Reptile Diversity on Roads Surrounding the Selman Living Laboratory, Woodward County, Oklahoma

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Abstract: As human impacts on the environment accumulate, comprehensive species lists are needed as baselines to measure future change. During 2015–2022, we conducted 226 circuits of an 80.5 km road network surrounding the Selman Living Laboratory, Woodward County, Oklahoma. Sampling occurred during April-October and totaled 12000 road km. Roads were unpaved and not regularly maintained, resulting in slow speeds and light traffic. We documented 88% of the expected snake species in the study area. We observed 310 snakes representing 22 species, 81 turtles from three species, and 62 Slender Glass Lizards (*Ophisaurus attenuatus*). Western Ribbonsnakes (*Thamnophis proximus*, n = 63) were the most frequently encountered species, followed by Slender Glass Lizards, and Ornate Box Turtles (*Terrapene ornata*, n = 45). Neonates were well-represented, including 15.7% of all observations and 92.3% of observed species. We found 45 snakes (15.8% of observed snakes), 10 Slender Glass Lizards (16.1%), and zero turtles dead on the road. Road mortality was lower than rates reported in other studies. The study area harbors an intact reptile assemblage, even though 99% is private land, where ranching and fossil fuel exploration has been ongoing for over a century.

Introduction

As human impacts on the environment accumulate, documenting existing biodiversity is increasingly important. Long-term monitoring and comprehensive species lists are needed to document changes in assemblages and serve as baselines to measure future change (Green et al., 2009). Even though reptiles are important components of terrestrial ecosystems, species lists for reptiles are often incomplete due to the time and expense of data collection (Thompson et al., 2003; van Rooijen, 2009). Thorough surveys that document species occurrence and relative abundance in reptile assemblages are needed (Busby and Parmalee, 1996; Cagle, 2008).

Biological field stations are uniquely positioned for long-term monitoring of reptile assemblages (Michener et al., 2009). In rapidly changing environments, field stations provide stable habitats to monitor and a steady stream of researchers and students over time, allowing monitoring programs to exceed the career of any one researcher. As a local example, Watters et al. (2021) recently published an annotated list of reptiles and amphibians encountered during a 65-year period at the University of Oklahoma Biological Station at Lake Texoma.

In 1998, The Selman Living Laboratory (SLL) was acquired by the University of Central Oklahoma and soon after established as a member of the Organization of Biological Field Stations (McNulty et al., 2017). Located in the Cimarron

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Gypsum Hills of Woodward County, Oklahoma (36.685278, -99.277222, WGS84), the SLL consists of two tracts totaling 1.35 km^2, including several entrances to an extensive gypsum cave system. The SLL is the site of longitudinal studies on cave-dwelling bats, rodent Leishmaniasis, seasonal vegetation dynamics, and population genetics of small mammals. For the past eight years, the senior author (HLC) has conducted surveys for reptiles on the road network surrounding the SLL. Here, we summarize these surveys, presenting data on species richness, relative abundance, and road mortality of reptiles encountered on roads near the SLL during 2015–2022.

Materials and Methods

Study Area.—The study area was an 80.5 km network of farm roads within a 132 km^2 area in Woodward and Harper Counties, Oklahoma (Fig. 1). Climate and topography were typical of the Cimarron Gypsum Hills, a semi-arid region of rolling hills and plains, caves, canyons, and gypsum outcrops. Three creeks flowed intermittently northeast through the study area and drained into the Cimarron River less than 3 km north. Habitats surrounding roads were utilized for oil and gas wells, iodine production, cattle grazing, and wheat farming, with remnant mixed-grass prairie habitat interspersed, and numerous farm ponds constructed for watering livestock. Using aerial photographs taken on 21 June 2017 (Google Earth Pro, 2020), we counted 18 ranch houses, an iodine plant, and at least 45 pads for oil and gas wells in the study area. Two natural areas, Alabaster Caverns State Park (0.81 km^2) and Cimarron Bluff Wildlife Management Area (13.88 km^2), were on the eastern and northern boundaries of the study area, respectively. The study area was 1–3 km west of Oklahoma State Highway 50, and 5–6 km east of Oklahoma State Highway 34, the only paved roads in the vicinity. Study area roads were dirt or gravel and not regularly maintained, becoming impassable to two-wheel drive vehicles after even moderate rainfall. Because of the unevenness of the roads, speed limits were not posted, and traffic volume was low and comprised of local traffic. Often, no other vehicles were encountered during 2–3 h surveys. Roads were unevenly distributed, with two large parcels (64.7 km^2 and 18.1 km^2) near the center of the study area that were not bisected by roads. Within the largest of these parcels was the 1.35 km^2 Selman Living Laboratory.

