

# FINAL PERFORMANCE REPORT



**Federal Aid Grant Number F18AF00629 (T-107-R-1)**

**Survey of the Distribution, Habitat, and Current and Historical  
Presence of *Pseudogymnoascus destructans* in the Tri-colored Bat in  
Oklahoma**

**Oklahoma Department of Wildlife Conservation**

**October 1, 2018 – June 30, 2024**

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**State:** Oklahoma

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**Grant Program:** State Wildlife Grants

**Grant Title:** Survey of the Distribution, Habitat, and Current and Historical Presence of *Pseudogymnoascus destructans* in the Tri-colored Bat in Oklahoma

**Grant Period:** October 1, 2018 to June 30, 2024

**Principal Investigators:** Dr. Janet K. Braun, Dr. Brandi Coyner, and Dr. Hayley C. Lanier, Sam Noble Oklahoma Museum of Natural History, University of Oklahoma

### EXECUTIVE SUMMARY/ABSTRACT:

Over the course of this project, Tricolored bats (*Perimyotis subflavus*) were surveyed by acoustic recording and mist netting in central and western Oklahoma and the captured bats, as well as historic museum specimens, were swabbed and tested for the presence of *Pseudogymnoascus destructans*, the fungus which causes white-nose syndrome. Acoustic recorders were used to record bat vocalizations at 31 sites. One recorder was placed at a single site on the University of Oklahoma campus (Cleveland County) for nearly five years to collect a month-by-month baseline, and to examine annual variation in the composition of the bat community. The second recorder was moved between 30 sites to collect bat vocalizations for a total of 843 nights. Tricolored Bats (*Perimyotis subflavus*) were detected at 23 of the 28 sites at which bat vocalizations were recorded: Alfalfa, Blaine, Caddo, Cleveland, Comanche, Custer, Ellis, Greer (2x), Hughes, Jefferson, Johnson, Kay, Lincoln, Marshall, Murray, Okfuskee, Oklahoma, Osage (2x), Payne, Stephens, and Tillman counties. Vocalizations from twelve species of bats were recorded: *Antrozous pallidus*, *Corynorhinus townsendii*, *Eptesicus fuscus*, *Lasionycteris noctivagans*, *Lasiurus borealis*, *Lasiurus cinereus*, *Myotis ciliolabrum*, *Myotis lucifugus*, *Myotis velifer*, *Nycticeius humeralis*, *Parastrellus hesperus*, *Perimyotis subflavus*, and *Tadarida brasiliensis*. Mist nets were used to survey for *P. subflavus* at 35 sites in ten counties during the summers of 2019, 2021, and 2022 and one hundred seventy-six (176) net-nights of effort were expended. No *P. subflavus* individuals were captured, but 20 bats of four other species were netted. The presence of the fungus that causes white-nose syndrome, *Pseudogymnoascus destructans* (*Pd*), was evaluated from historical museum collections, live-captured bats, and on swabs taken from winter hibernacula surveys from six caves: three gypsum caves in western Oklahoma (Nescatunga, Selman, and Washita caves), and three hibernacula in limestone caves in the Arbuckle Mountains (Wild Woman, Little Crystal, and Corner Post caves). All of the 308 specimens of *Perimyotis subflavus* from 14 museum collections (all from Oklahoma) were negative for *Pd*, indicating no historical prevalence of *Pd* on *P. subflavus* in Oklahoma. Similarly, all 19 of the summer-captured bats that were swabbed were negative for the fungus. In contrast, 24 swabs taken from 279 bats swabbed or found dead in winter hibernacula (2020, 2021, 2022, 2023) in five of the six caves were positive for *Pd*, including three *P. subflavus*, and the first *Pd*-positive results from the Arbuckle Mountains.

## **OBJECTIVE:**

To determine the presence or absence of the Tri-colored Bat (*Perimyotis subflavus*) in Oklahoma using acoustic detection and trapping (mist netting) surveys. The current and historical presence or absence of *Pseudogymnoascus destructans* in this species will also be evaluated. The locations and number of *P. subflavus*, and habitat and natural history data, recorded during the project will be provided in each Performance Report.

## **RESULTS AND DISCUSSION:**

### **The presence of *Pseudogymnoascus destructans* in Oklahoman bats**

From October through December 2018, 308 specimens of *Perimyotis subflavus* from 14 museum collections were examined (Figs. 1-2). These collections were: the Biological Collections of California State University at Long Beach, Cornell University's Museum of Vertebrates, Florida Museum of Natural History at the University of Florida, Sternberg Museum of Natural History of Forts Hays University, the Louisiana State University Museum of Natural Science, the Collection of Vertebrates at Oklahoma State University, the Museum of Texas Tech University, the U.S. National Museum of Natural History, the University of Central Oklahoma Vertebrate Collection, the University of Colorado's Museum of Natural History, the University of Kansas Natural History Museum, University of Michigan Museum of Natural History, the University of New Mexico Museum of Southwestern Biology, and the Sam Noble Oklahoma Museum of Natural History at the University of Oklahoma. For each specimen, the identification and data were verified, specimen tags were imaged, and the specimen was swabbed to test for the presence of *Pseudogymnoascus destructans* (*Pd*).

The PIs requested swabs of *Pd* positive and negative animals from the U.S. Geological Survey to serve as controls. On 5 February 2019, seven swabs were received, and their receipt was coordinated with the Oklahoma Department of Wildlife Conservation. During the spring of 2019, two undergraduate lab assistants, Lisa Ratliff and Kim Jones, supervised by Co-PI Lanier analyzed the swabs from these specimens for the presence of *Pd*. The known positive and negative swabs from the USGS were run to confirm that the extraction and qPCR protocols were running accurately and to serve as standards for qPCR tests. All of the samples from museum specimens of *Perimyotis subflavus* from Oklahoma were negative for *Pd* indicating no historical prevalence of *Pd* on *P. subflavus* in the state.

In addition to the museum specimens, we extracted DNA from swabs that were collected from 19 bats that we captured and swabbed during our netting surveys in 2019, 2021, and 2022: eleven *Lasiurus borealis*, one *Lasiurus cinereus*, six *Nycticeius humeralis*, and one *Tadarida brasiliensis*. DNA also was extracted from two bats that were donated to the museum as salvaged specimens in 2019: one *Lasiurus borealis* (Cleveland County) and one *Nycticeius humeralis* (Garvin County). All of the swabs from these bats, all of which were captured or salvaged during the summer months, were negative for *Pd*, indicating continued low prevalence in the state.

Figure 1.—Swabbed Museum Specimens by County (The number of specimens is given below the name.)

