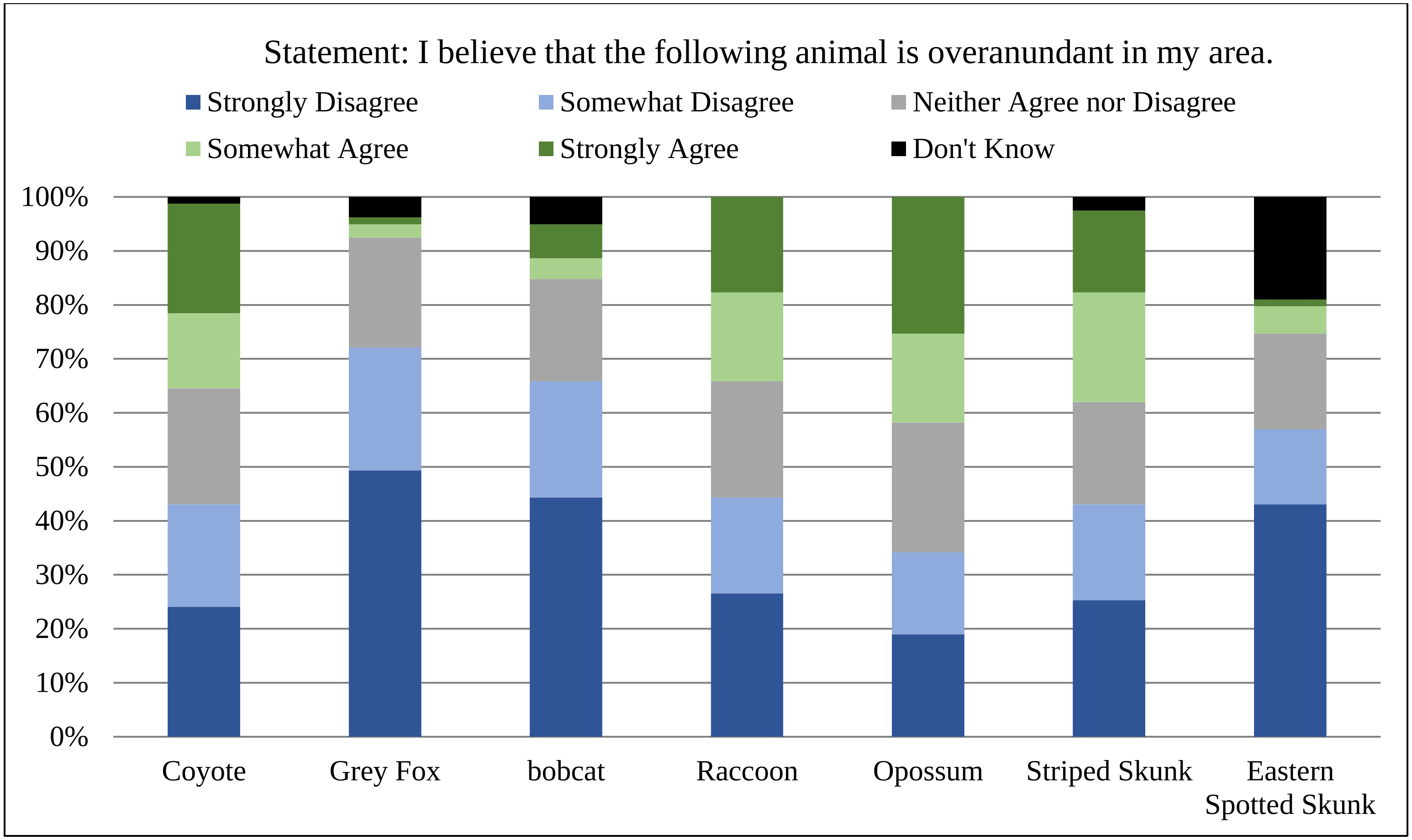

Figure 6. Bar graph illustrating the opinions regarding overabundance for each mesocarnivore species included in survey. Only includes 79 respondents within the study area.