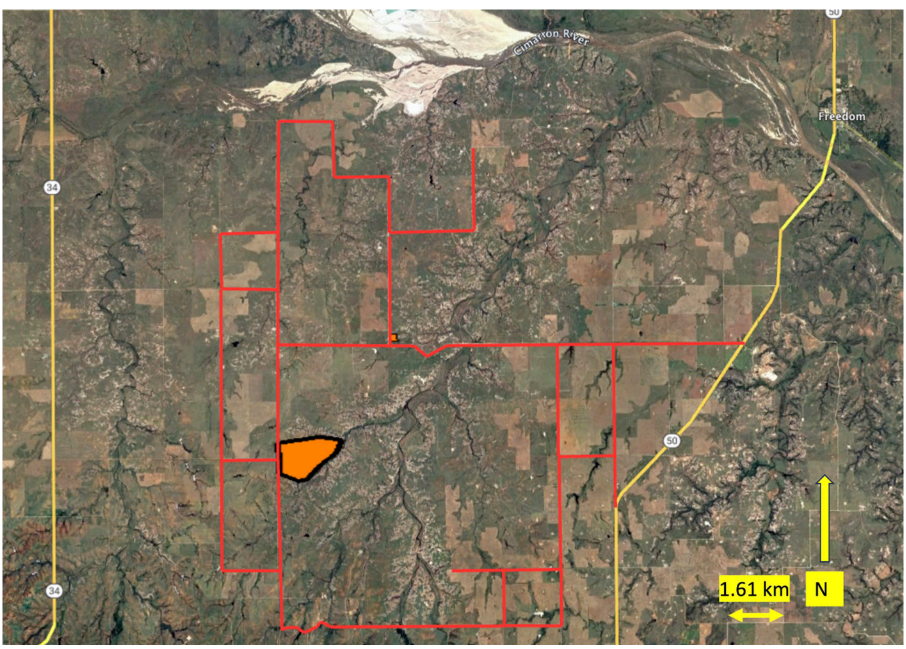

Fig. 1. Annotated map of the study area derived from Google Earth Pro (2020). The red lines show the network of dirt roads surveyed during the study. The orange polygons show the Selman Living Laboratory.

Road Surveys.—During 2015–2022, HLC made 48 trips to the study area (Table 1). Trips occurred opportunistically during April–October (Table 1). Trips lasted 1-4 days (mode = 2 days), with the SLL used for overnight stays. During each trip, HLC completed 1-12 circuits (mean $\pm$ SD = 4.7 $\pm$ 2.95 circuits/trip) of the road network around SLL. A total of 226 circuits (*ca*. 12000 road km) were completed (Table 1). The most common circuits were 48 km (n = 110) and 58 km (n = 78), which took 2–3 hours to survey, depending on how many sightings occurred. After heavy rains some roads were impassable, and abbreviated circuits were taken. Most circuits were early morning, late afternoon, or night, but depending on weather conditions, some circuits were conducted late mornings and early afternoons.