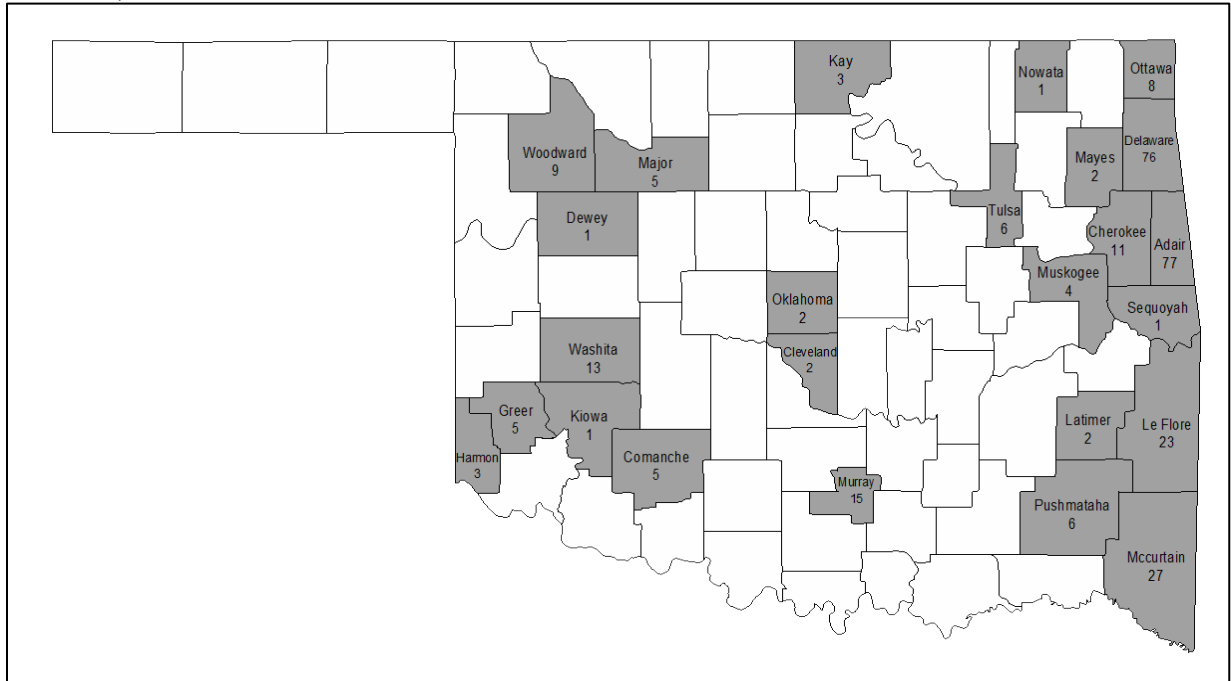
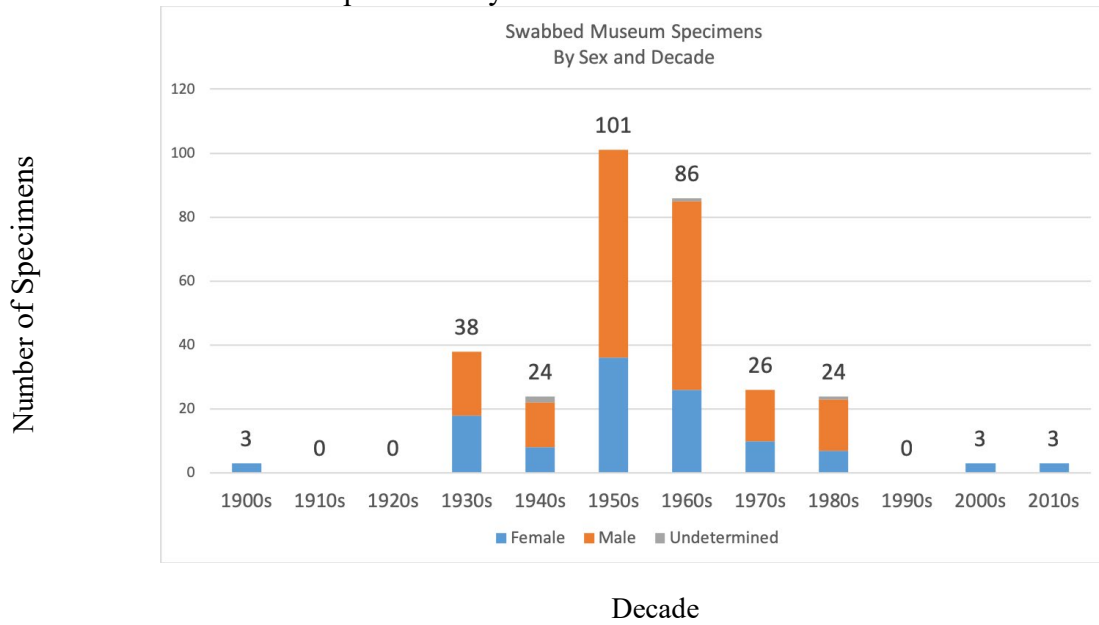


Figure 2.—Swabbed Museum Specimens by Sex and Decade



## Winter Surveys for *Pseudogymnoascus destructans*

We had the opportunity to extend our survey of *Pd* to bats sampled from winter hibernacula through the analysis of swabs that were provided to us from three caves in western Oklahoma by Dr. Jason Shaw and a team from the University of Sciences and Arts of Oklahoma (2020-2023). These caves were Washita Cave, Selman Cave, and Nescatunga Cave, and swabs were collected from three different species of hibernating bats. In 2022, swabs also were provided from three caves in the Arbuckle Mountains by Dr. Kevin Blackwood with the Oka' Water Institute at East Central Oklahoma State University. These caves were Wild Woman Cave, Little Crystal Cave, and Corner Post Cave, and the bats that were swabbed were of uncertain identification but were suspected to be *Perimyotis subflavus*. Hibernating bats were examined visually for signs of the fungus as they were swabbed. Around 8% of all winter swabs were positive (Table 1), with no statistically significant differences in positivity rate between years. While *Pd* has been previously documented from Washita, Selman, and Nescatunga Caves, the evidence of positive swabs from Wild Woman Cave and Little Crystal Cave is the first indication of the fungus in the Arbuckle Mountains. The rate of positive swabs was statistically indistinguishable between *Perimyotis subflavus* (9% positive) and *Myotis velifer* (8% positive) and between caves in Western Oklahoma (Chi-sq test,  $p > 0.05$ ).

**Table 1.** Locations of Winter Hibernacula Swabs of the Presence of *Pseudogymnoascus destructans*

Cave	Species	2020		2021		2022		2023	
		+ <i>Pd</i>	- <i>Pd</i>	+ <i>Pd</i>	- <i>Pd</i>	+ <i>Pd</i>	- <i>Pd</i>	+ <i>Pd</i>	- <i>Pd</i>
Washita Cave	<i>Myotis velifer</i>	0	20	<i>ns</i>	<i>ns</i>	3	18	0	21
	<i>Perimyotis subflavus</i>	1	4	<i>ns</i>	<i>ns</i>	0	4	1	3
Selman Cave	<i>Eptesicus fuscus</i>	0	1	0	0	0	0	0	0
	<i>Myotis velifer</i>	2	28	0	20	3	19	4	18
Nescatunga Cave	<i>Perimyotis subflavus</i>	0	1	0	5	0	3	0	2
	<i>Myotis velifer</i>	<i>ns</i>	<i>ns</i>	2	23	2	22	2	19
Wild Woman Cave	<i>Perimyotis subflavus</i>	<i>ns</i>	<i>ns</i>	0	4	0	1	1	3
	unknown bats	<i>ns</i>	<i>ns</i>	<i>ns</i>	<i>ns</i>	2	5	<i>ns</i>	<i>ns</i>
Little Crystal Cave	unknown bats	<i>ns</i>	<i>ns</i>	<i>ns</i>	<i>ns</i>	1	10	<i>ns</i>	<i>ns</i>
Corner Post Cave	unknown bats	<i>ns</i>	<i>ns</i>	<i>ns</i>	<i>ns</i>	0	1	<i>ns</i>	<i>ns</i>

## Acoustic Surveys and Data

### Data for Acoustic Sites

Two acoustic recorders and the Kaleidoscope software for acoustic analysis were purchased in November 2018 and the PIs began obtaining proficiency with the acoustic recorders and software. In March 2019, Co-PI Coyner attended a one-day, in-depth seminar in Gainesville, FL, provided by Wildlife Acoustics, maker of the acoustic detectors and analysis software. The seminar, "Kaleidoscope 5 for Bat Research," covered the basics of ultrasound, recording

technologies, auto identification and the manual vetting of calls, as well as best practices for analyzing and reporting. Kaleidoscope Pro is one of three USFWS-approved automated ID software programs that is used under the U.S. Fish and Wildlife Service’s Indiana Bat Summer Survey Guidelines.

One recording device was mounted on the building of the San Noble Oklahoma Museum of Natural History and was operational nearly year-round for five years (January 2019 through August 2023) to examine not only the bat community at a representative site in Central Oklahoma, but also to examine month-to-month changes in the bat community and seasonal patterns of activity and occurrence. The other recording unit was deployed between March and October each year (2019 – 2023) and moved to a new location and county approximately every month to capture data regarding the bat communities at five to seven unique locations each year. Over the course of the grant, the second recording device was placed at 30 locations in 25 counties in central and western Oklahoma (Table 2).

