



Winter Acoustic Bat Monitoring

*2021-2022 Results from Mount Rushmore National Memorial,
Badlands National Park, Devils Tower National Monument, and
Wind Cave National Park*

Natural Resource Data Series NPS/MORU/NRDS—2022/1358





ON THIS PAGE

Bat acoustic monitoring equipment at Devils Tower National Monument.
(NPS / MAX MADDUX)

ON THE COVER

Bat acoustic monitoring equipment at Mount Rushmore National Memorial.
(NPS / RENE OHMS)

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Natural Resource Data Series NPS/MORU/NRDS—2022/1358

Max L. Maddox¹

¹National Park Service
Mount Rushmore National Memorial
13000 Highway 244
Keystone, SD 57751

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Abstract

The Black Hills and Northern Great Plains regions of South Dakota and Wyoming harbor numerous bat species that utilize the region's unique landscape features to carry out vital life functions. While extensive summer acoustic monitoring has been conducted by the Northern Great Plains Inventory and Monitoring Network, winter acoustic surveys have been limited to only a few parks in the region, and there is still much unknown about winter bat activity in this area. Acoustic detectors were deployed at Mount Rushmore National Memorial, Badlands National Park, Devils Tower National Monument, and Wind Cave National Park between mid-October through the beginning of February with the goals of 1) determining which species were present at each park during the months surveyed, 2) tracking how bat activity levels shifted based on environmental factors, and 3) identifying areas of potential importance to overwintering bats. Acoustic recordings were analyzed using SonoBat and a manual review process. Echolocation calls from 11 bat species were documented throughout the study, with the most frequently identified species being silver-haired bats, hoary bats, and big brown bats. The federally threatened northern long-eared bat was only documented from Wind Cave National Park. Overall activity levels generally peaked shortly after sunset and appeared to follow trends in nightly temperatures.

Acknowledgments

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Thanks to the Northern Great Plains Inventory and Monitoring Network (NGPN) for loaning their detectors, microphones, and other equipment for use in this project. Thanks to Angela Jarding (Wildlife Biologist at WICA), Hollie Pucket (Biological Science Technician at WICA), Russ Cash (Chief of Resources Management at DETO), Eddie Childers (Wildlife Biologist at BADL), and Paul Roghair (Biological Science Technician at BADL) for assistance in detector deployment at their respective parks.

Terms and Codes

Park Codes

MORU – Mount Rushmore National Memorial

BADL – Badlands National Park

DETO – Devils Tower National Monument

WICA – Wind Cave National Park

Species Codes

Coto – *Coryrhinus townsendii* (Townsend’s big-eared bat)

Epfu – *Eptesicus fuscus* (Big brown bat)

Labo – *Lasiurus borealis* (Eastern red bat)

Laci – *Lasiurus cinereus* (Hoary bat)

Lano – *Lasionycteris noctivagans* (Silver-haired bat)

Myci – *Myotis ciliolabrum* (Western small-footed bat)

Myev – *Myotis evotis* (Western long-eared bat)

Mylu – *Myotis lucifugus* (Little brown bat)

Myth – *Myotis thysanodes* (Fringed myotis)

Myvo – *Myotis volans* (Long-legged myotis)

Myse – *Myotis septentrionalis* (Northern long-eared bat)

Pesu – *Perimyotis subflavus* (Tricolored bat)

Introduction

The Northern Great Plains and Black Hills regions of South Dakota and Wyoming encompass a diverse array of habitat types and landscape features that are utilized by bats to carry out many of their life functions such as feeding, mating, and hibernation. At least 12 species of bats have been documented in this area, including the federally threatened northern long-eared bat (*Myotis septentrionalis*). This species and others have experienced declines attributed to threats such as habitat loss, disturbance, and the spread of white-nose syndrome (WNS), a disease caused by exposure to the fungus *Pseudogymnoascus destructans* (Pd). Pd has continued to spread across North America and has been detected at Badlands National Park (BADL), Devils Tower National Monument (DETO), and Wind Cave National Park (WICA). Pd has not yet been confirmed at Mount Rushmore National Memorial (MORU) but is expected to have spread to this park as well.