During sampling, HLC drove 16–24 km/h, scanning roads for reptiles. All snakes and turtles encountered were documented. For lizards, relatively small-bodied species that occupied roadside habitats, such as collared lizards, horned lizards, and whiptails, were not recorded, but occurrences of Slender Glass Lizards (*Ophisaurus attenuatus*) were recorded. For each sighting, HLC plotted location on a study area map and recorded GPS coordinates. Species, condition (alive or dead), and age class (adult or juvenile) were recorded, but specimens were not measured nor marked. HLC photographed some specimens and deposited photos in the University of Central Oklahoma Natural History Museum. If captured, specimens were released at the point of capture.

Table 1. Distance (km) surveyed by month and year for reptile surveys on roads surrounding the Selman Living Laboratory.

Year	April	May	June	July	August	September	October	Total	Circuits
2015	0	0	0	0	164	0	0	164	3
2016	174	290	232	174	348	348	338	1902	34
2017	266	193	0	579	48	193	0	1279	27
2018	0	0	483	451	0	193	0	1127	20
2019	97	0	354	145	48	193	0	837	16
2020	0	475	97	97	209	145	48	1070	24
2021	0	1081	356	436	728	819	0	3420	65
2022	0	431	241	1030	0	453	0	2155	37
Total	536	2470	1762	2912	1546	2343	386	11955	
Circuits	11	51	34	51	28	43	8		226

Data Analysis.— Our analyses focused on species richness, relative abundance, and rates of road mortality. Species richness was visualized using a species accumulation curve, a plot of number of species encountered vs. time. Our estimate of species richness was compared to the total species pool, estimated by examining range maps in the most recent edition of "A Field Guide to Oklahoma's Amphibians and Reptiles (Sievert and Sievert, 2021). We used Spearman's Rho to explore the correlation between the number of dead individuals and live individuals of each species. A significant correlation (alpha = 0.05) would be expected if natural history differences among species were absent, with outliers suggesting natural history differences that made species more or less susceptible to road mortality.

Results

We made 453 observations of 26 species, including 310 snakes (0.026 snakes/km) representing 22 species (Table 2), 81 turtles from three species (0.0068 turtles/km), and 62 Slender Glass Lizards (*Ophisaurus attenuatus*, Table 2). Neonates were well-represented in the sample, including 15.7% of total observations and 92.3% of observed species. Western Ribbonsnakes (*Thamnophis proximus*, n = 63) were the most frequently encountered species, followed by Slender Glass Lizards and Ornate Box Turtles (*Terrapene ornata*, n = 45). We could not positively identify 28 snakes to species, including 26 racer/coachwhips (*Coluber* spp.) that crossed the road too fast for identification, and two dead gartersnakes (*Thamnophis* spp.) that were too badly damaged to identify. Among snakes, eight species were represented by more than 10 individuals, whereas three species were only observed once (Table 2). New snake species were added to the list for five years, but no new species have been observed for the last three years (Fig. 2).

We found 55 individuals (12.9% of total observations) of 17 species (65.3% of observed species) dead on the road, including 45 snakes (15.8% of observed snakes) and 10 Slender Glass Lizards (16.1%). No dead turtles were encountered. Among snake species, the relative abundance of live and dead individuals was significantly correlated (r_s= 0.742, P = 0.00008, Fig. 3).

Table 2. Total number of snakes, turtles, and lizards (dead + alive) observed by species each year on roads surrounding the Selman Living Laboratory. The last column is the number of individuals found dead in each species.