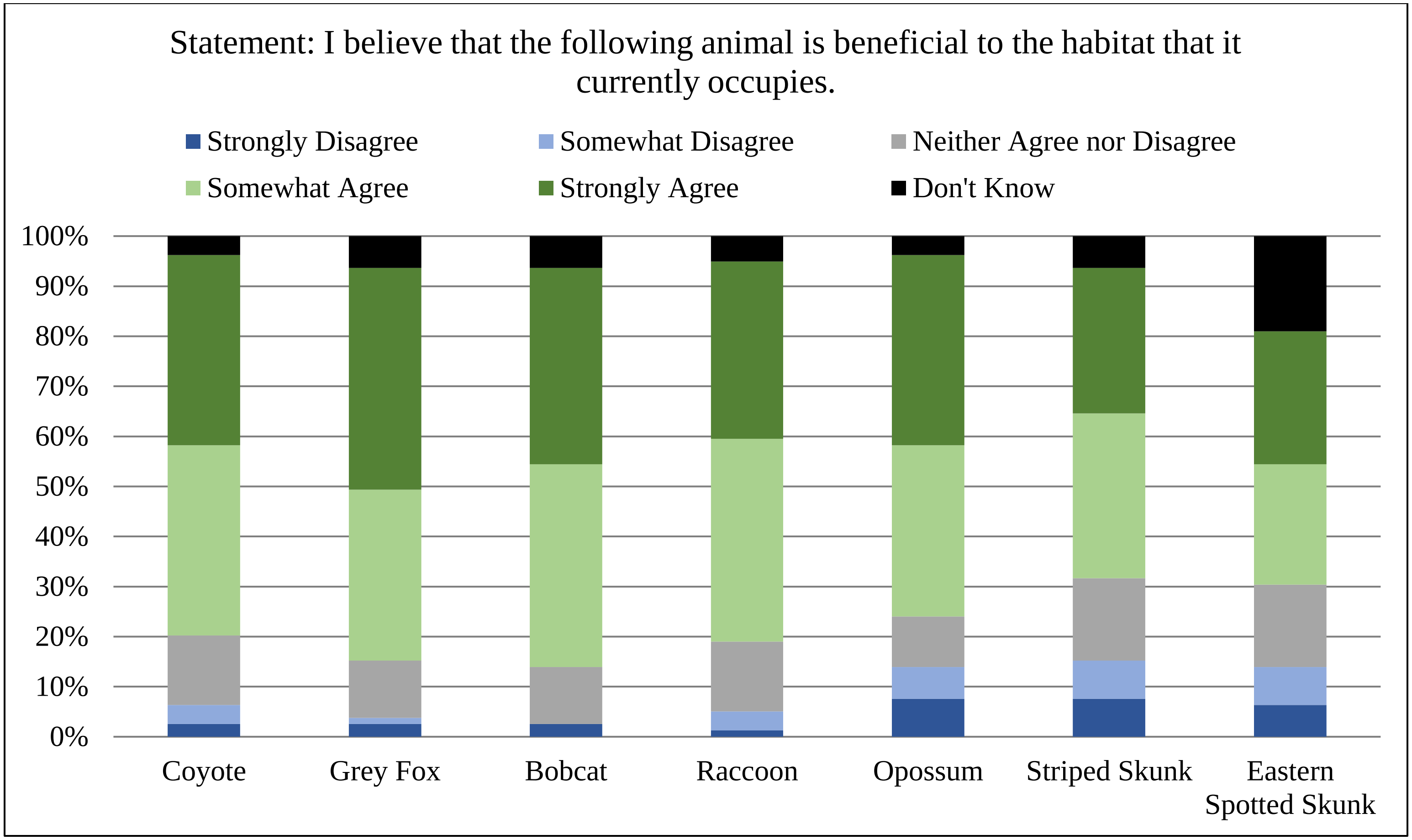

Figure 7. Bar graph illustrating the opinions regarding whether or not each mesocarnivore species included in survey is beneficial to its habitat. Only includes 79 respondents within the study area.

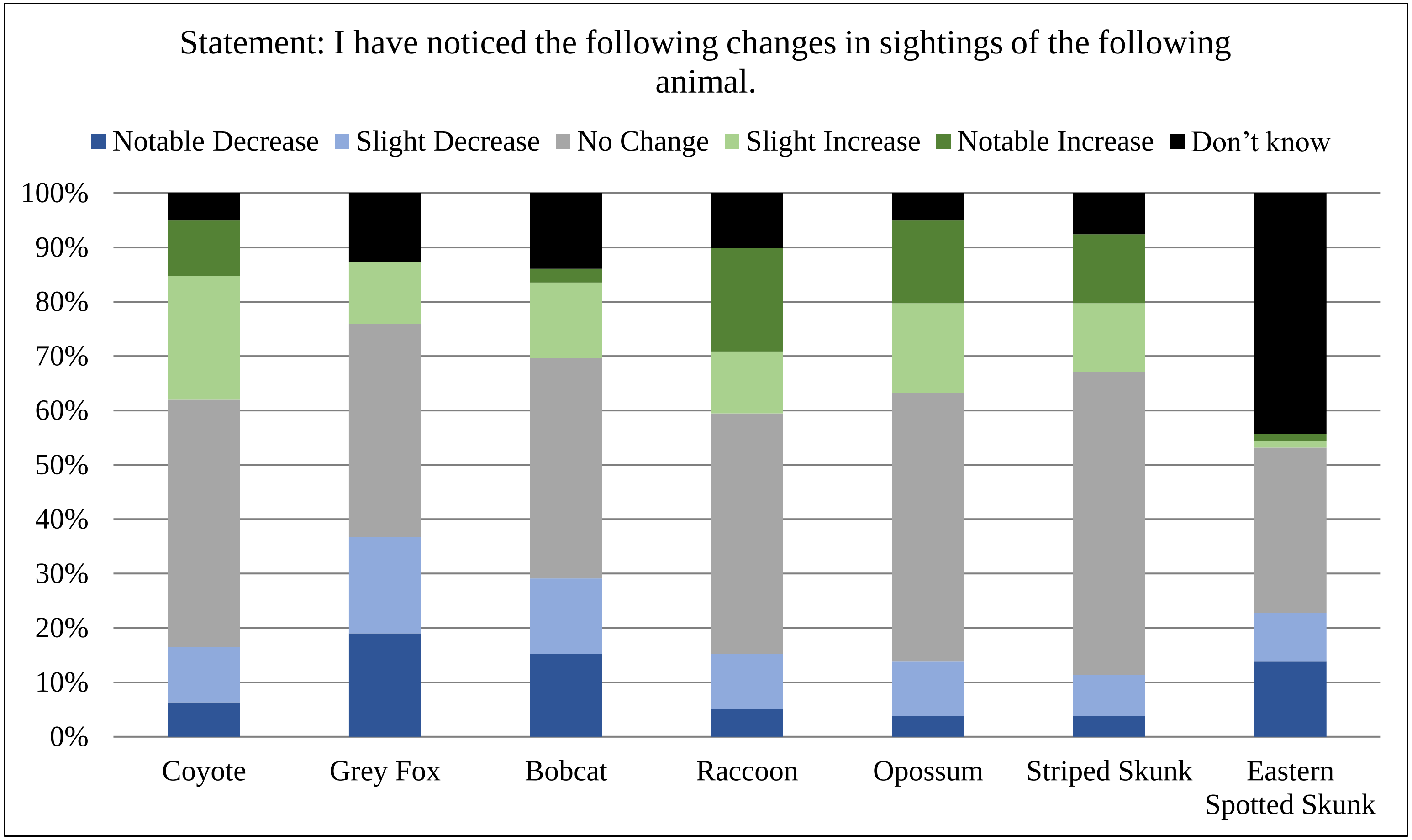

Figure 8. Bar graph illustrating the opinions regarding observational changes for each mesocarnivore species included in survey. Only includes 79 respondents within the study area.