**Table 2.** Locations of Acoustic Recorders, Beginning and Ending Dates, and Number of Nights

Year 1 (October 2018 – September 2019)

<b>ID</b>	<b>County</b>	<b>Recorder Location</b>	<b>Latitude</b>	<b>Longitude</b>	<b>Dates</b>	<b>Nights</b>
1	Cleveland	Sam Noble Museum of Natural History, 2401 Chautauqua Ave, Norman	35.194124	-97.448528	1 Jan-27 Sept 2019	269
2	Marshall	University of Oklahoma Biological Station, Willis	33.881383	-96.799831	13 Mar-16 Apr 2019	34
3	Payne	5120 E McElroy Rd, Stillwater	36.132371	-96.99011	26 Apr-31 May 2019	35
4	Harper	8 mi E Selman, Cimarron Bluff Wildlife Management Area, (elevation 502 m)	36.80899	-99.3402	12-15 Jun 2019	3
5	Woodward	2.75 mi E Fort Supply, Cooper Wildlife Management Area	36.5754	-99.5075	15-18 Jun 2019	3
6	Cleveland	3910 180th Ave NE, Newalla	35.26558	-97.178025	19 Jun-17 Jul 2019	28
7	Comanche	2.25 mi S, 10 mi W Medicine Park, The Narrows, Wichita Mountains National Wildlife Refuge, (elevation 466 m)	34.70104	-98.67983	20-26 Jul 2019	6
8	Johnston	2.25 mi S, 2 mi E Tishomingo, Picnic Area, Tishomingo National Wildlife Refuge, (elevation 194 m)	34.19588	-96.6428	1-7 Aug 2019	6
9	Johnston	7 mi N, 6 mi E Tishomingo, Desperado Springs, Blue River Wildlife Management Area, (elevation 242 m)	34.33364	-96.59568	21 Aug-17 Sept 2019	27

Year 2 (October 2019 – September 2020)

ID	County	Recorder Location	Latitude	Longitude	Dates	Nights
1	Cleveland	Sam Noble Museum of Natural History, 2401 Chautauqua Ave, Norman	35.194124	-97.448528	27 Sept 2019-1 Oct 2020	370
10	Osage	1 mi N, 3.25 mi W Whippoorwill, Hulah Wildlife Management Area	36.928786	-96.189018	1 Oct-1 Nov 2019	31
11	Grady	1 mi S, 2.67 mi W Intersection Hwy 62 and Hwy 277, Chickasha	35.038709	-97.984117	2 Mar-1 Apr 2020	30
12	Garfield	1.4 mi N, 1.1 mi W Drummond, Drummond Flats Wildlife Management Area	36.3240	-98.0531	3 Jun-1 Jul 2020	28
13	Okfuskee	4.75 mi W Mason, Deep Fork Wildlife Management Area	35.5679	-96.4380	1 Jul-31 Jul 2020	30
14	Okfuskee	4.7 mi W Mason, Deep Fork Wildlife Management Area	35.5667	-96.4354	3 Sept-1 Oct 2020	28

Year 3 (October 2020 – September 2021)

ID	County	Recorder Location	Latitude	Longitude	Dates	Nights
1	Cleveland	Sam Noble Museum of Natural History, 2401 Chautauqua Ave, Norman	35.194124	-97.448528	1 Oct 2020-30 Sept 2021	365
15	Ellis	8.2 mi S, 4.2 mi E Harmon, Four Canyon Preserve	36.025575	-99.483845	2 Oct 2020-2 Nov 2020	31
16	Lincoln	0.75 mi N, 4 mi E Rossville	35.604554	-96.929406	4 Mar 2021-2 Apr 2021	29
17	Custer	0.5 mi S, 5.2 mi W Butler, Washita National Wildlife Refuge	35.630286	-99.2782	16 Apr 2021-14 May 2021	28
18	Oklahoma	Arcadia Conservation Education Area	35.626176	-97.389322	17 May 2021 - 15 June '21	29
19	Greer	6.25 mi N, 5.4 mi W Reed, Doc Hollis Lake, Sandy Sanders Wildlife Management Area	34.990845	-99.791095	23 Jun 2021-28 Jul 2021	35
20	Tillman	2.5 mi N, 2.75 mi W Tipton, Gist Wildlife Management Area	34.538682	-99.18985	2 Aug 2021-20 Sept 2021	49

Year 4 (October 2021 – September 2022)

ID	County	Recorder Location	Latitude	Longitude	Dates	Nights
1	Cleveland	Sam Noble Museum of Natural History, 2401 Chautauqua Ave, Norman	35.194124	-97.448528	1 Oct 2021-30 Sept 2022	365
21	Jefferson	0.5 mi S, 5 mi W Addington, Waurika Lake	34.235146	-98.055508	30 Sept 2021 - 29 Oct '21	29
22	Greer	1.5 mi N Granite o Hwy 6	34.977382	-99.380268	31 Mar 2022-3 May 2022	33
23	Blaine	10.5 mi W Geary, American Horse Lake	35.62828	-98.50598	3 May 2022-31 May 2022	28
24	Hughes	3.75 mi S, 1.5 mi E Holdenville, Oklahoma State Fish Hatchery	35.02756	-96.37004	2 Jun 2022-5 Jul 2022	33
25	Murray	0.25 mi S, 1.5 mi E Sulphur, Chickasaw National Recreation Area	34.504291	-96.941813	12 Jul 2022-18 Aug 2022	37
26	Alfalfa	8.25 mi N Jet, Salt Plains National Wildlife Refuge, Bonham Pond	36.78622	-98.18178	19 Aug 2022-30 Sept 2022	42

Year 5 (October 2022 – September 2023)

ID	County	Recorder Location	Latitude	Longitude	Dates	Nights
1	Cleveland	Sam Noble Museum of Natural History, 2401 Chautauqua Ave, Norman	35.194124	-97.448528	1 Oct 2022-1 Sept 2023	335
27	Caddo	1 mi S, 3.75 mi W Albert, Fort Cobb Wildlife Management Area, Fort Cobb Lake	35.219004	-98.478121	30 Sept 2022-1 Nov 2022	32
28	Stephens	2 mi S, 8.5 mi E Bray, Fuqua Lake	34.605868	-97.667424	6 Mar 2023-4 Apr 2023	29
29	Blaine	1.7 mi N, 1 mi W Canton, Canton Lake, US Army Corp of Engineers Canton Lake Office	36.078856	-98.605346	4 Apr 2023-5 May 2023	31
30	Osage	1.25 mi S, 4.8 mi W Skiatook, Skiatook Lake	36.350206	-96.08721	5 May 2023-2 Jun 2023	28
31	Kay	8.5 mi E Ponca City, Kaw Lake	36.69915	-96.92954	2 Jun 2023-3 July 2023	31

The stationary recording device at the University of Oklahoma campus on the Sam Noble Oklahoma Museum of Natural History’s building was operational for 1,704 nights (nearly five full years). Once each month, the data card was removed from the recorder and the stored call recordings were downloaded and analyzed. The data from this recording unit are summarized in Table 3 and show the month-to-month patterns of presence and relative abundance of the bat species that occurred at this site. As expected, bat calling activity was very low between December and February each year, and only a few calls representing zero to two species were recorded each month during the winter season. Calling activity and bat diversity increased dramatically in March and remained high (typically five to seven species per month) through October. November activity was variable, and that variation corresponded with nighttime temperatures. Over the course of 1,704 nights, eight species of bats were recorded at this location. *Lasiurus borealis*, *Lasiurus cinereus*, *Nycticeius humeralis*, and *Tadarida brasiliensis* were the most frequently detected species and were present most months between March and October each year. A sufficient number of calls were recorded for these four species on a monthly basis that their presence was often confirmed through the auto-identification process using the Kaleidoscope software. *Perimyotis subflavus* was present at this site (Site 1) from March through November, however, it exhibited lower calling activity and confirming its presence usually required the manual evaluation of the call recordings except in late summer (August and September) when its calling frequencies were higher. *Eptesicus fuscus* also was detected regularly from March through September each year, but its calling activity was low and required manual evaluation of the call recordings most months. Recordings of *Eptesicus fuscus* vocalizations were rare in October and November suggesting that the individuals that were present during the spring and summer migrated elsewhere in the fall in preparation for hibernation. Calling activity by *Lasionycteris noctivagans* was infrequent but detected annually between March and November but with a decrease in frequency and occurrence in mid-summer (May – July). This species has a more northerly distribution and appears to be uncommon in central Oklahoma during the summer months but is a fairly common migrant during the spring and fall. *Myotis velifer* was the most infrequently recorded of the eight bat species and was detected only by a handful of recorded calls in July and August during two of the five summers during which the recorder was operational.



**Table 3.** Summary of Detected Species at the Sam Noble Oklahoma Museum of Natural History (Site 1) by Month. Automated ID is indicated by a plus (+) symbol, whereas manual identification by Co-PI Coyner, Co-PI Lanier, or Graduate RA Meacham) is indicated by an asterisk (\*). The recorder was first deployed in January 2019 and no data were collected in September 2023, due to a temporary removal of the recording equipment to avoid damage during roof repairs on the building.