Taxon*	2015	2016	2017	2018	2019	2020	2021	2022	Total	# dead
Western Ribbonsnake (*Thamnophis proximus*)	0	16	14	6	3	8	12	4	63	8
Common Gartersnake (*Thamnophis sirtalis*)	0	0	1	2	1	0	1	2	7	1
Plains Gartersnake (*Thamnophis radix*)	0	2	0	0	1	1	0	0	4	1
Checkered Gartersnake (*Thamnophis marcianus*)	0	0	0	1	0	2	1	1	5	1
Unidentified Gartersnake (*Thamnophis* spp.)	0	0	0	1	1	0	0	0	2	2
Coachwhip (*Coluber flagellum*)	0	7	3	4	2	6	1	1	24	3
North American Racer (*Coluber constrictor*)	0	5	1	1	2	5	5	4	23	5
Unidentified Racer/Coachwhip (*Coluber* spp.)	1	8	7	1	2	1	5	1	26	0
Great Plains Ratsnake (*Pantherophis emoryi*)	1	0	0	1	0	3	1	1	7	1
Western Ratsnake (*Pantherophis obsoletus*)	0	0	0	1	0	3	1	2	7	0
Gophersnake (*Pituophis catenifer*)	0	1	4	2	2	9	4	2	24	6
Prairie Kingsnake (*Lampropeltis calligaster*)	2	0	4	0	2	0	1	0	9	2
Speckled Kingsnake (*Lampropeltis holbrooki*)	1	3	0	0	0	0	0	1	5	3
Glossy Snake (*Arizona elegans*)	0	1	0	0	2	0	0	0	3	0
Diamond-backed Watersnake (*Nerodia rhombifer*)	0	0	1	0	0	2	1	0	4	0
Plain-bellied Watersnake (*Nerodia erythrogaster*)	1	0	1	0	0	1	2	1	6	2
Eastern Hog-nosed Snake (*Heterodon platirhinos*)	1	1	3	0	1	5	1	0	12	2
Plains Hog-nosed Snake (*Heterodon nasicus*)	0	0	1	0	0	0	0	0	1	0
Dekay's Brownsnake (*Storeria dekayi*)	0	0	2	1	0	0	0	1	4	0
Ring-necked Snake (*Diadophis punctatus*)	0	0	1	0	0	0	0	0	1	0
Long-nosed Snake (*Rhinocheilus lecontei*)	0	0	0	0	1	0	0	0	1	0
Prairie Rattlesnake (*Crotalus viridis*)	5	7	1	5	3	2	4	1	28	4
Western Diamond-backed Rattlesnake (*Crotalus atrox*)	1	8	2	0	1	2	5	7	26	3
Western Massasauga (*Sistrurus tergeminus*)	0	5	5	3	4	1	0	0	18	1
Slender Glass Lizard (*Ophisaurus attenuatus*)	0	22	9	0	12	5	8	6	62	10
Ornate Box Turtle (*Terrapene ornata*)	2	8	8	5	6	9	5	2	45	0
Pond Slider (*Trachemys scripta*)	0	1	4	3	4	6	5	5	28	0
Yellow Mud Turtle (*Kinosternon flavescens*)	0	1	1	2	2	0	2	0	8	0
Individuals	15	96	73	39	52	71	65	40	453	55
Species**	9	16	20	16	19	18	19	17	26	17
Circuits	3	34	27	20	16	24	65	37	226	