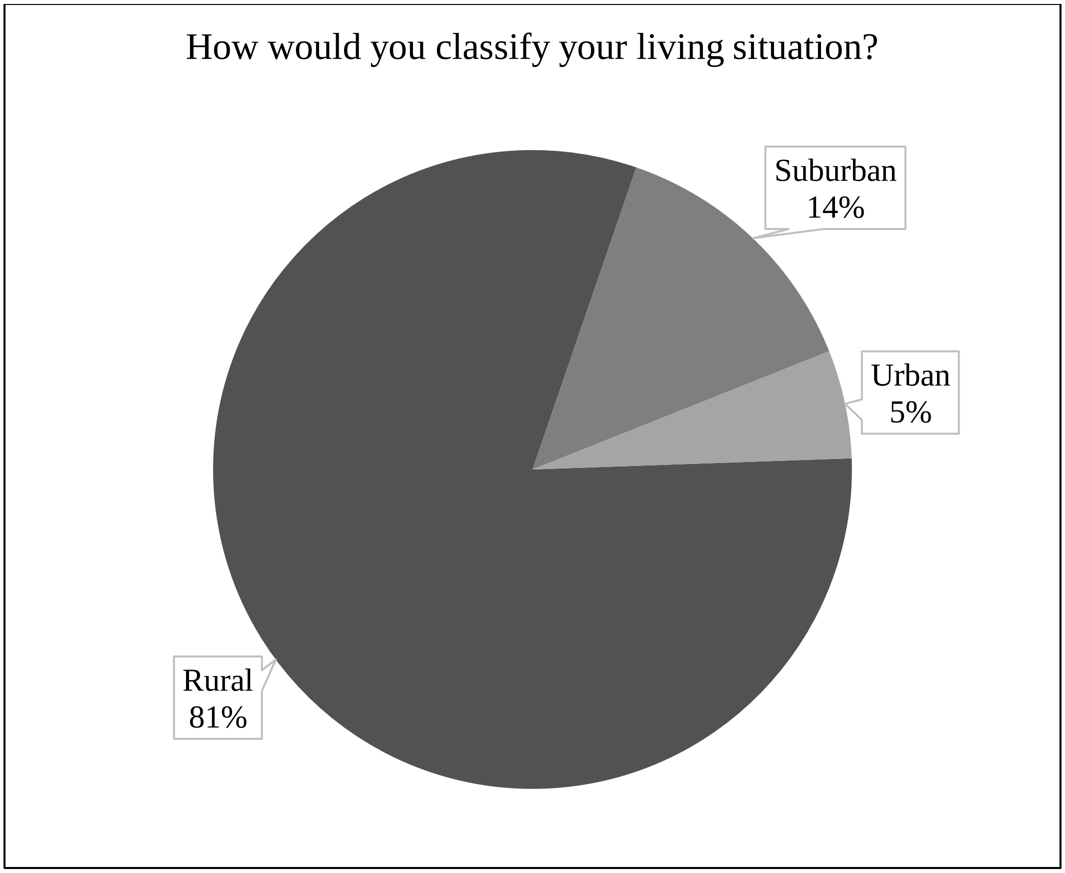

Figure 9. Pie chart illustrating reported living situation (rural, suburban, and urban) of survey respondents. Only includes 73 respondents within the study area.

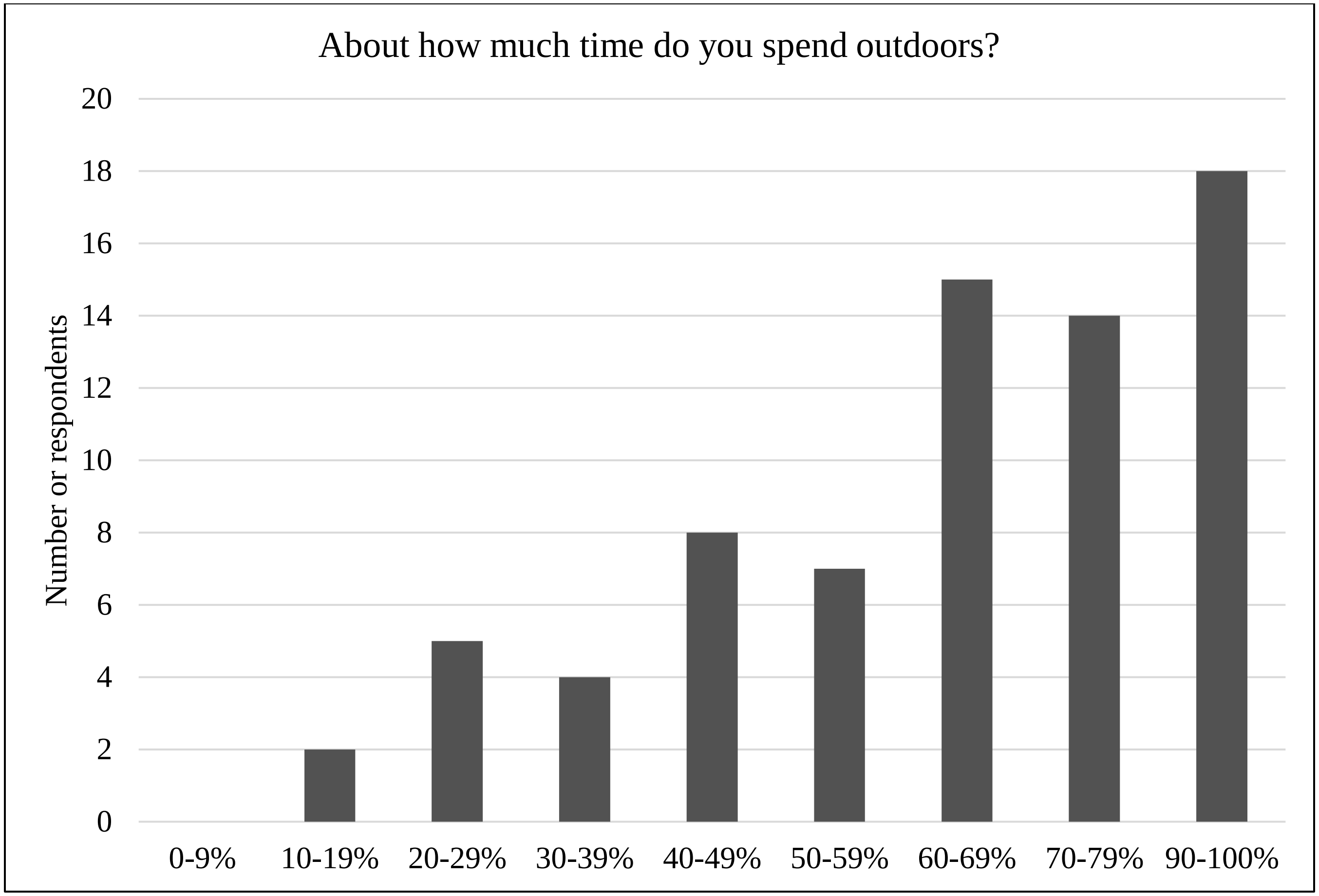

Figure 10. Bar graph illustrating the amount of time survey respondents believe they spend outdoors. Only includes 73 respondents within the study area.

