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Volume 3, 2025 Journal of North American Bat Research No. 12

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Cover Photograph: Top: Hibernating *Myotis velifer* (Cave Myotis) in a large cluster in a western Oklahoma gypsum cave. Bottom: Single *Myotis velifer* (Cave Myotis) roosting in a western Oklahoma gypsum cave. Photograph © Lynda Samanie Loucks.

The ***Journal of North American Bat Research*** (ISSN 2994-1075) is published by the Eagle Hill Institute, PO Box 9, 59 Eagle Hill Road, Steuben, ME 04680-0009. Phone: 207-546-2821 Ext. 4. E-mail: office@eaglehill.us. Webpage: https://www.eaglehill.us/nabr. Copyright © 2025, all rights reserved. Published on an article by article basis. **Special issue proposals are welcome**. The ***Journal of North American Bat Research*** is an open access journal. **Authors**: Submission guidelines are available at https://www.eaglehill.us/programs/journals/nabr/nabr.shtml. **Co-published journals:** The *Northeastern Naturalist*, *Southeastern Naturalist*, *Caribbean Naturalist*, and *Eastern Paleontologist*, each with a separate Board of Editors. The Eagle Hill Institute is a tax exempt 501(c)(3) nonprofit corporation of the State of Maine (Federal ID # 010379899).

Population Trends of *Myotis velifer* (Cave Myotis) and Presence of *Pseudogymnoascus destructans* in Gypsum Caves of Western Oklahoma

Lynda Samanie Loucks[1,*], Jason B. Shaw[2], and William Caire[1]

Abstract - This study provides population estimates for overwintering *Myotis velifer* (Cave Myotis) in 5 gypsum caves in western Oklahoma, before and after the spread of *Pseudogymnoascus destructans* (*Pd*), the causative agent of white-nose syndrome (WNS). Population estimates of Cave Myotis in these caves over a 37-year period (1988–2024) varied from 33,384 bats in 1988 to 172,354 bats in 2005, with a mean of 100,254 individuals. We report the first detections of *Pd*-positive Cave Myotis in western Oklahoma hibernacula in Major, Washita, and Woodward counties. From 2018 to 2023, 19 of 457 (4.2%) Cave Myotis tested positive by qPCR for *Pd*, although WNS has not been confirmed in this species in Oklahoma. Despite detection of *Pd*, these populations of Cave Myotis have not drastically declined, and mortalities have not been reported. Annual fluctuations in population estimates at the 5 hibernacula are likely due to numerous factors, and these sites should continue to be monitored with the arrival of *Pd* in the region.

Resumen - Este estudio proporciona y actualiza las estimaciones históricas de la población de *Myotis velifer* (Cave Myotis) en 5 hibernáculos principales del oeste de Oklahoma antes y después de la propagación de *Pseudogymnoascus destructans* (*Pd*), el agente causante del síndrome de la nariz blanca (WNS). Las estimaciones del tamaño de la población de *M. velifer* entre 1988 y 2024 en estas cuevas de yeso variaron de 33,384 murciélagos en 1988 a 172,354 murciélagos en 2005, con un promedio de 100,254 durante el período de 37 años. Informamos de las primeras detecciones de Cave Myotis *Pd* positivo en la hibernácula occidental de Oklahoma en los condados de Major, Washita y Woodward. De 2018 a 2023, 19 de 457 (4.2%) Cave Myotis dentro de 3 hibernáculos dieron positivo por qPCR para *Pd*. Aunque Cave Myotis han dado positivo para *Pd*, no se ha confirmado el WNS en esta especie en Oklahoma. A pesar de la detección de *Pd*, las poblaciones de Cave Myotis en Oklahoma no han disminuido drásticamente y no se han reportado muertes de murciélagos. Las fluctuaciones anuales en las estimaciones de población en las 5 hibernáculas estudiadas probablemente se deban a numerosos factores, y estos sitios deben continuar siendo monitoreados con la llegada de *Pd* a la región.

Introduction

White-nose syndrome (WNS) was first detected in North America in 2006 (Blehert et al. 2009) and has led to the deaths of millions of hibernating bats (Cheng et al. 2021, Frick et al. 2016, Loeb et al. 2015). The disease is caused by a pathogenic fungus, *Pseudogymnoascus destructans* (Blehert and Gargas) Minnis and D.L. Lindner (*Pd*) (Lorch et al. 2011), that infects cutaneous tissues and causes premature arousal of hibernating bats and depletion of fat stores (Frank et al. 2014). The fungus can persist in hibernacula throughout summer when bats are typically absent (Langwig et al. 2017, Verant et al. 2018), and cause infection when bats enter hibernacula in the fall. As of 2024, WNS has been confirmed on bats in 40 states (including Oklahoma) and 9 Canadian provinces, and *Pd* has been detected in an additional 4 states and 1 province (WNS Response Team 2025).