Year 1	Month											
	2018			2019								
Species	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
<i>Eptesicus fuscus</i>	-	-	-			*	*		*	*	*	*
<i>Lasionycteris noctivagans</i>	-	-	-			*	*				+	+
<i>Lasiurus borealis</i>	-	-	-	*		+	+	+	+	+	+	+
<i>Lasiurus cinereus</i>	-	-	-			*	*	+	*	*	*	+
<i>Myotis velifer</i>	-	-	-									
<i>Nycticeius humeralis</i>	-	-	-	*		+	*	+	+	+	+	+
<i>Perimyotis subflavus</i>	-	-	-			*					+	+
<i>Tadarida brasiliensis</i>	-	-	-				+	+	+	+	+	+
Total No. of Species				2	0	6	6	4	5	5	7	7

Year 2	Month											
	2019			2020								
Species	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
<i>Eptesicus fuscus</i>	*					+		*	*	*	*	+
<i>Lasionycteris noctivagans</i>	+					*		*	*	*	*	+
<i>Lasiurus borealis</i>	+	+				+	+	+	+	+	+	+
<i>Lasiurus cinereus</i>	*	*				+	*	*	*	*	*	+
<i>Myotis velifer</i>												
<i>Nycticeius humeralis</i>	+	+				+	+	+	+	+	+	+
<i>Perimyotis subflavus</i>	*					*	*	*		*	+	+
<i>Tadarida brasiliensis</i>	+		*			+	+	+	+	+	+	+
Total No. of Species	7	3	1	0	0	7	5	7	6	7	7	7

Year 3	Month											
	2020			2021								
Species	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
<i>Eptesicus fuscus</i>							*	*		*	+	*
<i>Lasionycteris noctivagans</i>	*	*				*	*			*	*	*
<i>Lasiurus borealis</i>	+	+		*		*	+	+	+	+	+	+
<i>Lasiurus cinereus</i>	*						+	+	*	*	+	+

<i>Myotis velifer</i>												
<i>Nycticeius humeralis</i>	+	+				*	*	*	*	+	+	+
<i>Perimyotis subflavus</i>	*	*				*	*	*		*	*	*
<i>Tadarida brasiliensis</i>	+	*			*		+	+	*	+	+	*
Total No. of Species	6	5	0	1	1	4	7	6	4	7	7	7

Year 4	Month											
	2021			2022								
Species	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
<i>Eptesicus fuscus</i>						*	*	*	*	*	+	*
<i>Lasionycteris noctivagans</i>	*	*						*	*	*	*	
<i>Lasiurus borealis</i>	+	+	*			*	+	+	+	+	+	+
<i>Lasiurus cinereus</i>	*					+	+	+	+	*	*	*
<i>Myotis velifer</i>											*	
<i>Nycticeius humeralis</i>	*	+	*			*	*	*	*	+	+	+
<i>Perimyotis subflavus</i>	*	*				*	*		*	*	*	*
<i>Tadarida brasiliensis</i>	*					*	+	+	+	+	+	*
Total No. of Species	6	4	2	0	0	6	6	6	7	7	8	6

Year 5	Month											
	2022			2023								
Species	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
<i>Eptesicus fuscus</i>							*	*	*	+	+	<i>ns</i>
<i>Lasionycteris noctivagans</i>	*							*	*	+	+	<i>ns</i>
<i>Lasiurus borealis</i>	+	+	*	*	*	+	+	+	+	+	+	<i>ns</i>
<i>Lasiurus cinereus</i>	*						*	+	*	+	+	<i>ns</i>
<i>Myotis velifer</i>										*		<i>ns</i>
<i>Nycticeius humeralis</i>	*	+	*			*	*	*	*	+	+	<i>ns</i>
<i>Perimyotis subflavus</i>	*	*				*	*	*	*	+	+	<i>ns</i>
<i>Tadarida brasiliensis</i>	*					+	+	+	*	+	+	<i>ns</i>
Total No. of Species	6	3	2	1	1	4	6	7	7	8	7	<i>ns</i>

The second recording device was deployed during the period of greatest bat activity (March through October), and it was moved approximately every five weeks to a new survey location. At the end of each acoustic survey period, typically lasting 28 to 35 days, the data from the recorder's SD cards were download, and the recorder was placed in a new location. At all Acoustic Sites, weather conditions for the month were recorded from the Oklahoma Mesonet, and moon phases and sunrise/sunset times for the month also were recorded. The Kaleidoscope software was used to conduct an initial analysis of the recorded calls and those calls that could not be identified by the software were analyzed individually by either Co-P.I. Brandi Coyner,

Co-P.I. Hayley Lanier, or Graduate Research Assistant Kailey Meacham. The data from the second recorder are summarized in Table 4. Typically, the species that were confirmed through the software analysis were species from which a larger number of calls were recorded. While the number of calls cannot be used to precisely estimate the number of bats of a given species at a site, they do provide a general pattern of abundance with a larger number of calls from a species indicating that the species exhibited greater foraging activity in the vicinity of the recorder or occurred in greater numbers. Species that were identified through the process of manually evaluating the recorded calls were typically ones that were recorded infrequently and were therefore less active and/or less common at a site. Bat calls were recorded at 29 of the 31 acoustic survey locations (the OU campus location and 30 remote locations). No bat calls were recorded at Site 8, which was surveyed for only six nights, or at Site 13 due to water damage to the recorder. Because of the University of Oklahoma’s COVID-19 travel and research restrictions, the second acoustic recorder was not deployed during the months of April and May 2020. Shortly after being redeployed during the summer of 2020, the second acoustic recorder was damaged when it took on water during a heavy storm and condensation accumulated in the display while it was stationed at Acoustic Site 13 in July. The PIs attempted to mitigate the condensation, but the acoustic recorder was determined to be permanently damaged, and a new SM4BAT FS recorder was purchased and received on 29 August 2020. As a result of the heavy rainfall that resulted in water damage, no recordings could be salvaged for Site 13 and no recorder was available to deploy in August of 2020.

**Tables 4a – 4e.** Summary of Detected Species at Acoustic Sites 2 – 31, arranged by region of the state (North-Central, Central, South-Central, Northwest, and Southwest) and labeled with the site number and county. Species identified at a site through Automated ID are indicated by a plus (+) symbol, whereas manual identification by Co-PI Coyner or Lanier are indicated by an asterisk (\*). No information is given for Acoustic Sites 8 and 13 for reasons explained above.

**Table 4a.** Acoustic Survey Summary for North-Central Oklahoma Sites

North-Central Region	Acoustic Site				
	3	10	12	30	31
	Payne	Osage	Garfield	Osage	Kay
<i>Antrozous pallidus</i>					
<i>Corynorhinus townsendii</i>					
<i>Eptesicus fuscus</i>	*	*			
<i>Lasionycteris noctivagans</i>	*	+		*	
<i>Lasiurus borealis</i>	+	*	+	+	+
<i>Lasiurus cinereus</i>	*	*		+	*
<i>Myotis ciliolabrum</i>					
<i>Myotis velifer</i>			*		
<i>Nycticeius humeralis</i>	+	*		*	*
<i>Parastrellus hesperus</i>					
<i>Perimyotis subflavus</i>	*	*		+	*
<i>Tadarida brasiliensis</i>	+	+	+	*	*

**Table 4b.** Acoustic Survey Summary for Central Oklahoma Sites

Central Region	Acoustic Site					
	6	11	14	16	18	24
	Cleveland	Grady	Okfuskee	Lincoln	Oklahoma	Hughes
<i>Antrozous pallidus</i>						
<i>Corynorhinus townsendii</i>						
<i>Eptesicus fuscus</i>		*			*	*
<i>Lasionycteris noctivagans</i>		*	*	*		*
<i>Lasiurus borealis</i>	+	+	+	*	+	+
<i>Lasiurus cinereus</i>	*	+	+	*	+	+
<i>Myotis ciliolabrum</i>		*				
<i>Myotis lucifugus</i>			+			
<i>Myotis velifer</i>		*				
<i>Nycticeius humeralis</i>	+	+	+	*	+	*
<i>Parastrellus hesperus</i>						
<i>Perimyotis subflavus</i>	*		+	*	*	+
<i>Tadarida brasiliensis</i>	+	*	+		+	+

**Table 4c.** Acoustic Survey Summary for South-Central Oklahoma Sites

South-Central Region	Acoustic Site					
	2	9	21	25	27	28
	Marshall	Johnston	Jefferson	Murray	Caddo	Stephens
<i>Antrozous pallidus</i>						
<i>Corynorhinus townsendii</i>						
<i>Eptesicus fuscus</i>	*	*		+		*
<i>Lasionycteris noctivagans</i>	+	*	*			
<i>Lasiurus borealis</i>	+	*	+	+	+	*
<i>Lasiurus cinereus</i>	*		*	*	*	*
<i>Myotis ciliolabrum</i>	*		*			
<i>Myotis lucifugus</i>	*					
<i>Myotis velifer</i>				*	*	
<i>Nycticeius humeralis</i>	+	+	+	*	+	*
<i>Parastrellus hesperus</i>	*		+			
<i>Perimyotis subflavus</i>	*	*	*	+	*	*
<i>Tadarida brasiliensis</i>	+		*		*	