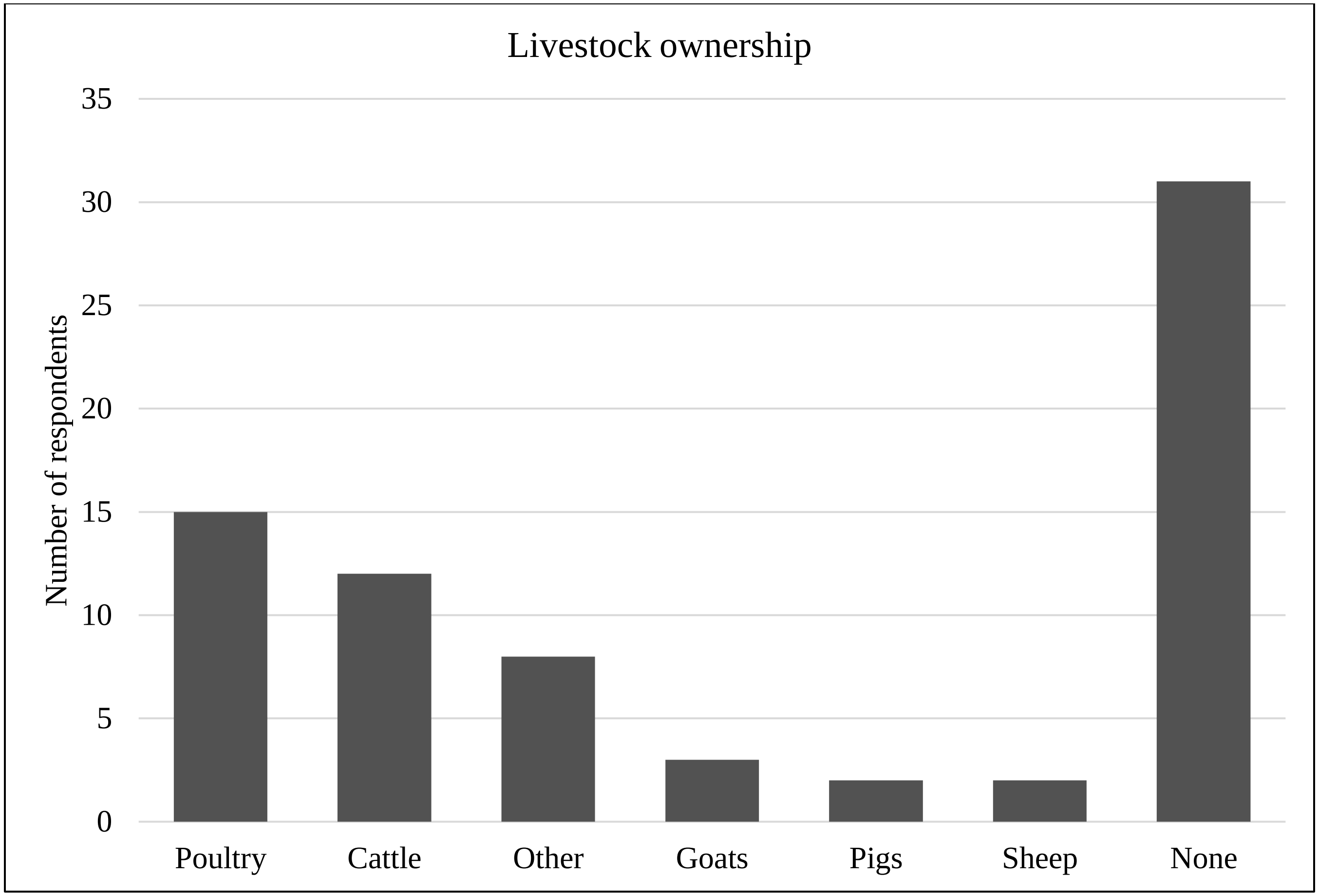

Figure 11. Bar graph illustrating whether or not the survey respondent was a livestock owner along with what species the respondent owned. Only includes 73 respondents within the study area.

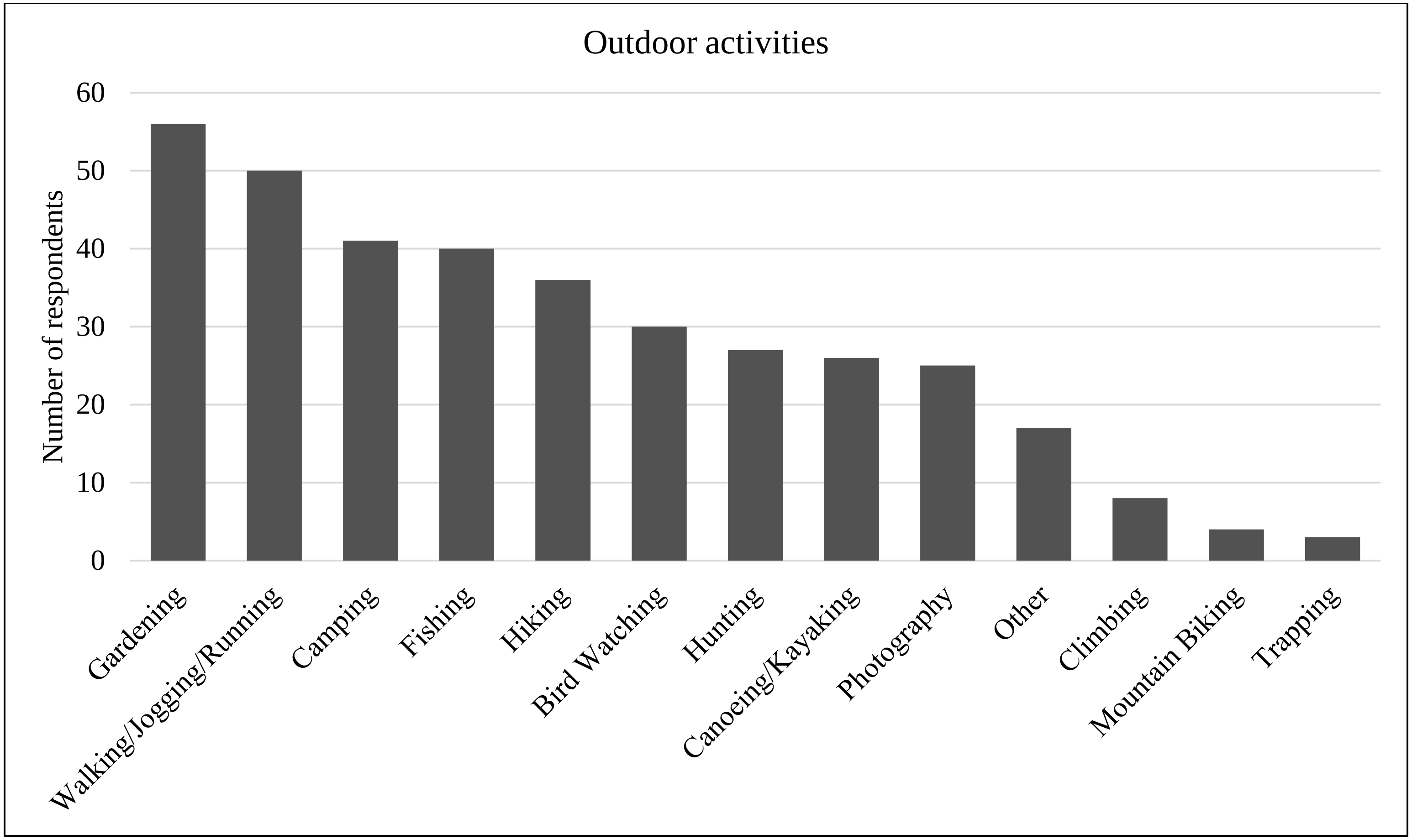

Figure 12. Bar graph illustrating the activities that survey respondents participated in. Only includes 73 respondents within the study area.