With increased concern surrounding bat conservation, robust monitoring efforts are currently being developed and implemented across many National Park Service (NPS) units. Survey methods include mist-netting, emergence counts, radio telemetry, and acoustic monitoring. Surveys are frequently conducted during the summer months when bats are most active, and risk of disturbance is limited. During the winter months, some bat species are known to migrate south to warmer regions, while others seek out nearby hibernacula. One symptom of WNS in bats is activity during daylight hours or during colder temperatures (Reeder et al. 2012), however preliminary research in areas where WNS is absent provides evidence that bats may also arouse from hibernation to seek water (Speakman and Racey 1989), to feed (Dunbar et al. 2007), or switch hibernation sites (Mormann and Robbins 2007). Regardless, there is still little known about winter bat activity, including which species overwinter in the Northern Great Plains and Black Hills regions.

Previously, MORU has conducted limited winter acoustic surveys which have documented bat activity of six species between the months of February and April. MORU lacks traditional hibernacula such as caves and mines, but it is hypothesized that bats may overwinter in rock crevices present within the many granite outcrops throughout the park. More extensive winter acoustic and emergence surveys have been conducted at DETO (Hammesfahr and Ohms 2018) documenting at least three species as well as several undetermined *Myotis* species from the months of September through April. Like MORU, DETO lacks traditional hibernacula but does have an extensive talus boulder field below the tower which may serve as a valuable overwintering site for bats. BADL has conducted summer acoustic surveys in previous years. While also lacking caves or mines, the park does have unique geologic features which form ridges and canyons, with cracks and crevices where bats may overwinter. WICA has conducted summer acoustic surveys previously, and the cave that serves as the park's namesake is a known hibernation site for several bat species, including the northern long-eared bat.

Primary objectives of this study were to (1) determine which bat species are present at the four aforementioned parks within the study area (Figure 1) between the months of October through February, (2) characterize both species-specific and total bat activity related to monitoring night, time of day, and temperature, and (3) to develop a preliminary understanding of which areas bats may be

utilizing in the winter at each park. To achieve this, a total of 12 acoustic detectors were deployed across all four parks based on areas of interest to resource managers and proximity to potential hibernacula and/or water sources. Results will inform management objectives and may support a need to identify hibernacula to mitigate future disturbance to overwintering bats.