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Associate Editor: Loren Ammerman, Angelo State University.

Of the 51 species of bats in the United States (Morgan et al. 2019), more than half hibernate, and WNS has caused population declines in several species, increasing their risk of extinction (Frick et al. 2015). Estimates of the size of hibernating populations are valuable for documenting changes in species abundance (Frick et al. 2015, Turner et al. 2011) and evaluating the impact of WNS on bats (Cheng et al. 2021). The North American Bat Monitoring Program (NABat) was initiated in 2015 to emphasize the importance of monitoring bat populations and coordinate these efforts across the continent (Loeb et al. 2015).

The geographic range of *Myotis velifer* (Allen) (Cave Myotis) includes the southwestern U.S. (from central Oklahoma and Kansas south to Texas and parts of Arizona, Nevada, New Mexico, and southeastern California), Mexico, and Central America, as far south as Honduras (Caire et al. 2024; Fig.1). Cave Myotis occur in the western half of Oklahoma (Caire et al. 2024) and have been documented in 24 of 77 counties (Loucks et al. 2023).

Cave Myotis in Kansas, Oklahoma, and northwestern Texas inhabit the same general region year-round and do not undergo long migrations (O'Shea et al. 2018). During summer these bats roost colonially in caves, mines, culverts, bridges, and occasionally buildings (O'Shea et al. 2018). Cave Myotis generally hibernate in subterranean locations, in large clusters of several hundred to thousands of animals (Ammerman et al. 2012), although smaller clusters or singles are also present (Caire et al. 2024). Researchers have been surveying Cave Myotis overwintering in gypsum caves of western Oklahoma since 1952 (Caire

Figure 1. Continental distribution of Cave Myotis (International Union for Conservation of Nature 2008) and locations of 6 hibernacula in western Oklahoma. Names of specific counties within Oklahoma are shown with gray letters. Regional map shows location of study area within Oklahoma.

and Loucks 2010; Caire et al. 2018; Humphrey and Oli 2015; Kunz 1971, 1974; Loucks 1996; Loucks and Caire 2007; Twente 1955). Caire et al. (2018) reported that the number of hibernating Cave Myotis in western Oklahoma and the Texas Panhandle varied from 34,625 to 195,234 during a 30-year period (1988–2017).

The Cave Myotis is currently listed by the International Union for Conservation of Nature (IUCN) as a species of least concern across its distribution (Solari 2019), although it is considered vulnerable in Arizona, Kansas, New Mexico, and Oklahoma, imperiled in Texas, and critically imperiled in California and Nevada (NatureServe 2024). Although previous capture records suggested stable abundance in Texas (Ammerman et al. 2012), recent population declines after confirmation of WNS in 2020 (Webb and Timmerman 2023; Texas Parks and Wildlife Department [TPWD] 2020, 2024) have prompted investigations and monitoring. Growth of *Pd* is favored in environments with relative humidity >70% (Marroquin et al. 2017) and temperatures of 12.5–15.8 ºC (Verant et al. 2012), and these microclimatic conditions occur within many Oklahoma caves (Caire and Loucks 2010, Caire et al. 2018, Creecy et al. 2015, Haase et al. 2021, Loucks 1996), making bats occupy-