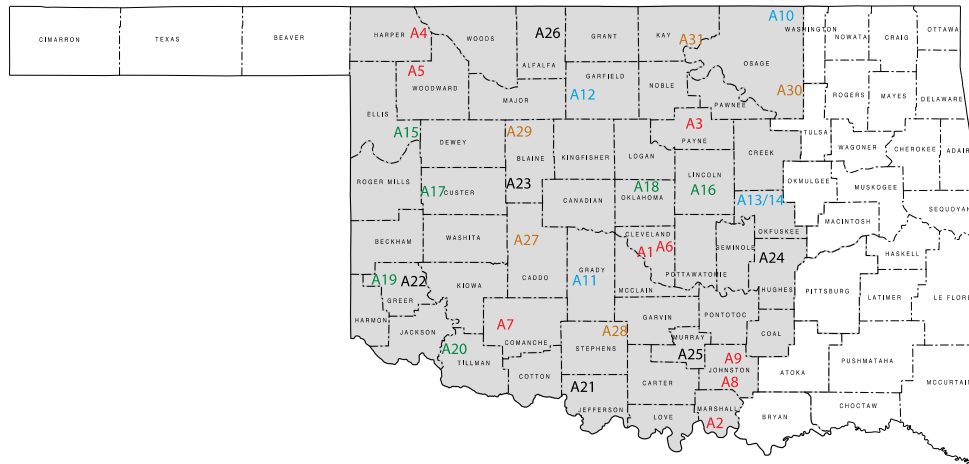
**Table 4d.** Acoustic Survey Summary for Northwest Oklahoma Sites

Northwest Region	Acoustic Site					
	4	5	15	23	26	29
	Harper	Woodward	Ellis	Blaine	Alfalfa	Blaine
<i>Antrozous pallidus</i>		*	+		*	
<i>Corynorhinus townsendii</i>			+			
<i>Eptesicus fuscus</i>	*	*	*	*	+	+
<i>Lasionycteris noctivagans</i>				*	+	+
<i>Lasiurus borealis</i>	+	+	*	+	+	+
<i>Lasiurus cinereus</i>	+	+	+	+	+	+
<i>Myotis ciliolabrum</i>			*		*	
<i>Myotis lucifugus</i>						
<i>Myotis velifer</i>		*	+	*	*	*
<i>Nycticeius humeralis</i>			+	*	+	+
<i>Parastrellus hesperus</i>			+			
<i>Perimyotis subflavus</i>			*		+	*
<i>Tadarida brasiliensis</i>	+	+	+	+	+	+

**Table 4e.** Acoustic Survey Summary for Southwest Oklahoma Sites

Southwest Region	Acoustic Site				
	7	17	19	20	22
	Comanche	Custer	Greer	Tillman	Greer
<i>Antrozous pallidus</i>	+	+	*		+
<i>Corynorhinus townsendii</i>		*			+
<i>Eptesicus fuscus</i>	*	*	+	*	+
<i>Lasionycteris noctivagans</i>		*	+	*	*
<i>Lasiurus borealis</i>	*	+	+	+	+
<i>Lasiurus cinereus</i>	*	+	+	*	+
<i>Myotis ciliolabrum</i>				+	+
<i>Myotis lucifugus</i>					
<i>Myotis velifer</i>	*	+	*	+	+
<i>Nycticeius humeralis</i>	+	+	+	+	*
<i>Parastrellus hesperus</i>				+	+
<i>Perimyotis subflavus</i>	+	*	*	+	+
<i>Tadarida brasiliensis</i>	+	+	+	+	+

**Figure 3.**—Map of locations of acoustic recorders for Year 1 (red), Year 2 (blue), Year 3 (green), and Year 4 (black) and Year 5 (orange).



### Acoustic Summary for Each Documented Bat Species

Twenty-two species of bats occur in Oklahoma – two species in the family Molossidae and 20 species in the family Vespertilionidae. Of these species, 12 were expected to occur in the study area (central and western Oklahoma exclusive of the panhandle) and the remaining nine species are believed to occur outside of the study area (*Corynorhinus rafinesquii*, *Lasiurus seminolus*, *Myotis austroriparius*, *Myotis grisescens*, *Myotis leibii*, *Myotis lucifugus*, *Myotis septentrionalis*, and *Myotis sodalists* occur in eastern Oklahoma, while *Myotis yumanensis* and *Nyctinomops macrotis* are found in the panhandle counties). The acoustic surveys detected all of the twelve species that have been previously documented within the study area at one or more survey sites. In addition, calls were recorded from one unexpected species, *Myotis lucifugus*, at two of the acoustic survey sites. As expected, none of the other extra-limital species were documented during our surveys. Below are summaries describing the distributions of the thirteen species that were documented during the acoustic survey. The references used in preparing these summaries are listed in the References section at the end of this report.

*Antrozous pallidus* (Pallid Bat): This species is uncommon in Oklahoma and specimen records indicate that it is found in rocky hills and canyonlands in the Black Mesa area, and the northwestern and southwestern corners of the main body of the state. It appears to be active from April through November and is thought to be largely inactive during the winter. It is presumed to hibernate, but no hibernacula are known for Oklahoma. Calls of this species were recorded at seven acoustic survey sites in the northwestern and southwestern portions of the state (Alfalfa, Comanche, Custer, Ellis, Greer, and Woodward counties).

*Corynorhinus townsendii* (Western Big-eared Bat): This species is present in western Oklahoma year-round and has a patchy distribution within the study area. It is typically found in association with gypsum formations and all known hibernacula in western Oklahoma are within gypsum caves. Calls of this species were recorded at three acoustic survey locations in three counties - Custer, Ellis, and Greer. Specimen records exist for Custer and Greer counties, both of

which encompass gypsum caves that are suitable roost and hibernation sites, but Ellis County occurs adjacent to but outside of the counties of previously known occurrence.

*Eptesicus fuscus* (Big Brown Bat): Specimen records indicate that this species is present in the state throughout the year, including during the winter months. It is widespread in eastern and central Oklahoma, but its documented range in western Oklahoma appears to be disjunct and centered around gypsum caves and canyonlands in the northwestern and southwestern corners of the state. Calls for this species were recorded at 21 acoustic survey sites in 19 counties including all six sites in the northwestern region and all five sites in the southwestern region of the study area (Alfalfa, Blaine, Cleveland, Comanche, Custer, Ellis, Grady, Greer, Harper, Hughes, Johnston, Marshall, Murray, Oklahoma, Osage, Payne, Stephens, Tillman, and Woodward). The acoustic data indicate that this species was active March through September. Calls were recorded in several counties that lack specimen records (e.g., Alfalfa, Blaine, Comanche, Ellis, Harper, Johnston, Marshall, and Tillman counties), but these are within the expected range of the species in Oklahoma.

*Lasionycteris noctivagans* (Silver-haired Bat): Calls of this species were recorded at 18 acoustic survey sites in 15 counties distributed across the study area (Alfalfa, Blaine, Cleveland, Custer, Grady, Greer, Hughes, Jefferson, Johnston, Lincoln, Marshall, Okfuskee, Osage, Payne, and Tillman). This tree-roosting species of bat appears to be uncommon in Oklahoma and no records of reproduction have been documented in the state. This species appears to occur in the state primarily during its spring and fall migrations and specimen records indicate that this is a cold-tolerant species that is present in the state at least from September through May (i.e., January, May, September, October, and November) including through the winter. The acoustic survey data supports this with calls recorded for the months of March, April, May, August, and September. At Acoustic Site 1, the number of calls peaked in April and May each spring and again in August and September, suggesting seasonal migration. Twelve of the counties where this species was detected during the acoustic surveys currently lack museum specimen records, suggesting that this species may be more widespread and common than traditionally believed.

*Lasiurus borealis* (Eastern Red Bat): This tree-roosting species was the most widespread and commonly detected bat species during the acoustic surveys. It was the only species for which calls were recorded at all 29 completed survey sites across the 25 counties. Calls of this species were recorded at sites in seven counties that currently lack museum records (Garfield, Harper, Hughes, Jefferson, Lincoln, Okfuskee, and Tillman), but these localities lie within the expected range of the species in Oklahoma. Specimen records indicate that this species is present in the state from April through December and the acoustic recorder detected this species in every month of the year (although calling activity was very limited in December, January, and February). The hibernation behavior for this species in Oklahoma is poorly known and further study of its winter habits is warranted.