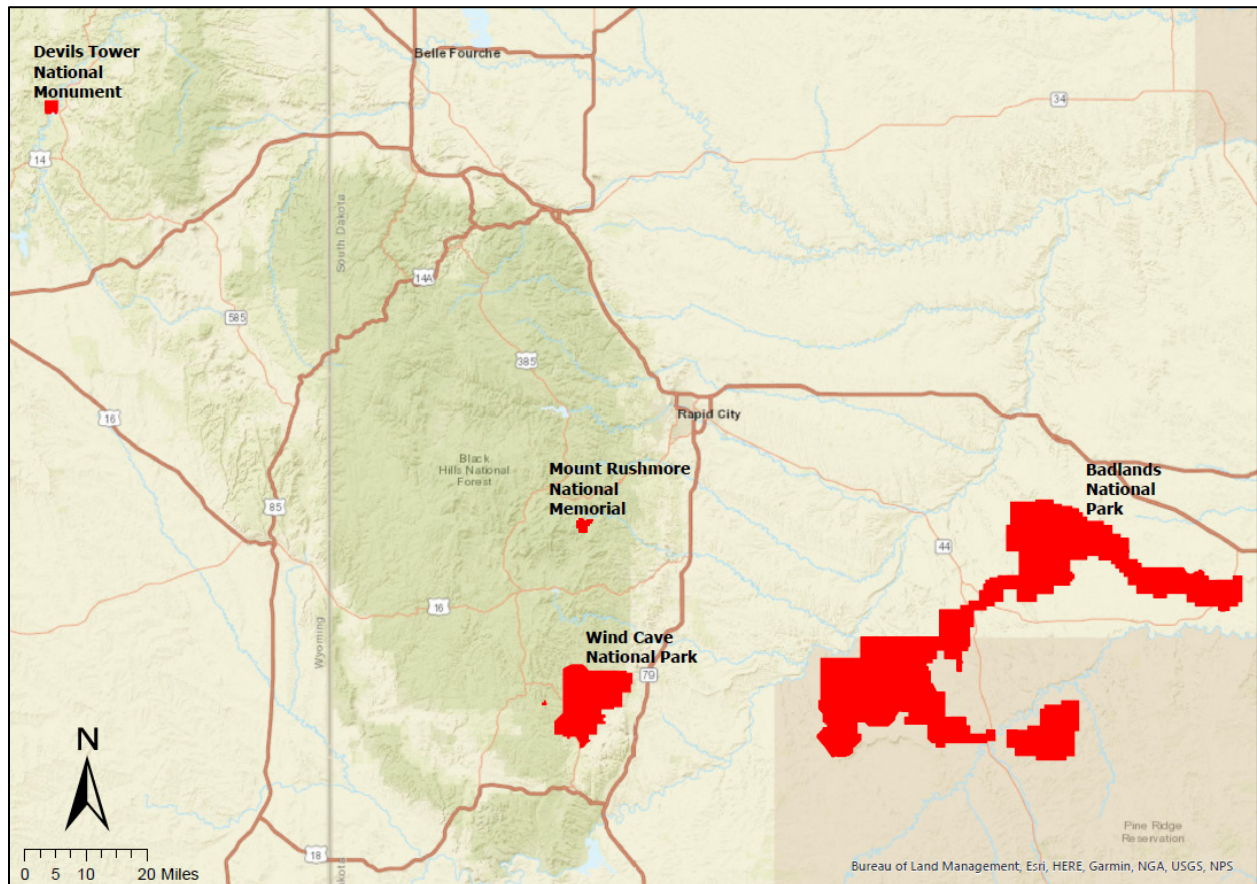


Figure 1. Relative location map of all four NPS park units surveyed.

Methods

Site Selection

Mount Rushmore National Memorial

MORU encompasses 1,278 acres and is primarily known for its iconic carving of four former U.S. presidents carved in granite at the center of the park. It is dominated by old growth ponderosa pine (*Pinus ponderosa*) forest, and includes numerous granite outcrops, several streams, and a small area of non-forested wetland. Over the course of this study, a total of eight deployment locations (Figure 2, Appendix A) were identified in the park for a total of 536 survey nights. Here “survey nights” are defined as nights active multiplied by number of detectors deployed (e.g., 10 detectors deployed for one night each are equivalent to a total of 10 survey nights). Three locations were discontinued early due to low quality calls or identification of alternative sites of greater interest, however their data is still included in this report and in summary figures. Sites varied in elevation and ecosystem type, with locations chosen based on management interest, proximity to potential hibernacula, or proximity to streams and ponds.