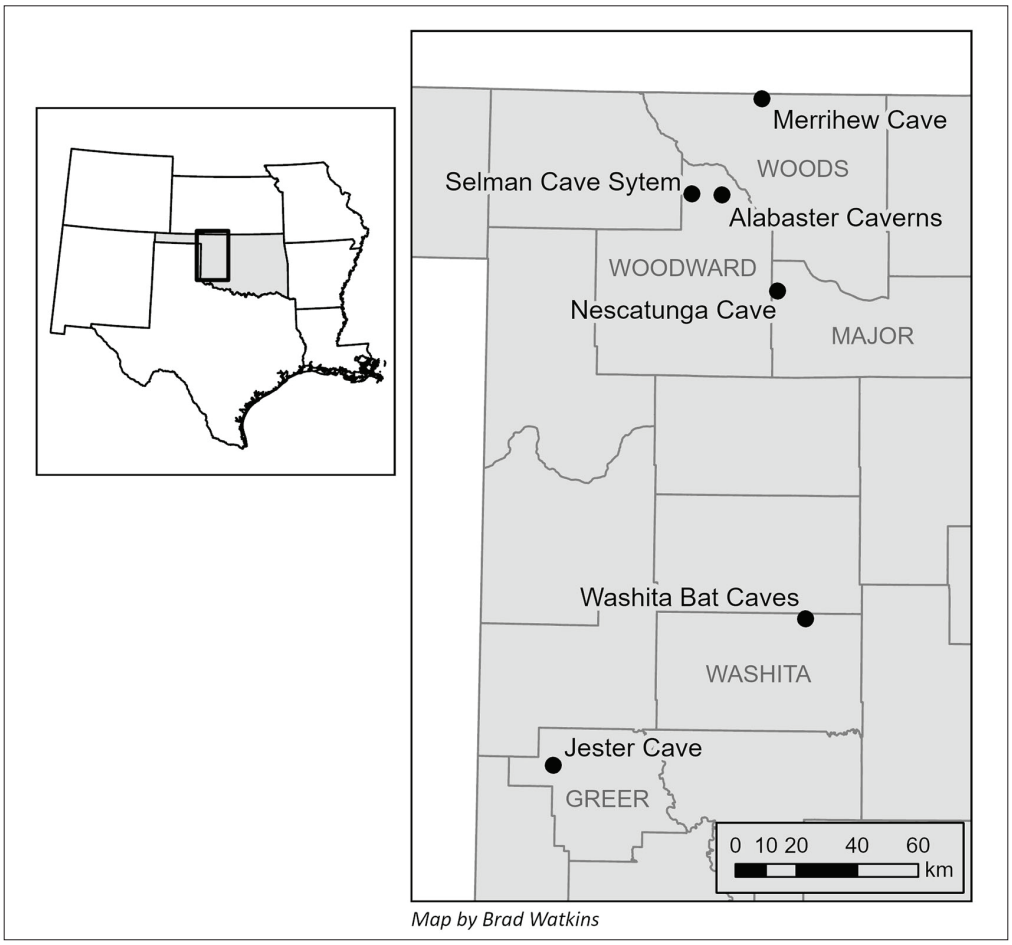

Figure 1 cont. Continental distribution of Cave Myotis (International Union for Conservation of Nature 2008) and locations of 6 hibernacula in western Oklahoma. Names of specific counties within Oklahoma are shown with gray letters. Regional map shows location of study area within Oklahoma.

ing these sites potentially vulnerable to WNS (Caire et al. 2018). Nevertheless, the status of Cave Myotis in Oklahoma has not been evaluated since *Pd* spread into the state.

The Oklahoma Department of Wildlife Conservation (ODWC) formed the Oklahoma Bat Coordinating Team (OBCT) during 2010, in response to the spread of *Pd* and WNS in North America (ODWC 2021). The presence of *Pd* on Cave Myotis in Oklahoma was first reported during 2010 in Woodward County, although re-evaluation by the National Wildlife Health Center (NWHC) determined the specimen was not actually infected (Brennan et al. 2015). None of the 83 soil samples collected from 18 hibernacula in Oklahoma from 2011 to 2012 were positive for *Pd* (Creecy et al. 2015). In 2011, the OBCT initiated state-wide winter surveillance for physical signs of WNS on bats, and in 2014 began swabbing hibernating animals for *Pd* analysis. *Pd* was first detected in Oklahoma on *Perimyotis subflavus* (Cuvier) (Tricolored Bat) in 2015, and WNS was confirmed in the same species in 2017 (Caire et al. 2018, ODWC 2021). Caire et al. (2018) reported that over a 4-year period (2014–2017), none of the 452 hibernating Cave Myotis sampled in 5 gypsum caves produced *Pd*-positive results with qPCR. Since these studies, clinical signs of WNS were reported on a single Tricolored Bat during 2024 in western Oklahoma (Loucks et al. 2025), in a cave also occupied by Cave Myotis. Seasonal movements of bats across the state have likely spread the fungus into western Oklahoma (Caire et al. 2018), although the severity of disease in this region remains unknown.

In this paper, we present estimates of the size of Cave Myotis populations in 5 hibernacula in western Oklahoma (Fig. 1), before and after the spread of *Pd* into this region. This study also reports on the continued *Pd* surveillance and swabbing of Cave Myotis from 2018 to 2024, allowing comparison of population trends after *Pd* exposure and providing a baseline for evaluation of future impacts on hibernating populations of Cave Myotis.