* Taxonomy according to Crother 2017

**unidentified *Coluber* were not included in species totals, except in 2015, when *Coluber* was not otherwise observed

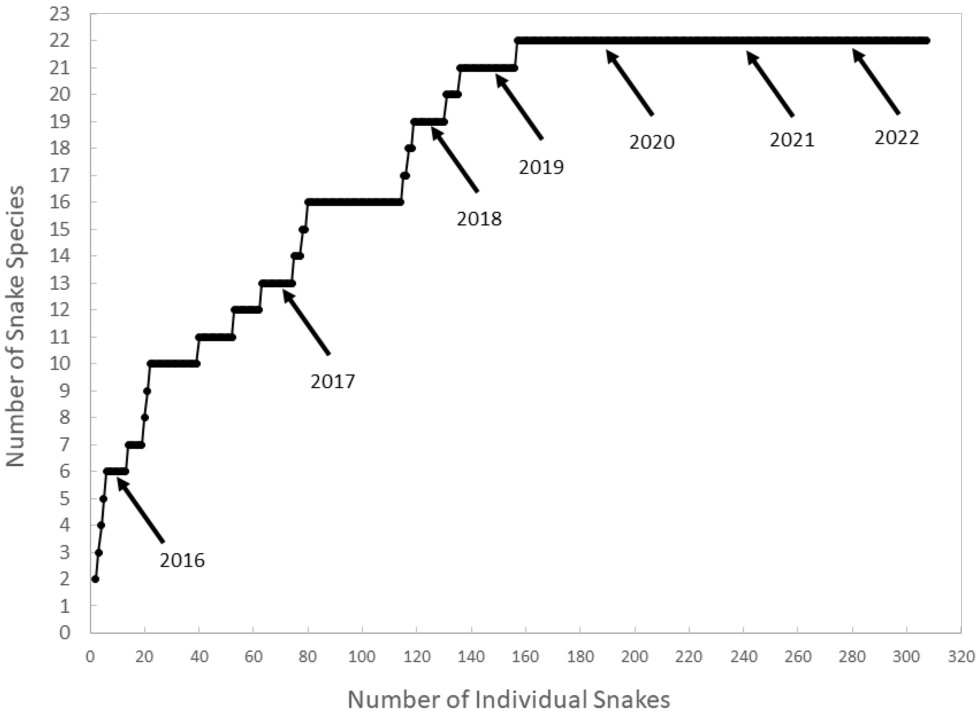

Fig. 2. Species accumulation curve for snakes on roads surrounding the Selman Living Laboratory. X-axis values increased each time a snake was encountered, whereas Y-axis values increased each time a new snake species was encountered.

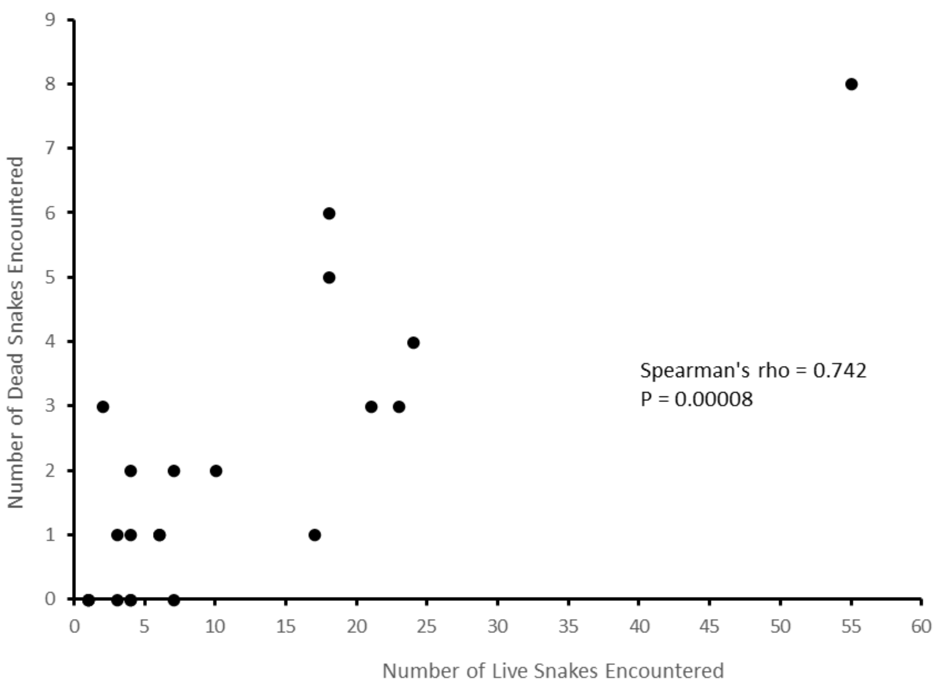

Fig. 3. Scatterplot of number of live individuals vs. number of dead individuals for each snake species encountered on roads surrounding the Selman Living Laboratory. Some points represent multiple species.