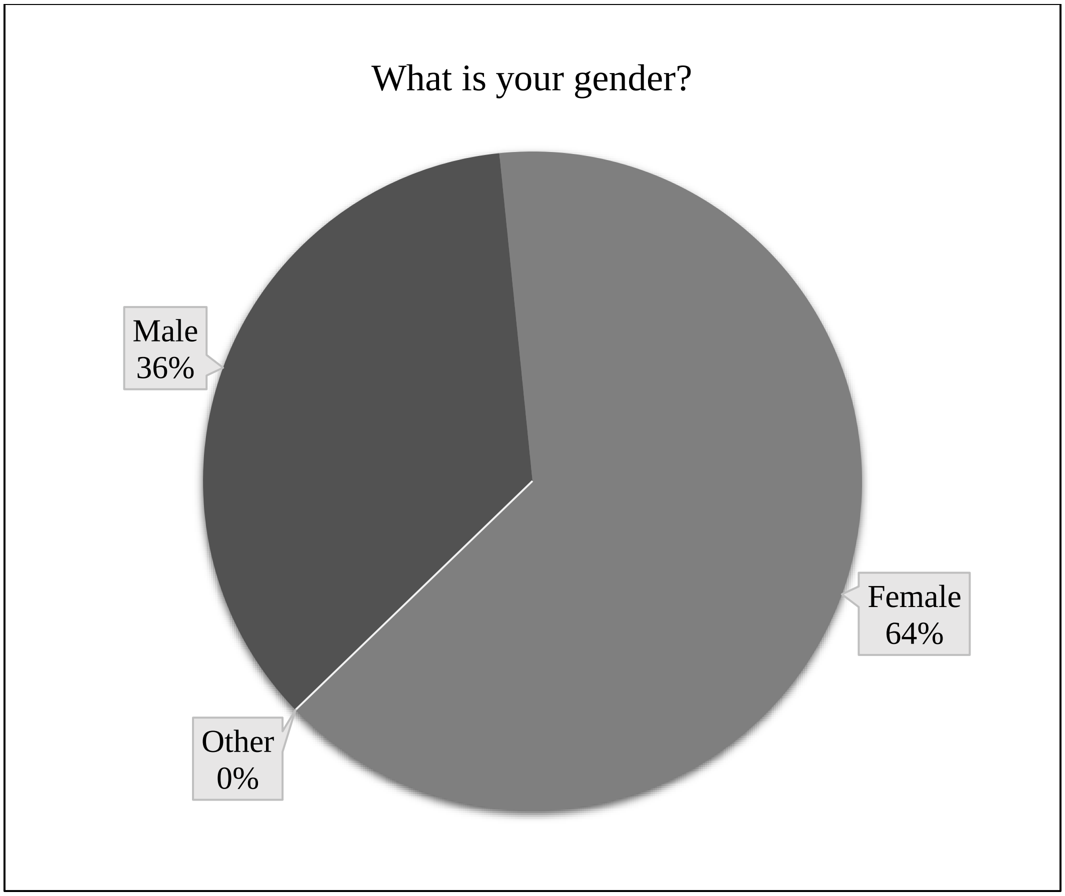

Figure 13. Pie chart illustrating gender of survey respondents. Only includes the 73 respondents within the study area.