Field-site Description

Hibernacula of Cave Myotis occur in the Central Great Plains ecoregion, which covers the western half of Oklahoma (Caire et al. 2024). The study region consists of mixed-grass or mesquite-grass prairies and is characterized by gypsum outcrops and karst features (Buckalew and Caddell 2003, Caddell and Rice 2012, Caire et al. 2024). Beginning in 1988, annual surveys of hibernating bats have been conducted by researchers from multiple organizations. Personnel from the University of Central Oklahoma (UCO) and the University of Science and Arts of Oklahoma (USAO) performed surveys at Nescatunga Cave (hereafter Nescatunga, in Major County), Selman Cave System (Selman, Woodward County), and Washita Bat Caves (Washita, Washita County). Staff members of Alabaster Caverns State Park worked at Alabaster Caverns (Alabaster, Woodward County), and the Central Oklahoma Grotto of the National Speleological Society (COG) surveyed bats in Jester Cave (Jester, Greer County). Although some of the caves are large and complex, many years of experience with these 5 hibernacula, and use of maps generated by COG, have allowed thorough population estimates. Alabaster is owned and managed by the state of Oklahoma Tourism and Recreation Department; Jester, Nescatunga, and Washita are on private property, accessible only with landowner permission; and Selman is owned and managed by UCO. The approximate length of cave passages is 1.2 km for Alabaster, 10.1 km for Jester, 2.4 km for Nescatunga, 4.5 km for Selman, and 0.7 km for Washita. The maximum distance between any 2 caves is 196 km, and the minimum distance is 11.8 km (Fig. 1).

Methods

In this paper, we provide annual estimates of the number of Cave Myotis for the years 2018–2024. Although the number of surveyors and sites sampled varied annually, the methods used to estimate the number of bats were consistent and followed Caire et al. (2018). Cave Myotis often form large clusters during hibernation, making it impossible to count every individual. However, estimates of surface area, coupled with a measure of mean packing density, can be used to approximate the number of bats in these large clusters (Thomas and LaVal 1988). In each hibernaculum, we first determined the number of bats in 2–3 small areas of 0.09 m^2 (1 ft^2) and then extrapolated this value to the total estimated surface area of the cave wall or ceiling covered by bats. The number of bats in 0.09 m^2 ranged from 210 to 288. In addition to these estimates for large clusters, surveyors individually counted singletons and the number of animals in small clusters. Surveys were typically conducted in January or February, when bat numbers peaked. Caves were visited only once during the hibernation season to minimize disturbance. National WNS decontamination protocols were followed after each visit (WNS Disease Management Working Group 2020, 2024). Estimates of the number of Cave Myotis present were entered into the NABat portal (https://sciencebase.usgs.gov/nabat/#/projects/6185).

We followed methods for collection of epidermal swabs of wings and muzzles, as described in protocols provided by NWHC (Alger and WNS National Response Team 2023; NWHC 2022). From 2018 to 2019, all swabs were analyzed by personnel at NWHC, in Madison, Wisconsin, using qPCR (Alger and WNS National Response Team 2023, Muller et al. 2013). In 2020, swabs collected from bats in Nescatunga also were analyzed by workers at NWHC. However, swabs collected from bats in Selman and Washita during 2020 and Selman, Washita, and Nescatunga in 2021–2023 were analyzed by personnel at the Sam Noble Oklahoma Museum of Natural History (OMNH) Norman, Oklahoma, using the primers of Shuey et al. (2014) and qPCR assays following NWHC protocols (Alger and WNS National Response Team 2023, Muller et al. 2013). The OMNH received swabs of *Pd* positive and negative animals from NWHC in 2019 to serve as controls, to confirm accurate extraction and qPCR techniques, and to use as standards for qPCR test results (Braun et al. 2024).

Diagnostic criteria for reporting results from swab analyses for both NHWC and OMNH were described by the WNS Response Team (2020). A sample was considered positive for *Pd* by qPCR if the cycle threshold value (Ct) $\leq$37, inconclusive if Ct >37 but $\leq$40, and negative if Ct >40, with the latter meaning that any *Pd* DNA that may have been present was below the level of detection. Bats within a sixth cave, Merrihew Cave (Woods County), were examined and swabbed for the presence of *Pd* by Kansas Department of Wildlife and Parks in 2018 and 2019; however, Merrihew was not part of our annual winter surveys, and long-term population trends could not be evaluated.