*Lasiurus cinereus* (Hoary Bat): Calls of this species were recorded at 27 of the 29 acoustic survey sites in 23 counties: Specimen records exist for only nine of the 23 counties from which calls were recorded during the acoustic surveys. Although no specimen records currently exist to document this species in the remaining 12 counties, these counties are within the expected range of this wide-ranging species in Oklahoma. Specimen records indicate that

this species is present in the state from April through October and the acoustic data indicate that this species was active from March through October. The absence of specimen records and acoustic data for the winter months supports the hypothesis that this species is nomadic and migrates southward in the fall and northward in the spring.

*Myotis ciliolabrum* (Western Small-footed Bat): This is an uncommon species in Oklahoma whose geographic range is poorly known. Only 13 specimen records exist for this species in the state and those were collected primarily during the months of July and August in four counties – Cimarron County in the western panhandle, and Comanche, Greer, and Kiowa counties in the vicinity of the Wichita Mountains. Despite this apparently small range, calls of this species were recorded at seven of the acoustic survey sites in seven counties (Alfalfa, Ellis, Grady, Greer, Jefferson, Marshall, and Tillman) all but one of which occur outside of the documented range in Oklahoma. This species warrants further study to determine its residency status in Oklahoma and to better delineate its geographic range. The acoustic data suggest that it may be more widespread in southwestern Oklahoma than previously believed, and its range may extend along the Red River valley as far east as Marshall County. This species also appears to occur at least locally in portions of northwestern Oklahoma. Alternatively, if these detections are the result of a software identification error, then additional high-quality, confirmed recordings may be needed for this species to improve the accuracy of the Kaleidoscope software.

*Myotis lucifugus* (Little Brown Bat): This species is known to migrate long-distances and individuals have been documented across a wide area within the United States and Canada. However, in Oklahoma, this species has been documented by only a small number of specimen and observational records in seven counties in the eastern quarter of the state. No maternity colonies or wintering sites are known for Oklahoma and available records indicate that the species is present primarily during the spring and early summer (February, April, May). No specimen records exist for this species within the study area; however, it was detected at two acoustic survey sites in two counties (Marshall and Okfuskee). The Marshall County calls were recorded between 13 March and 16 April 2019, and the Okfuskee County calls were recorded between 3 September and 1 October 2020. Each of these recordings was collected during a period that is likely to represent spring migration (Marshall County) or fall migration (Okfuskee County) for this species. No other species of *Myotis* are known from Marshall or Okfuskee counties, and the call recordings were manually verified by P.I. Coyner, therefore, we believe that their identification is accurate. These acoustic survey locations may represent the extreme western edge of the migratory range of *M. lucifugus* in Oklahoma.

*Myotis velifer* (Cave Myotis): Numerous specimen records are known for this species in western Oklahoma, and it is commonly found in association with gypsum caves. Individuals have been collected in all months of the year, including at hibernacula during winter. Bats of this species often leave their hibernacula in March and are active through October when they re-enter their hibernacula for the winter. Calls of this species were recorded at 15 acoustic survey sites in 13 counties (Alfalfa, Blaine, Caddo, Cleveland, Comanche, Custer, Ellis, Garfield, Grady, Greer, Murray, Tillman, and Woodward). The recordings at sites in central Oklahoma are likely to be migrants or vagrants, while the sites in western Oklahoma are likely to occur near maternity colonies and summer roosts.



*Nycticeius humeralis* (Evening Bat): Calls of this species were recorded at 26 of the 29 sites and in 22 counties. It was recorded at all 17 acoustic survey sites in central Oklahoma except for the Garfield County site, which had sparse tree cover. Surprisingly, it was found at all of the survey sites in western Oklahoma as well, except for the two most northwestern sites (Harper and Woodward counties). This species of bat roosts in foliage and is associated with forested landscapes. Its overall population appears to be increasing, and its range has been expanding westward in Oklahoma for at least the past three decades. Specimen records are currently lacking for thirteen of the counties from which it was recorded in this survey (Alfalfa, Blaine, Custer, Ellis, Grady, Greer, Hughes, Jefferson, Kay, Lincoln, Okfuskee, Stephens, and Tillman) and this provides further support for the hypothesis that its geographic range is expanding. Specimen records indicate that this species is present in the state from April through December, but primarily during the summer months of July and August. The acoustic data indicate that this species was active to some degree in every month of the year except for February, but its activity level was greatly reduced during the winter.

*Parastrellus hesperus* (Canyon Bat or American Parastrelle): In Oklahoma, this species has been documented by approximately 40 specimen records, and the dates of these specimens indicate that the species is active in the state from April through August and is limited to the Wichita Mountains (Comanche, Greer, and Kiowa counties) and Black Mesa (Cimarron County) areas. Calls for this species were recorded at five of the acoustic survey sites in five counties (Ellis, Greer, Jefferson, Marshall, and Tillman). All of these counties except for Greer, have no prior documentation for this species and its range may be larger than it was previously understood to be, or individuals may wander widely outside of the pup-rearing and hibernating seasons. This species warrants additional survey work and research to determine its residency status and distribution in Oklahoma. Because of the potential for false positives in acoustic data, additional high-quality, confirmed recordings for *Parastrellus hesperus* may be helpful for improving the accuracy of the Kaleidoscope software.

*Perimyotis subflavus* (Tricolored Bat): Calls of this species were recorded at 24 out of the 29 acoustic survey sites and across 21 counties: Alfalfa, Blaine, Caddo, Cleveland, Comanche, Custer, Ellis, Greer, Hughes, Jefferson, Johnston, Kay, Lincoln, Marshall, Murray, Oklahoma, Okfuskee, Osage, Payne, Stephens, and Tillman. Specimen records indicate that this is a widespread species in Oklahoma that is present in the state throughout the year. *Perimyotis subflavus* enter their hibernacula early in the fall (October) after mating and leave their hibernacula late in the spring (April-May). The acoustic data indicate that this species is active from March through October, with a very small level of activity in November.

*Tadarida brasiliensis* (Brazilian (Mexican) Free-tailed Bat): Calls of this species were recorded at 25 of the 29 acoustic survey sites and in 21 counties. This species was documented at all eleven of the sites in western Oklahoma and was absent from only four of the central Oklahoma sites in Johnson, Lincoln, Murray, and Stephens counties. This is a wide-ranging species in western, central, and southeastern Oklahoma. The acoustic data indicate that it is active from March through September, and there was one outlying recording collected in February of 2021. It is widely believed that the subspecies that occurs in most of the study area does not hibernate and is migratory, moving southward beginning in September and reappearing in early April.

## **NABat Data Archival**

In 2023, we established an NABat data archive and uploaded 12 months of call files and their associated metadata to the NABat database. The bulk loading of these data with their associated weather summaries was complex, but as we worked, we developed a workflow to better summarize Mesonet data for the appropriate timeframe and ensure that the uploaded data were associated with the appropriate weather and metadata to make the call files useful to other practitioners. Since these data have been uploaded, they already have been requested for use 11 times, suggesting that creating an NABat data archive is a useful approach for ensuring that data are reused across projects. During the final year of the grant, we archived the remaining call data from this project with the assistance of a postgraduate research student.

## **Netting Surveys for *Perimyotis subflavus***

To supplement the acoustic surveys, we conducted a series of netting surveys for bats at locations near a subset of the acoustic survey sites. These surveys occurred between June and mid-September when bats are most active, and it includes approximately half of the fall migration period for the migratory species. Once a survey site was chosen, three to six net sets were erected two to three hours before sunset. These were usually placed over water, such as a stream or pond, or placed across a trail, closed road, or similar open passageway surrounded by trees and other tall vegetation. Nets were opened at dusk and checked every 15 minutes by the survey team for the next three to four hours to remove and process any bats that were captured. Bat activity typically declines substantially three to four hours after sunset and that was the cue used to take down the nets and poles for the night. At each netting site, weather conditions were recorded from the nearest Oklahoma Mesonet station, as well as the moon phase and the sunrise/sunset times. Also at each net site, the survey crew noted whether bat activity was observed.

In 2019, three field technicians were hired to assist P.I.s Braun, Coyner and Lanier with field work. These were Elyse Ellsworth, graduate field assistant, Sierra Smith, undergraduate field assistant, and Emilee Romero, undergraduate field assistant. No netting of bats occurred in 2020 or in the spring of 2021 because of travel restrictions that were put in place by the University of Oklahoma in response to the COVID-19 pandemic. The netting surveys were able to resume in August and September of 2021 and Bret Demory was hired to assist with field work during that season. In July and August 2022, Elyse Freitas and Emilee Romero were hired as field technicians to assist with the final series of netting surveys.