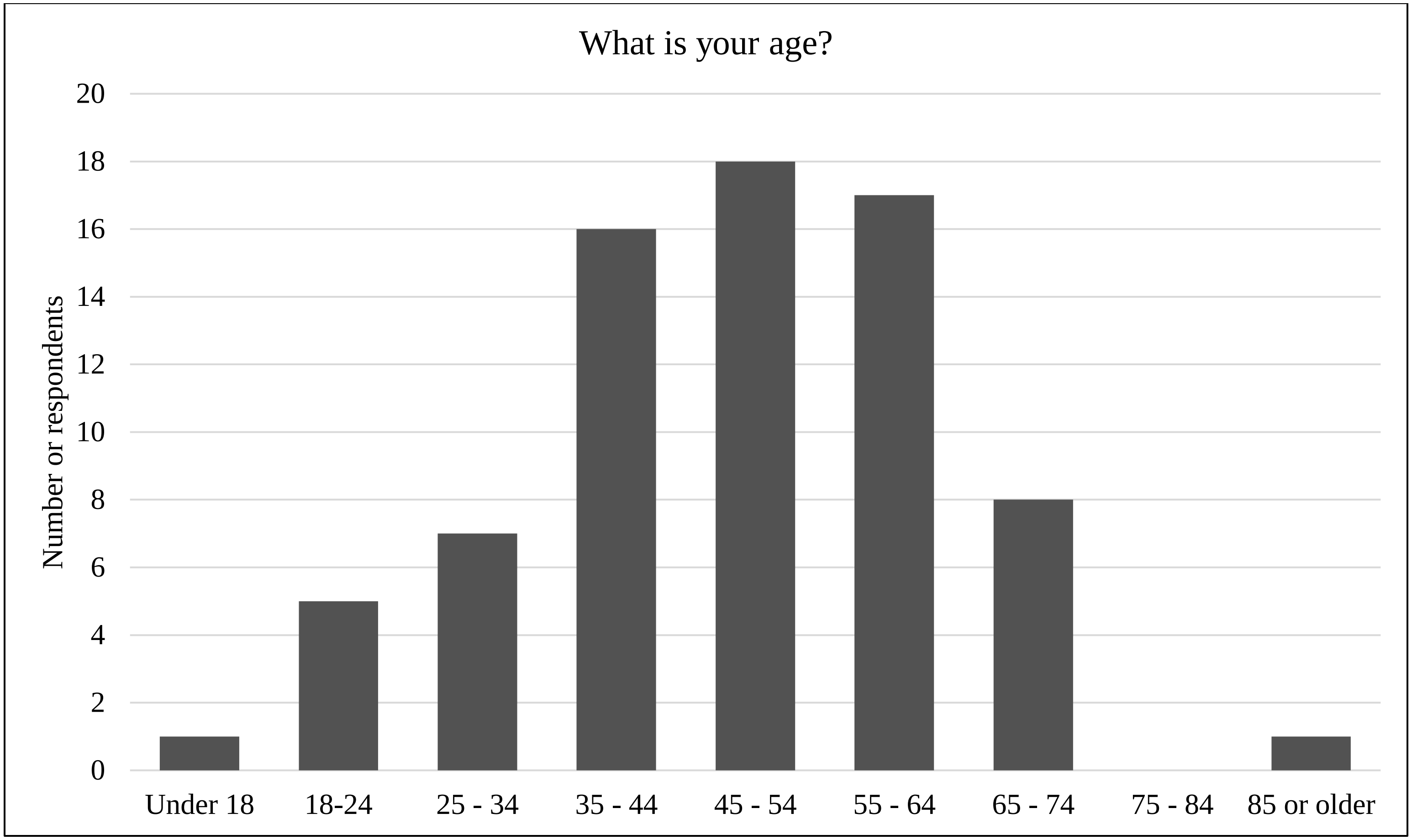

Figure 14. Bar graph illustrating age demographics of the survey respondents. Only includes the 73 respondents within the study area.

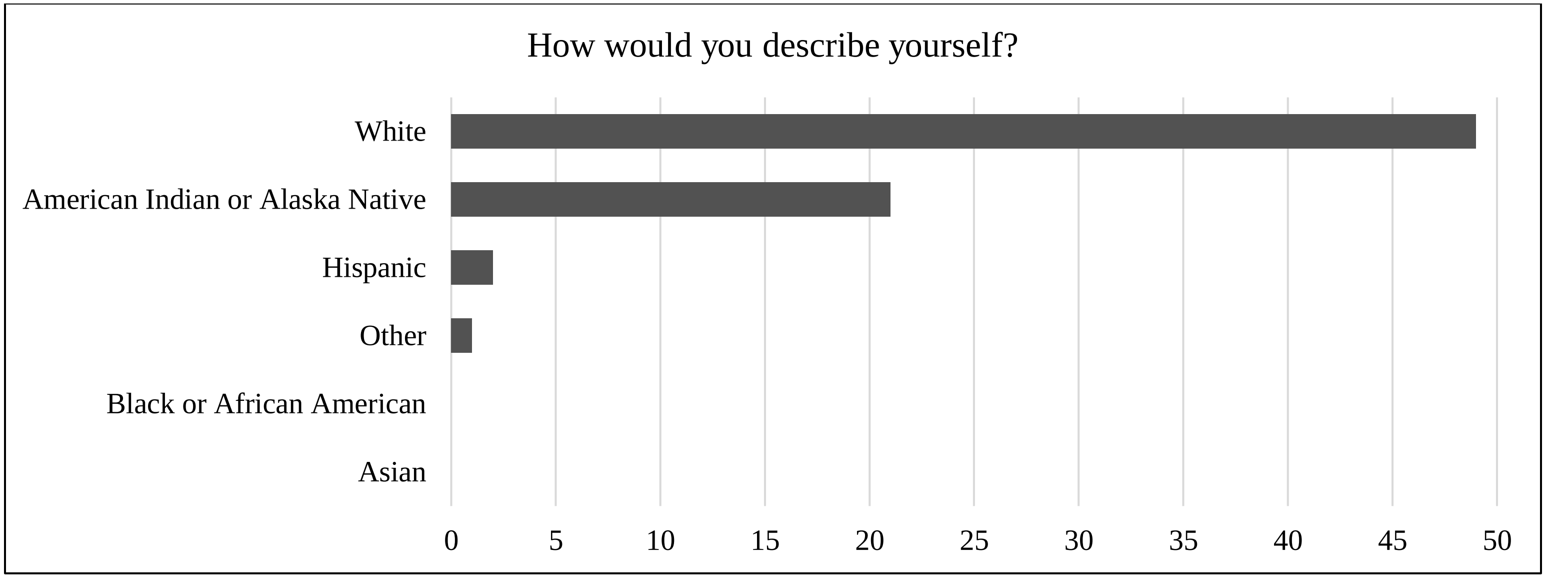

Figure 15. Bar graph illustrating reported ethnicity of survey respondents. Only includes 73 respondents within the study area.