Results

The minimum, maximum, and mean number of Cave Myotis present in each hibernaculum (Table 1) varied over the 37 years (Fig. 2). Population estimates from 1988 to 2017 reported in Caire et al. (2018) are included in Table 1 and Figure 2 to preserve historical values and allow for continued long-term compilation of annual estimates. Selman has the largest known population of Cave Myotis in Oklahoma, and possibly across its distribution, and has been surveyed annually for 37 years, from 1988 to 2024. The number of Cave Myo-

Table 1. Estimated number of hibernating *Myotis velifer* (Cave Myotis) at 5 gypsum caves in western Oklahoma, in January or February from 1988 to 2017 (Caire et al. 2018), and from 2018 to 2024 (this study). Hibernacula are Alabaster Caverns (Alabaster), Jester Cave (Jester), Nescatunga Cave (Nescatunga), Selman Cave System (Selman), and Washita Bat Caves (Washita). Minimum, maximum, and mean are listed for each of the 5 hibernacula. A blank cell indicates that a survey was not conducted during that year; *n* represents the total number of surveys conducted for that site during the survey period.

Year	Alabaster	Jester	Nescatunga	Selman	Washita	Total
1988		5204	2406	25,774		33,384
1989		9869	3039	25,437		38,345
1990		10,113	3146	25,120		38,379
1991		12,231	5254	20,035		37,520
1992		10,423	4537	42,231	3705	60,896
1993		19,908	3011	71,766	6071	100,756
1994		17,976	5336	41,705	4297	69,314
1995	4827	15,281	5165	48,535	4608	78,416
1996	7162	16,943	4852	27,050	3184	59,191
1997	9729	12,336	13,970	76,194	4268	116,497
1998	16,450	8501	10,675	38,785	3471	77,882
1999	19,098	10,462	5173	69,676		104,409
2000	19,889	22,330	6676	53,092		101,987
2001	26,021	14,186		72,696	11,114	124,017
2002	30,810	12,561		76,396	12,112	131,879
2003	35,434	17,844		64,683	9897	127,858
2004	43,359	25,970		77,310	7865	154,504
2005	42,255	17,893		110,178	2028	172,354
2006	37,543	15,572		72,695	3410	129,220
2007	16,152	15,660		100,380	9676	141,868
2008	14,506	8729		60,196	6787	90,218
2009	14,668	10,236		56,947	1920	83,771
2010	6732	12,110		55,192	1082	75,116
2011	7958	16,364	1805	46,988	6833	79,948
2012	10,055	6637	10,406	26,302	8076	61,476
2013	5680	11,210	10,321	50,599	30,453	108,263
2014	6196	15,720	7664	32,406	10,866	72,852

Table 1 cont. Estimated number of hibernating *Myotis velifer* (Cave Myotis) at 5 gypsum caves in western Oklahoma, in January or February from 1988 to 2017 (Caire et al. 2018), and from 2018 to 2024 (this study). Hibernacula are Alabaster Caverns (Alabaster), Jester Cave (Jester), Nescatunga Cave (Nescatunga), Selman Cave System (Selman), and Washita Bat Caves (Washita). Minimum, maximum, and mean are listed for each of the 5 hibernacula. A blank cell indicates that a survey was not conducted during that year; *n* represents the total number of surveys conducted for that site during the survey period.

Year	Alabaster	Jester	Nescatunga	Selman	Washita	Total
2015	6411	9274	23,973	83,476	39,199	162,333
2016	16,035	12,503	12,277	41,603	22,116	104,534
2017	18,834	14,720	9048	106,910	20,649	170,161
2018	5939	19,106	11,130	61,384	23,505	121,064
2019	22,838	17,290	13,497	74,966	9374	137,965
2020	16,707	13,163	9120	75,928	13,783	128,701
2021	25,568		10,929	59,508		96,005
2022	23,384		15,099	61,688	22,268	122,439
2023	22,940	9640	17,083	37,570	17,194	104,427
2024	11,997	11,633	18,693	34,360	14,769	91,452
Minimum	4827	5204	1805	20,035	1082	33,384
Maximum	43,359	25,970	23,973	110,178	39,199	172,354
Mean	18,173	13,703	9048	56,912	11,153	100,254
n	30	35	27	37	31	