Discussion

We documented an apparently healthy and intact reptile assemblage: we observed 22 of 25 snake species (88%) and three of five turtle species expected to occur in the study area (Sievert and Sievert, 2021), with neonates representing 92.3% of observed species and 15.7% of all observations. We did not observe *Rena dissecta*, *Tantilla nigriceps*, and *Hypsiglena jani*, relatively small, nocturnal snakes, nor the highly aquatic turtles *Chelydra serpentina* and *Apalone spinifera*. It is likely that further road sampling, or the addition of different sampling methods, such as turning over objects in terrestrial habitats, using terrestrial drift fences with pitfall and funnel traps, and aquatic trapping with hoop nets, would eventually reveal the species not encountered.

Ours is the third study in the last decade to present a comprehensive species list for snakes in Oklahoma (McKnight et al., 2015; Watters et al., 2021). The three studies suggest Oklahoma snake assemblages are diverse and remain relatively intact despite 150 years of anthropogenic change. Between 22-24 species were observed in each study, accounting for 76-88% of local species pools (Table 3; species pools estimated from Sievert and Sievert, 2021). Despite the similarity in the results, the three studies used radically different methodologies (Table 3) but had one thing in common; sampling with high intensity (McKnight et al., 2015; Watters et al., 2021).

Table 3. A comparison of snake diversity documented during three recent Oklahoma studies.

	Selman Living Lab (This study)	Lake Texoma (Watters et al. 2021)	Boehler Seeps and Sandhills Preserve (McKnight et al. 2015)
Species Observed	22	24	22
Species Pool	25	30	29
% of Pool Observed	88%	80%	76%
Methods	8 years road surveys	65 years class field trips	2 years multiple methods

Road surveys of snakes produce biased samples because of interspecific variation in home range area, movement rates, habitat preference, and body size (Dodd et al., 1989; Jochimsen et al., 2014). As a result, in many systems multiple sampling methods are required for accurate estimates of species diversity and relative abundance, because small-bodied species with low movement rates remain undetected or underrepresented in road surveys (Seigel et al., 2002; Sullivan et al., 2017). However, snakes are difficult to trap, and several studies report incidental captures, on roads or otherwise, as the most effective way of sampling snakes (Busby and Parmalee, 1996; McKnight et al., 2015; Sullivan et al., 2017). Persistent surveys of the same network of roads can yield accurate estimates of species diversity in snake assemblages (Sullivan et al., 2017), but biases associated with relative abundance data likely remain inherent.

There are diminishing returns on adding new species to species lists by repeated sampling (van Rooijen, 2009). We repeatedly sampled the same area for eight years and eventually captured most of the expected species, observing one new species during the fifth year of sampling. Similarly, a study involving pitfall and funnel trapping of snakes in New Mexico added a new species after seven years of trapping the same sites (Bateman et al., 2009), and a study involving pitfall trapping of small reptiles in Western Australia added a new species after 16,500 individuals were captured (Thompson et al., 2003).

Observed mortality rates for snakes in our study were lower than rates reported in other studies (Smith and Dodd, 2003; Jochimsen et al., 2014; Lutterschmidt et al., 2019). Moreover, the absence of dead turtles in our sample is encouraging in light of numerous studies where road mortality had negative consequences on population structure and viability in turtles (Steen and Gibbs, 2004; Aresco, 2005; Piczak et al., 2019). None of the roads in our study area were paved, and speed limits were not posted because speeds in excess of 40 km/h were not sustainable due to road conditions. Moreover, after heavy rains when reptiles often move, road mortality was likely reduced because roads were impassable to vehicles. In contrast, studies reporting high rates of road mortality in snakes and turtles typically involved paved divided highways that were always passable, with multiple lanes and speed limits of 88 km/h or greater (Smith and Dodd, 2003; Aresco, 2005; Lutterschmidt et al., 2019). Our study area has been ranched and explored for oil and gas for over a century, and only about 1% of the study area is protected land. Despite these conditions, the reptile assemblage is diverse.

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References

Aresco MJ. 2005. The effect of sex-specific terrestrial movements and roads on the sex ratio of freshwater turtles. Biol Conserv 123:37–44.