Over the course of three summer field seasons, netting surveys were conducted at 35 locations in ten counties. In total, 176 net-nights of effort was expended at these sites, and this resulted in the capture 20 bats of at least four species. The results from those surveys are summarized in Table 5. Although each site that was selected for a netting survey was in a county that was known to or likely to support *Perimyotis subflavus*, no individuals of that species were captured. Eleven *Lasiurus borealis* were netted at seven sites making it the most frequently captured bat species. Six *Nycticeius humeralis* were captured at five sites and individual *Lasiurus cinereus* and *Tadarida brasiliensis* were captured at single sites. At the last survey

location, a bat was caught in a net temporarily but escaped before it could be removed, identified, and swabbed.

### Summary of Netting Surveys by Site

1. Oklahoma: Harper Co.: 8 mi E Selman, Cimarron Bluff Wildlife Management Area, 502 m, 36.80899, -99.34030  
12 June 2019: 3 sets of nets; no bats were captured.
2. Oklahoma: Woods Co.: 5 mi W Lookout, Cimarron Hills Wildlife Management Area, 517 m, 36.94280, -99.36382  
13 June 2019: 3 sets of nets; 1 female *Tadarida brasiliensis* (Brazilian Free-tailed Bat) was captured, swabbed, and vouchered; bats were observed flying. This female had an open vagina, but no embryo(s) was present.
3. Oklahoma: Harper Co.: 1.5 mi N, 7.75 mi E Dunlap, Cooper Wildlife Management Area, 667 m, 36.62886, -99.53826  
14 June 2019; 3 sets of nets (4 total nets); no bats were captured.  
17 June 2019; 2 sets of nets (4 total nets); no bats were captured.
4. Oklahoma: Harper Co.: 1.25 mi N, 7.75 mi E Dunlap, Cooper Wildlife Management Area, 36.62457, -99.53711  
14 June 2019; 1 net; no bats were captured.  
17 June 2019; 1 net; no bats were captured.
5. Oklahoma: Woodward Co.: 2.75 mi E Fort Supply, Cooper Wildlife Management Area, 605 m, 36.57543, -99.50840  
16 June 2019; 5 sets of nets (6 total nets); no bats were captured.
6. Oklahoma: Comanche Co.: 2.25 mi S, 10 mi W Medicine Park, The Narrows, Wichita Mountains National Wildlife Refuge, 466 m, 34.70104, -98.678983  
20 July 2019; 4 sets of nets (6 total nets); 2 (1 male, 1 female) *Nycticeius humeralis* (Evening Bat) were captured, swabbed, and vouchered; bats were observed flying. The female was not reproductively active (vagina closed, no embryos) and the male had scrotal testes. It has been suggested that this species mates in the fall; capture data from Net Sites 6, 7, 12, and 14 suggests that mating may take place in Oklahoma in late summer.
7. Oklahoma: Comanche Co.: 9.5 mi W Medicine Park, Panther Creek, Wichita Mountains National Wildlife Refuge, 34.73267, -98.67934, elevation 474 m  
21 July 2019; 4 sets of nets; 1 male *Nycticeius humeralis* (Evening Bat) was captured, swabbed, and vouchered; bats were observed flying. This male had scrotal testes measuring 7 x 3 mm.

8. Oklahoma: Comanche Co.: 1.5 mi S, 7.5 mi W Medicine Park, Quanah Parker Lake and Dam, Wichita Mountains National Wildlife Refuge, 442 m, 34.71229, -98.64104  
22 July 2019; 4 sets of nets (5 total nets); 1 female *Nycticeius humeralis* (Evening Bat) was captured, swabbed, and vouchered; bats were observed flying. This female was not reproductively active (vagina closed, no embryos).
9. Oklahoma: Comanche Co.: 2.5 mi S, 13 mi W Medicine Park, Treasure Lake Road, Wichita Mountains National Wildlife Refuge, 34.69821, -98.73413, elevation 451 m  
23 July 2019; 5 sets of nets; no bats were captured; bats were observed flying.
10. Oklahoma: Comanche Co.: 5.5 mi W Medicine Park, Jed Johnson Lake Dam, Wichita Mountains National Wildlife Refuge, 34.72666, -98.59872, elevation 497 m  
24 July 2019; 4 sets of nets (5 total nets); 1 male *Lasiurus borealis* (Eastern Red Bat) was captured, swabbed, and vouchered; bats were observed flying. This male had scrotal testes measuring 6 x 4 mm, supporting previous information indicating that mating takes place in late summer.
11. Oklahoma: Comanche Co.: 11.75 mi W Medicine Park, Refuge Headquarters, Wichita Mountains National Wildlife Refuge, 34.73352, -98.71085, elevation 484 m  
25 July 2019; 6 sets of nets; 2 male *Lasiurus borealis* (Eastern Red Bat) and 1 female *Lasiurus cinereus* (Hoary Bat) were captured, swabbed, and vouchered; 1 male *Lasiurus borealis* (Eastern Red Bat) was captured, swabbed, and released; bats were observed flying. All male *Lasiurus borealis* had scrotal testes, one measuring 6 x 4 mm, supporting previous information indicating that mating takes place in late summer. The female *Lasiurus cinereus* was not reproductively active (closed vagina, no embryos) supporting previous information indicating that mating takes place in the spring.
12. Oklahoma: Johnston Co.: 2.25 mi S, 2 mi E Tishomingo, picnic area, Tishomingo National Wildlife Refuge, 194 m, 34.19588, -96.64280  
1 August 2019; 4 sets of nets (5 total nets); 1 male *Nycticeius humeralis* (Evening Bat) was captured, swabbed, and vouchered; this is the first record of this species for Johnston County (only one other record of a bat, *Lasiurus borealis*, is known for the county); no bats were observed flying. This male had scrotal testes measuring 7 x 4 mm.
13. Oklahoma: Johnston Co.: 3.2 mi S, 1.5 mi E Tishomingo, Goose Pen Pond, Tishomingo National Wildlife Refuge, 191 m, 34.18956, -96.64898  
2 August 2019; 3 sets of nets (4 nets); no bats were captured; bats were observed flying or activity noted from about 2100 to about 2230.
14. Oklahoma: Johnston Co. : 7 mi N, 6 mi E Tishomingo, Desperado Springs, Blue River Public Fishing and Hunting Area, 242 m, 34.33364, -06.59568; net surveys were conducted on two nights – 3 and 6 August 2019  
3 August 2019; 5 sets of nets; 1 male *Nycticeius humeralis* (Evening Bat) was captured, swabbed, and vouchered; this is the second record of this species for Johnston County (only one other record of a bat, *Lasiurus borealis*, is known for the county); bats were

observed flying beginning at about 2037. This male had scrotal testes measuring 7 x 4 mm.

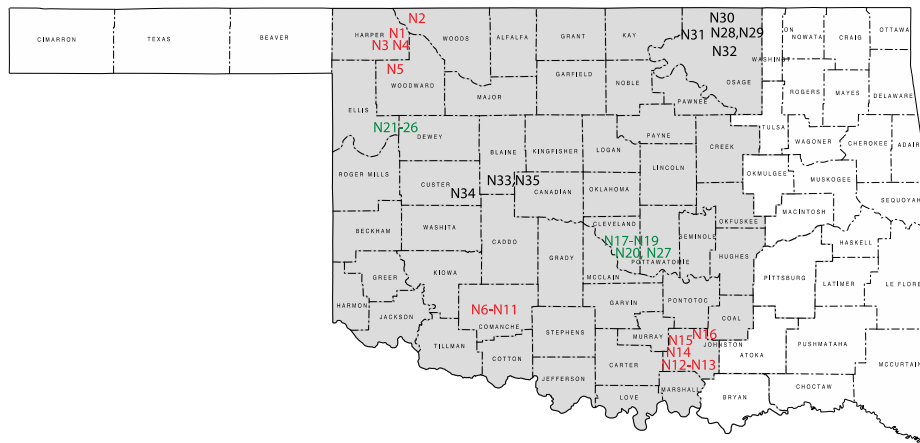
6 August 2019; 5 sets of nets (6 total nets); no bats were captured; bats were observed flying.