tis at individual sites ranged from a low of 1082 in Washita during 2010, to a high of 110,178 in Selman during 2005 (Table 1). The highest annual total number of hibernating Cave Myotis occurred during 2005, with 172,354 bats documented from 4 caves (Alabaster, Jester, Selman, and Washita). The highest annual total number of hibernating Cave Myotis from all 5 caves (Alabaster, Jester, Nescatunga, Selman, and Washita) happened in 2017 ($n = 170,161$; Table 1). The highest estimate during the study for Alabaster ($n = 43,359$) and Jester ($n = 25,970$) was in 2004, and for Nescatunga ($n = 23,973$) and Washita ($n = 39,199$) in 2015. The 4 lowest estimates were documented during consecutive years from 1988 to 1991, although estimates during this time were made for only 3 caves (Alabaster, Jester, Selman). The lowest annual estimate including all 5 caves was reported in 1996 ($n = 59,191$). The total annual number of Cave Myotis estimated to be in these caves was >100,000 for 20 of 37 years (Table 1). We observed no evident trend of declining populations of Cave Myotis in the 5 hibernacula (Fig. 2) after first detection of *Pd* on Cave Myotis in Oklahoma during 2020 (Table 2).

Between 2018 and 2023, we swabbed 457 Cave Myotis and examined the samples for the presence of *Pd* using qPCR (Table 2; Braun et al. 2024; for NWHC Case Reports, see Supplemental File 1, available online at http://www.eaglehill.us/NABRonline/suppl-files/