Bateman HL, Chung-MacCoubrey A, Snell HL, Finch DM. 2009. Abundance and species richness of snakes along the Middle Rio Grande riparian forest in New Mexico. Herpetol Conserv Biol 4:1–8.

Busby WH, Parmelee JR. 1996. Historical changes in a herpetofaunal assemblage in the Flint Hills of Kansas. Am Midl Nat 135:81–91.

Cagle NL. 2008. Snake species distributions and temperate grasslands: a case study from the American tallgrass prairie. Biol Conserv 141:744–755.

Crother BI, editor. 2017. Scientific and standard English names of amphibians and reptiles of North America north of Mexico, with comments regarding confidence in our understanding, 8th ed. SSAR Herpetological Circular 43. 102 p.

Dodd Jr CK, Enge KM, Stuart JN. 1989. Reptiles on highways in north-central Alabama. J Herpetol 23:197–200.

Green MJB, How R, Padmalal UKGK, Dissanayake SRB. 2009. The importance of monitoring biological diversity and its application in Sri Lanka. Trop Ecol 50:41–56.

Google Earth Pro. 2020. Available from: https://www.google.com/earth/versions/ (accessed May 1, 2020).

Jochimsen DM, Peterson CR, Harmon LJ. 2014. Influence of ecology and landscape on snake road mortality in a sagebrush-steppe ecosystem. Anim Conserv 17:583–592.

Lutterschmidt WI, Weidler JM, Schalk CM. 2019. Hot moments and hot spots in the bayou: spatiotemporal patterns of road occurrence in a snake assemblage in Louisiana, USA. Herpetol Conserv Biol 14:533–545.

McKnight DT, Harmon JR, Mcknight JL, Ligon DB. 2015. Taxonomic biases of seven methods used to survey a diverse herpetofaunal community. Herpetol Conserv Biol 10:666-678.

McNulty SA, White D, Huffy M, and Foster P. 2017. The Organization of Biological Field Stations at fifty. Bull Ecol Soc Am 98:359-373.

Michener WK, Bildstein KL, McKee A, Parmenter RR, Hargrove WW, McClearn D, Stromberg M. 2009. Biological field stations: research legacies and sites for serendipity. BioScience 59:300-310.

Piczak ML, Markle CE, Chow-Fraser P. 2019. Decades of road mortality cause severe decline in a common snapping turtle (*Chelydra serpentina*) population from an urbanized wetland. Chelonian Conserv Biol 18:231–240.

Seigel RA, Smith RB, Demuth J, Ehrhart LM, Snelson Jr FF. 2002. Amphibians and reptiles of the John F. Kennedy Space Center, Florida: a long-term assessment of a large protected habitat (1975–2000). Fla Sci 65:1–12.

Sievert G, Sievert L. 2021. A field guide to Oklahoma's amphibians and reptiles, 4th ed. Oklahoma City (OK): Oklahoma Department of Wildlife Conservation. 231 p.

Smith LL, Dodd Jr CK. 2003. Wildlife mortality on U.S. Highway 441 across Paynes Prairie, Alachua County, Florida. Fla Sci 66:128–140.

Steen DA, Gibbs JP. 2004. Effects of roads on the structure of freshwater turtle populations. Conserv Biol 18:1143–1148.

Sullivan BK, Leavitt DJ, Sullivan KO. 2017. Snake communities on the urban fringe in the Sonoran Desert: influences on species richness and abundance. Urban Ecosyst 20:199–206.

Thompson GG, Withers PC, Pianka ER, Thompson SA. 2003. Assessing biodiversity with species accumulation curves; inventories of small reptiles by pit-trapping in Western Australia. Austral Ecol 28:361–383.

van Rooijen J. 2009. Estimating the snake species richness of the Santubong Peninsula (Borneo) in two different ways. Contrib Zool 78:141–147.

Watters JL, Carpenter GC, Siler CD. 2021. Updated checklist of amphibians and reptiles at the University of Oklahoma Biological Station at Lake Texoma, Oklahoma. Proc Okla Acad Sci 101:33-42.

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