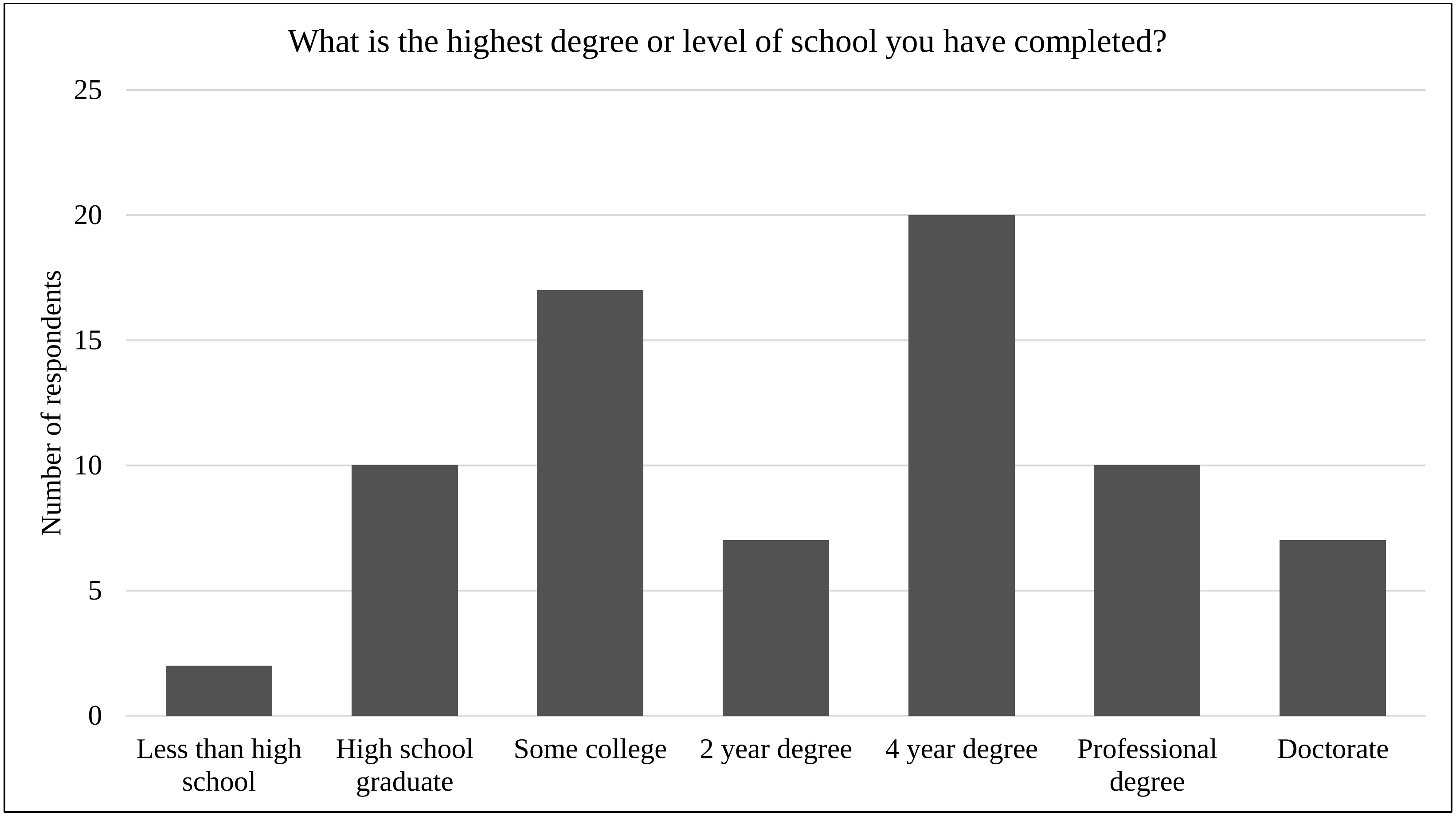

Figure 16. Bar graph illustrating education level of survey respondents. Only includes 73 respondents within the study area.

Thesis Summary

I successfully recorded the presence of eastern spotted skunks in Oklahoma, but amount of data collected rendered me unable to establish many patterns or come to strong conclusions on habitat preference, activity patterns, behavioral adaptations, and other life-history characteristics of the species. It is possible that shorter surveys would have allowed me to survey additional sites that may have contributed to more eastern spotted skunk detections. I used a sampling method that allowed me to select sites based on habitat features I believed would be most likely to occupy eastern spotted skunks. Many areas with confirmed eastern spotted skunk presence yielded no detections which may be a testament the elusiveness of the species. This study provides the first concentrated effort to sample for eastern spotted skunks in Oklahoma, and although my results are limited, I am confident that this study will establish a basis for continued concentrated sampling in Oklahoma as well as provide additional study-design information to improve sampling techniques when researching eastern spotted skunks.

The detection rates of the additional mesocarnivores may have been directly influenced by the distance between camera locations and my site selection parameters. Northern raccoons represented the species with the most detections in this study. According to a study by Kissell and Kenedy (1992), the average density for northern raccoon tends to be 1 individual per 70.4 ha and 34.5 ha (depending on available resources) would make it possible for the species to visit more than one camera location. Gray fox home-range can vary from 142 ha to 185 ha during the months of my survey seasons (Fuller 1978), which may explain higher observation rates for this species as well. Coyotes, bobcats, and striped skunks have much larger home ranges, which may have been a contributing factor to low detections for those species (Kitchener 1991; Knowlton 1972; Frey and Conover 2007). Interestingly, the WCS™ Rosebud Skunk Paste Bait and On-Target™ Liquid Grub Lure is specifically marketed toward attracting skunks, however, striped skunks represented the second smallest number of observations in this study compared to the other mesocarnivores.

I intentionally selected survey sites with dense canopy cover and the presence of understory vegetation. Therefore, my survey sites were biased to only include habitats with these specific variables. All species of mesocarnivores were found in areas with the highest canopy cover, and all but striped skunks were found in areas with the lowest canopy cover. Striped skunks are notable habitat generalists, but evidence supports that they are likely found in higher densities in areas with deciduous and mixed forests in a patch mosaic type landscape (Amspacher et al. 2021). Amspacher et al. (2021) suggest that this is likely due to the presence of den sites and foraging opportunities. A majority of my survey locations occurred in a pine-dominated forest, which may have contributed to the low trap success of striped skunks. In a northeast Oklahoma study comparing furbearer trap success during 1984-1985 and 1994-1995, Winton (1998) determined that striped skunk populations were relatively low in the area, which could also explain low trap success in my study.

Due to low detection rates of bobcat, eastern spotted skunk, and striped skunk, all generalizations that I can conclude lack significant support. Eastern spotted skunks have experienced a drastic decline over the past several decades due to multiple environmental stressors including disease, over-harvest, changing agricultural practices, loss of old forests, and shifting predator dynamics (Eng and Jachowski 2019, Gompper and Hackett 2005, Lesmeister et al. 2009, Nilz and Finck 2008, Perry et al. 2018), which is potentially the reason for the lack of observations for this species in this study. Bobcats tend to prefer wooded habitats but are less likely to be found in denser forests (Whitaker and Hamilton 1998). This may help explain my low trap success for the species. I was able to determine naïve estimates for these species, but these estimates often underestimate the Proportion of Area Occupied (POA) or occupancy probability because the data only represents recorded detection events. For the additional 4 species, my models suggest that canopy cover and visual obstruction were good predictors of mesocarnivore presence. Coyote occupancy seems to depend more on lower levels of canopy cover, as this was the covariate measured in the model with the highest reasonable support for both seasons. These results are consistent with known coyote habitat preference for grasslands and edge habitats (Gier 1974). Northern raccoon also seemed to show preference for specific canopy cover levels. Northern raccoons are habitat generalists that thrive in woody habitats with hollow trees, rock crevices, or other structures that they can use as den sites (Chamberlain et al. 2002), all of which were present throughout my survey area. Visual obstruction was the highest rated covariate model for gray fox where occupancy probabilities increased as visual obstruction decreased. Gray foxes tend to prefer forested areas (Sullivan 1996) which may account for the high rate of detections in this study. Conversely, Virginia opossum occupancy probabilities seem to be influenced by a different covariate for each season. My models suggest that Virginia opossum would have a greater probability of occurring in areas with low canopy cover during the first season and a higher probability of occurring in areas with lower visual obstruction during the second season. Virginia opossums are known as habitat generalists, however Beatty et al. (2016) suggest that they tend to avoid open grasslands and prefer forested areas with shrubby understory.

The occupancy models included in my study are important for providing a baseline understanding of habitat preference for each of these furbearers that may be useful in conducting population studies in the future. My study does not provide accurate density measures for the species included in my analysis, but it does show patterns of occupancy that contribute to distribution data for eastern Oklahoma. My results also provide a basis for more intensive mesocarnivore studies in eastern Oklahoma forests and in varying habitats across the state. These future studies will be invaluable in supplying Oklahoma Department of Wildlife Conservation and other state natural resource with more accurate distribution and population information necessary for maintaining precise conservation status information. Oklahoma's contribution to reporting authorities like NatureServe is crucial in maintaining records that can be used to monitor populations for potential conservation crises.