15. Oklahoma: Johnston Co.: 9.25 mi N, 5 mi E Tishomingo, Blue River Public Fishing and Hunting Area, 266 m, 34.36697, -96.59200  
4 August 2019; 6 sets of nets; no bats were captured; bats were observed flying beginning at 2050.
16. Oklahoma: Johnston Co.: 2 mi N, 2 mi W Bromide, Arbuckle Springs Wildlife Management Area, 304 m, 34.44861, -96.53294  
5 August 2019; 4 sets of nets; 1 bat (*Lasiurus borealis*) was captured but escaped from the net before it could be removed; bats were observed flying.
17. Oklahoma: Cleveland Co.: 3910 180<sup>th</sup> Ave NE, Newalla, 35.265580, -97.178025  
8 August 2021; three sets of nets (six total nets); no bats were captured; bats were observed flying beginning at 2145.
18. Oklahoma: Cleveland Co.: 3910 180<sup>th</sup> Ave NE, Newalla, 35.265580, -97.178025  
9 August 2021; four sets of nets (four total nets); no bats were captured; bats were observed flying beginning at 2100. One American bullfrog (*Lithobates catesbeianus*) was caught and released from a low hanging net.
19. Oklahoma: Cleveland Co.: 3910 180<sup>th</sup> Ave NE, Newalla, 35.265580, -97.178025  
10 August 2021; four sets of nets (four total nets); no bats were captured; bats were observed flying beginning at 2100. Bat and insect activity was much less than on 8 and 9 August.
20. Oklahoma; Cleveland Co.: 2 mi. S, 7.75 mi E Slaughterville, Dahlgren Reservoir, Lexington Wildlife Management Area, 35.058117, -97.198059  
22 August 2021; four sets of nets (six total nets); two female *Lasiurus borealis* (Eastern Red Bat) were captured, swabbed, and vouchered; bats were observed flying ca. 2040.
21. Oklahoma: Ellis Co.: 8.2 mi. S, 4.2 mi. E Harmon, Four Canyon Preserve, 661 m, 36.02987, -99.49825  
10 September 2021; four sets of nets (five total nets); two female *Lasiurus borealis* (Eastern Red Bat) were captured, swabbed, and vouchered; bats were observed flying ca. 2020. Caire et al. (2010) did not detect this species during surveys of the Four Canyon Preserve in 2005 and 2006. Roehrs et al. (2008) reported one male from 27.2 km S, 4.2 km E Arnett in Packsaddle WMA on West Creek. The *Lasiurus borealis* captured at this site are the second and third specimens reported for the county.
22. Oklahoma: Ellis Co.: 8.2 mi. S, 4.2 mi. E Harmon, Four Canyon Preserve, 658 m, 36.02599, -99.48265

- 11 September 2021; three sets of nets (five total nets); no bats were captured; bats were observed flying beginning at 2020.
23. Oklahoma: Ellis Co.: 8.2 mi. S, 4.2 mi. E Harmon, Four Canyon Preserve, 659 m, 36.02599, -99.48265  
12 September 2021; four sets of nets (six total nets); no bats were captured; bats were observed flying beginning at 2014.
24. Oklahoma: Ellis Co.: 8.2 mi. S, 4.2 mi. E Harmon, Four Canyon Preserve, 658 m, 36.02407, -99.480  
13 September 2021; four sets of nets (five total nets); no bats were captured; bats were observed flying beginning at 2030.
25. Oklahoma: Ellis Co.: 8.2 mi. S, 4.2 mi. E Harmon, Four Canyon Preserve, 661 m, 36.02987, -99.49825  
14 September 2021; four sets of nets (six total nets); one female *Lasiurus borealis* (Eastern Red Bat) was captured, swabbed, and released; bats were observed flying ca. 2015. See information for Site 21; this individual is the third *Lasiurus borealis* reported for the preserve and the fourth for the county.
26. Oklahoma: Ellis Co.: 8.2 mi. S, 4.2 mi. E Harmon, Four Canyon Preserve, 659 m, 36.02599, -99.48265  
15 September 2021; four sets of nets (five total nets); no bats were captured.
27. Oklahoma; Cleveland Co.: 2 mi. S, 7.75 mi E Slaughterville, Dahlgren Reservoir, Lexington Wildlife Management Area, 35.058117, -97.198059  
23 August 2021; four sets of nets (six total nets); no bats were captured or observed flying. Bat activity was very low.
28. Oklahoma: Osage Co.: 0.75 mi. N, 3 mi W Whippoorwill, Hulah Wildlife Management Area, 36.91977, -96.17966  
25 July 2022; 5 sets of nets (5 total nets); one female *Lasiurus borealis* (Eastern Red Bat) was captured, swabbed, and vouchered.
29. Oklahoma: Osage Co.: 1 mi. N, 3.25 mi W Whippoorwill, Hulah Wildlife Management Area, 36.928786, -96.189018  
26 July 2022; 4 sets of nets (4 total nets); no bats were captured; bats were observed flying.
30. Oklahoma: Osage Co.: 2.5 mi. N, 3.25 mi W Whippoorwill, Hulah Wildlife Management Area, 36.94889, -96.18419, 246 m  
27 July 2022; 4 sets of nets (5 total nets); no bats were captured; no bats were observed flying.
31. Oklahoma: Osage Co.: jct. Salt Creek and Hwy 11/18, 2.3 mi S, 0.5 mi E Shidler, 36.749186, -96.651491

- 28 July 2022; 3 sets of nets (3 total nets); no bats were captured; no bats were observed flying.
32. Oklahoma: Osage Co.: 1.4 mi S, 0.5 mi E jct Hwy 60 and CR 4291, Lake Pawhuska, 36.64396, -96.39668, 254 m  
30 July 2022; 4 sets of nets (4 total nets); no bats were captured; bats were observed flying.
  33. Oklahoma: Blaine Co.: 10.5 mi W Geary, American Horse Lake, 35.62828, -98.50598  
10 August 2022; 3 sets of nets (4 nets); no bats were captured; no bats were observed flying.
  34. Oklahoma: Custer Co.: jct. E1000 and N2420, Ol' Fishin Hole, Weatherford, 35.56460, -98.68380  
11 August 2022; 3 sets of nets (6 nets); no bats were captured; bats were observed flying.
  35. Oklahoma: Blaine Co.: 10.5 mi W Geary, American Horse Lake, 35.62828, -98.50598  
12 August 2022; 3 sets of nets (4 nets); one bat (species undetermined) was captured but escaped before removal from net.

**Figure 4.** Map of netting locations for Year 1 (red), Year 3 (green), and Year 4 (black). Note, no netting surveys could be conducted during Year 2 (2020) because of COVID-19 restrictions.



**Table 5.** Summary of Data from Netting Survey Sites

Site Number	County	Survey Effort # Net-Nights	Bats Obs. (Y/N)	Capture Results
1	Harper	3		no bats captured
2	Woods	3	Y	1 <i>Tadarida brasiliensis</i> captured
3	Harper	8		no bats captured
4	Harper	2		no bats captured
5	Woodward	6		no bats captured
6	Comanche	6	Y	2 <i>Nycticeius humeralis</i> captured
7	Comanche	4	Y	1 <i>Nycticeius humeralis</i> captured
8	Comanche	5	Y	1 <i>Nycticeius humeralis</i> captured
9	Comanche	5	Y	no bats captured
10	Comanche	5	Y	1 <i>Lasiurus borealis</i> captured
11	Comanche	6	Y	3 <i>Lasiurus borealis</i> captured 1 <i>Lasiurus cinereus</i> captured
12	Johnston	5	Y	1 <i>Nycticeius humeralis</i> captured
13	Johnston	4	Y	no bats captured
14	Johnston	11	Y	1 <i>Nycticeius humeralis</i> captured
15	Johnston	6	Y	no bats captured
16	Johnston	4	Y	1 <i>Lasiurus borealis</i> captured
17	Cleveland	6	Y	no bats captured
18	Cleveland	4	Y	no bats captured
19	Cleveland	4	Y	no bats captured
20	Cleveland	6	Y	2 <i>Lasiurus borealis</i> captured
21	Ellis	5	Y	2 <i>Lasiurus borealis</i> captured
22	Ellis	5	Y	no bats captured
23	Ellis	6		no bats captured
24	Ellis	5	Y	no bats captured
25	Ellis	6	Y	1 <i>Lasiurus borealis</i> captured
26	Ellis	5		no bats captured
27	Cleveland	6		no bats captured
28	Osage	5	Y	1 <i>Lasiurus borealis</i> captured
29	Osage	4	Y	no bats captured
30	Osage	5		no bats captured
31	Osage	3		no bats captured
32	Osage	4	Y	no bats captured
33	Blaine	4		no bats captured
34	Custer	6	Y	no bats captured
35	Blaine	4		1 undetermined bat/escaped net
Total	35 sites 10 counties	176 net-nights		11 <i>Lasiurus borealis</i> 1 <i>Lasiurus cinereus</i> 6 <i>Nycticeius humeralis</i> 1 <i>Tadarida brasiliensis</i> 1 species undetermined



**SIGNIFICANT DEVIATIONS:**

There were no significant deviations from the grant's objectives or from the methods that we proposed to use.

**EQUIPMENT:**

No equipment was purchased using grant funds.

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**Date Prepared:** September 16, 2024

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