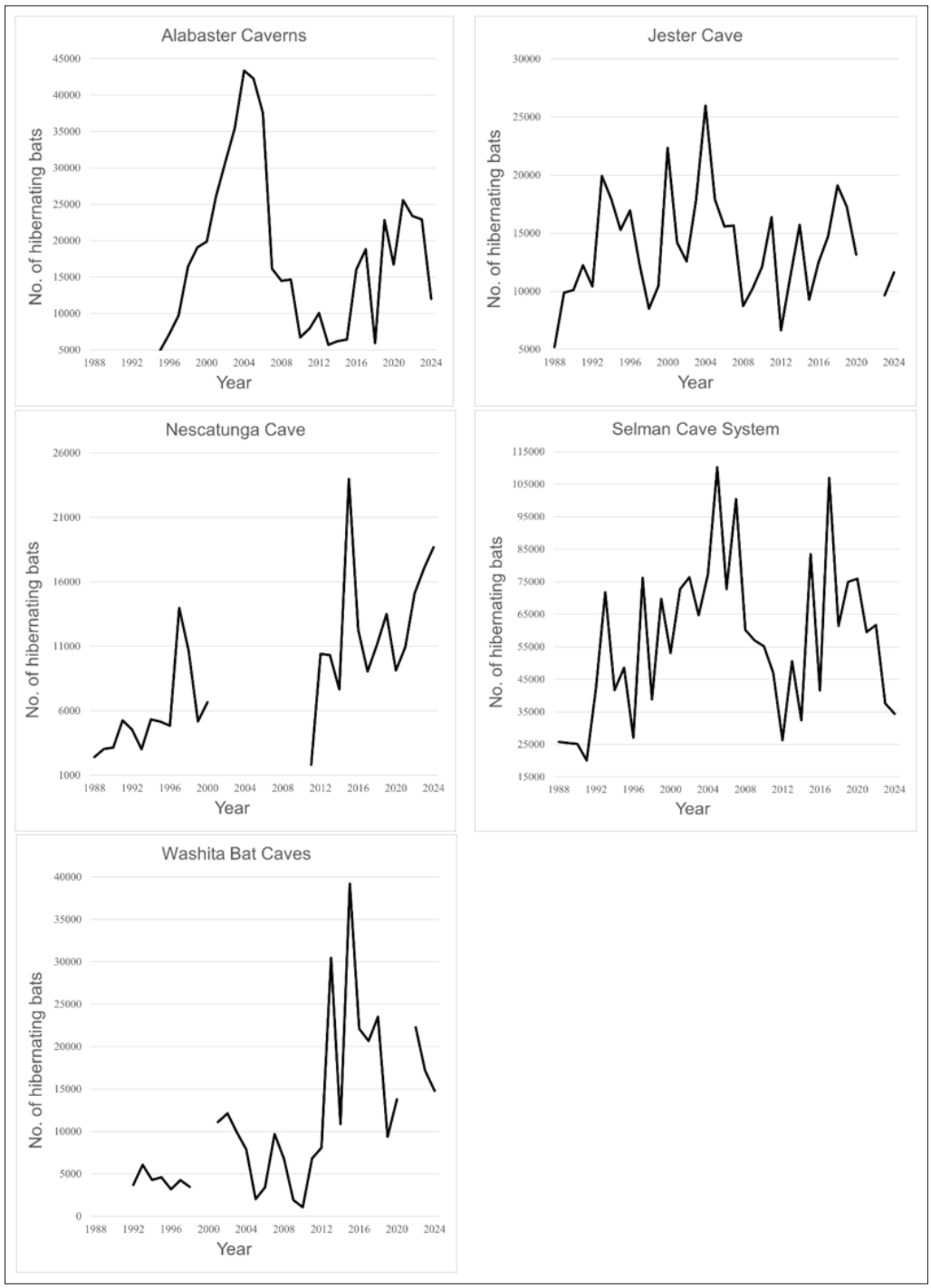

Figure 2. Interannual variation in estimated number of hibernating *Myotis velifer* (Cave Myotis), at 5 gypsum caves in western Oklahoma, in January or February, from 1988 to 2017 (Caire et al. 2018) and from 2018 to 2024 (this study). Note differences in axis scales.

nabr-021-Loucks-s1.pdf). During 2018, none of 95 samples collected from bats within 6 caves were positive, and during 2019, 14 of 98 samples from 2 caves were inconclusive. The first detections of *Pd*-positive Cave Myotis in Oklahoma were documented in 2020 from 1 bat in Nescatunga and 2 individuals in Selman. In 2021, 2 Cave Myotis tested positive. In 2022 and 2023, prevalence was similar (9.4–12% of 64–67 bats) in the 3 sites that were visited. During the entire 6 years, 19 (4.2%) Cave Myotis tested positive for *Pd*. Although no bats were swabbed during 2024, no mortalities or visible signs of the fungus were reported during any annual surveys.

Discussion

Populations of Cave Myotis varied in size among hibernacula and years (Table 1; Fig. 2). Total population estimates ranged from 33,384 bats in 1988 to 172,354 individuals in 2005, with a mean across the study period (1988–2024) of 100,254 bats (Table 1). The highest population estimates were in 2005 and 2017, and the lowest were between 1988 and 1991, when surveys occurred in only 3 caves instead of 5. Over half (54%) the annual total estimates were >100,000 bats.

Table 2. Results of qPCR analysis of swab samples from *Myotis velifer* (Cave Myotis) that were analyzed by the National Wildlife Health Center, from 2014 to 2017 (Caire et al. 2018), or by the National Wildlife Health Center and the Sam Noble Oklahoma Museum of Natural History, from 2018 to 2023 (this study). The number of bats swabbed are listed for each hibernaculum. Inconclusive or positive results for *Pd* are indicated in parentheses; all other tests were negative.

Year	*n*	Alabaster	Jester	Merrihew	Nescatunga	Selman	Washita
2014	80	15	16			25	24
2015	121	24	25		24	24	24
2016	148	25	25		49	24	25
2017	103	24	17		23	18	21
2018	95	15	15	3	18	22	22
2019	98		15	14 (10[I])	23	23 (4[I])	23
2020	88		15		23 (1)	30 (2)	20
2021	45				25 (2)	20	
2022	67				24 (2)	22 (3)	21 (3)
2023	64				21 (2)	22 (4)	21
Total	909						

[I] No *Pd*-positive results, all samples categorized as inconclusive.

Variation among years is probably influenced by several factors, including climatic fluctuations, habitat modification and degradation, human disturbance, and movements of bats among known and perhaps undiscovered hibernacula (Caire et al. 2018). Variations at individual hibernacula also may be impacted by weather, structural changes, internal microclimates, and distribution of bats within hibernacula (Caire et al. 2024). For example, Cave Myotis often shift from roosting as singles and small clusters to larger clusters as cave temperatures decrease (Kunz 1971), although singles and small clusters are present throughout hibernation (Loucks and Caire 2007). Our experience within the 5 hibernacula and use of consistent methods to estimate population size aid evaluation of long-term population trends, although variation in calculations of cluster density occurs between years and impacts estimates. Fluctuations in populations of Cave Myotis before and in the 4 years (2020–2024) after documentation of *Pd* in western Oklahoma were similar in magnitude (Fig. 1).

Before 2020, Cave Myotis did not test positive for *Pd* by qPCR in Oklahoma. Following the first *Pd*-positive bat in western Oklahoma, a Tricolored Bat, discovered in 2019 in Nescatunga (Loucks et al. 2025), it was expected that Cave Myotis also would test positive because the 2 species roost in the same hibernacula. We report in this study the first cases of *Pd*-positive Cave Myotis in Oklahoma in bats from 3 hibernacula (Table 2). During 2018–2023, 19 of 457 (4.2%) swabbed Cave Myotis tested positive for *Pd* (Table 2). As of 2024, 5 species—*Corynorhinus townsendii ingens* (Handley) (Ozark Big-eared Bat), *Eptesicus fuscus* (Palisot de Beauvois) (Big Brown Bat), *M. septentrionalis* (Trouessart) (Northern Long-eared Bat), Cave Myotis, and Tricolored Bat—have been reported as *Pd*-positive in Oklahoma (Braun et al. 2024, Loucks et al. 2025, ODWC 2021).