Using camera traps to collect data has been a widely used and essential tool for gathering information remotely and noninvasively. However, I wanted to go further and gather data from individuals who live in the area where this study was conducted to contribute additional perspective on the animals included in my study. My goal was to receive 500 responses to my human dimension survey in an effort to determine the general public perceptions of mesocarnivores as well as gather additional eastern spotted skunk location information from individuals living in eastern Oklahoma. I was unsuccessful in reaching my goal of 500 responses, however, I was able to collect responses from all areas of my survey site. My limited sample size prevents me from assuming public perceptions across Oklahoma, however it does give us a glimpse into how residents in rural eastern Oklahoma may perceive these animals. Results from my survey indicate that coyotes and bobcats were perceived to be the most threatening to livestock whereas Virginia opossums and striped skunks were perceived to be the least threatening to livestock. A majority of the respondents own livestock, with poultry making up the highest percentage of livestock ownership, immediately followed by cattle. Therefore, I infer that general livestock ownership, as well as the type(s) of livestock owned, may have influenced this answer. Conversely, respondents tend to believe that each of the species listed in the survey were beneficial to their respective habitat, even if they were perceived to be a threat to livestock and produce. Respondents indicated that they felt that all of the species, with the exception of Virginia opossums, are overabundant in the survey area. When asked about the respondents personal observations, my results show that observation rates for gray fox decreased the most while observation rates for coyotes increased. My survey provided a small glimpse into how the public views furbearing mesocarnivores located in eastern Oklahoma forests. Assessing these additional species is important, as they are largely underrepresented in population studies due to their perceived abundance.

Only 13 respondents selected that they had personally observed an eastern spotted skunk in the past. Of those respondents, three indicated that the observation occurred within the last year and 3 indicated that their observation occurred between one and five years ago. The remaining observations were more than five years ago or the respondent declined to indicate when their observation occurred. These observations occurred throughout my survey area, including areas where I was unable to confirm eastern spotted skunk presence during my camera trap survey. My survey successfully made 4 connections with community members of the study area who are interested in discussing their recent eastern spotted skunk sightings. Although this data is extremely limited, it does provide an opportunity to collaborate with these individuals in future studies examining a more accurate distribution and/or population estimates for the species within Oklahoma.

Much of the land in eastern Oklahoma is rural, so it is not surprising that a majority of the respondents indicated that they lived in a rural situation. Furthermore, the majority of respondents spend more than half of their time outdoors with gardening and exercise being the highest reported outdoor activities. These particular factors may have had an impact on the survey respondents' perceptions of the species in the survey, as they may increase the chances for humans to come in contact with wildlife and/or increase the possibility of wildlife damage to livestock and produce. Additionally, more than 60% of the respondents identified as female, more than 60% were between the age of 25 and 64, ethnicity was made up of mostly "White" individuals followed by "American Indian or Alaskan Native," and a majority indicated that their education level was at least "some college." Understanding how demographics influence perceptions of wildlife may help with natural resource education and outreach planning along with promoting wildlife conservation in ways that appeal to stakeholders.

In a survey examining the social context of wildlife management across the U.S., Manfredo et al. (2018) determined that wildlife value orientation types vary by ethnicity (orientation types defined in Chapter 3; Table 2). Manfredo et al. (2018) discovered different wildlife-related recreation activities in both past participation and future interest. A majority of individuals who responded were rural White and Native Americans, therefore, I would expect a majority of our respondents to have Traditionalist and Pluralist wildlife value orientations as defined by Manfredo et al. (2018). Understanding these slight variations may be an important contributing factor in developing and maintaining conservation strategies in eastern Oklahoma while simultaneously providing insights necessary for strengthening communication between scientists and the public.

My low response rate makes it difficult to determine perception trends based on the responses relating to the individual's demographics or assumed biases. In the future, I expect to explore potential differences in perceptions depending on the respondents' age, gender, and education level. I also look forward to understanding if the amount of time the respondent spends outdoors, the types of activities the respondent participates in, or the ownership of livestock influence the way respondents perceive these mesocarnivores within eastern Oklahoma, however, due to my small sample size, I do not believe that these outcomes will serve as a reliable indicator to the general perceptions of this area. Lastly, I hope to compare the perceptions of the respondents from eastern Oklahoma to the respondents located in the rest of Oklahoma and in other states.

Results from my study, although limited, do successfully contribute additional insight on eastern spotted skunk observation rates from residents in eastern Oklahoma. I was also able to gain useful information on general public perceptions of furbearing mesocarnivores of eastern Oklahoma that may aid in planning future studies aimed at closing knowledge gaps for each of these species. I hope that the information resulting from this survey will be applicable in designing similar studies intended on providing information to make more informed and efficient wildlife management decisions in Oklahoma.

In conclusion, I recommend that camera trapping and other noninvasive efforts that contribute to eastern spotted skunk distribution and detectability studies continue with the goal of discovering additional locations with confirmed presence of the species in Oklahoma. I also recommend that all new observations be reported as these reports serve a crucial role in improving what we currently know about the distribution of eastern spotted skunks. Studies involving radio collars and frequent location monitoring with the goal of finding den sites and/or determining activity patterns would aid in more-effective comparison studies on the Ouachita Mountains eastern spotted skunk population on both the Oklahoma and Arkansas side of the Forest. Additionally, future studies should focus on understanding and reporting occupancy, distribution, and population density for each of these harvested furbearing mesocarnivore species across Oklahoma and in other states that are not reporting conservation statuses for these animals. Maintaining accurate and up-to-date databases will help promote persistence of our wildlife populations by ensuring access to data and trends that may indicate a decreasing population before the decline is irreparable: a situation that was not available for eastern spotted skunks. Using human dimensions studies may serve as a practical tool to accumulate unique data regarding these animals, however, more efforts are needed to increase response rates. In future human-dimensions studies, I recommend a more intensive follow-up procedure to increase participation. Stedman et al. (2004) sent surveys to hunters in order to understand hunter behavior with a higher success rate. They attribute their higher response rate to informing camp owners of the surveys before the survey was sent out. Due to the important data that human-dimension surveys can contribute, a critical component to continued success is to understand how to increase public engagement with human-dimensions work. Involving stakeholders is integral to planning and implementing wildlife management strategies and efficient conservation landscape design (Bartuszevige et al. 2016). This involvement will increase productivity for conserving species of conservation concern, but may also help manage species that may be detrimental to an ecosystem such as an overabundant or invasive species (Jonker et al. 2010).

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