Although population declines occur within 2–3 years after detection of the pathogen in some species (Auteri et al. 2020, Frick et al. 2017, Langwig et al. 2017), we have not seen steep declines in Cave Myotis in Oklahoma. WNS has been reported in Cave Myotis in neighboring states—Kansas (Kansas Department of Wildlife and Parks 2018), New Mexico (Bureau of Land Management 2023), and Texas (TPWD 2020, 2024)—and population declines and mortalities in Texas (TPWD 2024) have led to increased surveillance. Physical signs of WNS have not been reported on Cave Myotis in Oklahoma, and the disease has not been confirmed through skin histopathology in this species, as of 2024. Reports have indicated that after WNS-related mortalities and population declines, hibernating populations have apparently stabilized in some regions of the U.S. (Dobony and Johnson 2018, Frick et al. 2017, Loeb and Winters 2022, Perea et al. 2024). Development of tolerance and eventual resistance to the disease may occur (Auteri et al. 2020, Frick et al. 2017, Langwig et al. 2017). Brennan et al. (2015) detected antibodies to unidentified *Pseudogymnoascus* in Cave Myotis within the same 5 hibernacula in this study, although resistance to *Pd* specifically has not been verified. In Cave Myotis in Oklahoma, mass mortality has not been evident, populations have not rapidly declined, and physical signs of disease have not been observed.

Cutaneous infection by *Pd* disrupts torpor (Frank et al. 2014), leading to frequent arousals during hibernation and premature depletion of fat stores. Therefore, body mass is a strong predictor of WNS survival, and species with greater body mass, like Cave Myotis (12–16 g), may have a greater chance of surviving *Pd* infections than smaller-bodied bats (Haase et al. 2021). Over 8 hibernation seasons (1979–1986, 2005–2006), average mass of Cave Myotis entering hibernation was 14.4 g for males and 15.4 g for females; males lost an average of 2.9 g (20.1%), and females lost 3.4 g (22.1%), between October and March (Caire and Loucks 2010). Based on energetic models, Haase et al. (2021) estimated Cave Myotis have enough fat to survive, on average, for an additional month of hibernation past their expected date of spring emergence. Whether or not this apparent surplus is sufficient

to counter loss of fat caused by more frequent arousals due to *Pd* infection in the field is unknown. Additional factors, like thermoregulatory patterns, may also influence host response to pathogen invasion and impact differences in survival among species (Moore et al. 2017). Continued monitoring of Cave Myotis is important to confirm the response to pathogen detection in these populations.

Currently 52% of all bat species in North America are at risk of severe population decline and possible extinction due to multiple threats, including WNS, wind-energy development, climate change, and habitat loss (North America Bat Conservation Alliance 2023). WNS has killed millions of cave-dwelling bats in eastern North America over the past decade (Cheng et al. 2021, Frick et al. 2015), and the continued westward spread of WNS, coupled with additional threats, dictate that continued monitoring of hibernating populations, like those of the Cave Myotis, is necessary to document population changes over time. Cave Myotis are historically one of the most common bat species in western Oklahoma and an important part of the ecosystem. Reduction of human disturbance (Bernard et al. 2020), alteration of wind-turbine operations during high-risk periods for bats (Baerwald et al. 2009, Hayes et al. 2019), cave protection (Hammerson et al. 2017), and strategies that focus on habitat restoration and land protection near hibernacula (Frick et al. 2023) are examples of conservation efforts that can benefit bats, including Cave Myotis, and aid in future conservation.

Acknowledgments

We thank students and faculty at UCO and USAO, who helped with field data collection, and personnel at UCO's Selman Living Lab and other landowners for access to caves. We thank Duane Del Vecchio and the Central Oklahoma Grotto for winter population surveys. Personnel from Alabaster Caverns State Park, USFWS, and ODWC provided assistance and data access. We thank A. E. Ballmann (NWHC) and H. C. Lanier (OMNH) for analysis of swabs and providing diagnostic results. We are grateful to Tina Cheng and Brad Watkins, for help with range maps, and the reviewers and editors, for manuscript comments.

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