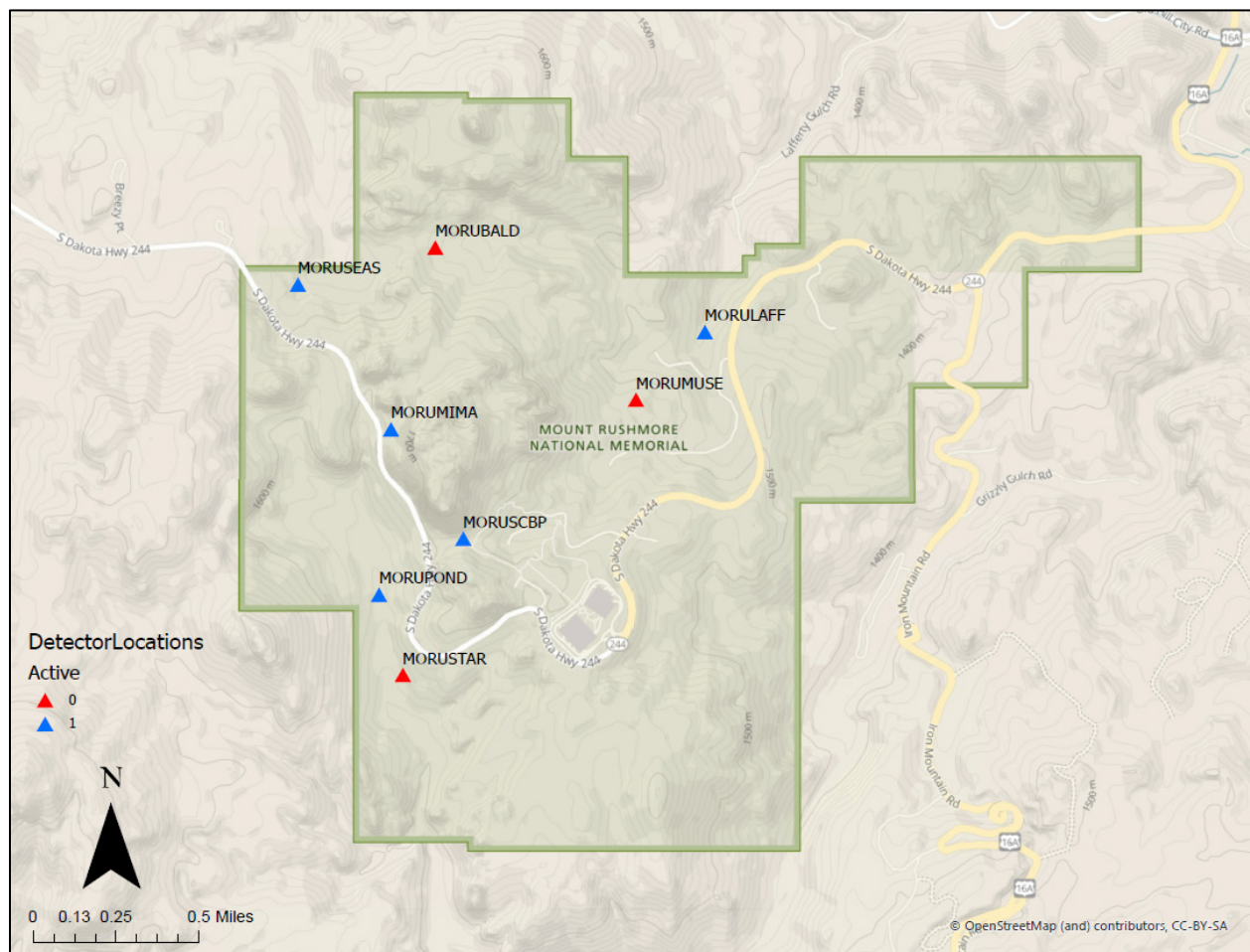


Figure 2. Detector deployment locations at Mount Rushmore National Memorial. Red triangles indicate sites discontinued early in the study.

Badlands National Park

BADL lies to the east of the Black Hills and was the largest park surveyed at 244,000 acres, though detector deployments were concentrated in the eastern half of the North Unit of the park (Figure 3, Appendix A) to facilitate access and focus on areas of management interest. The park is composed primarily of mixed-grass prairie and the unique badlands formations that are the park's namesake. These badlands formations contain canyons, channels, cliffs, and crevices that bats may use as hibernacula in the winter months. There are also several streams and ponds throughout the park that may serve as water sources for bats when not frozen. Three acoustic detector deployment sites were chosen at BADL (Figure 3, Appendix A) for a total of 84 survey nights. Sites were chosen based on proximity to potential hibernacula and management interest.

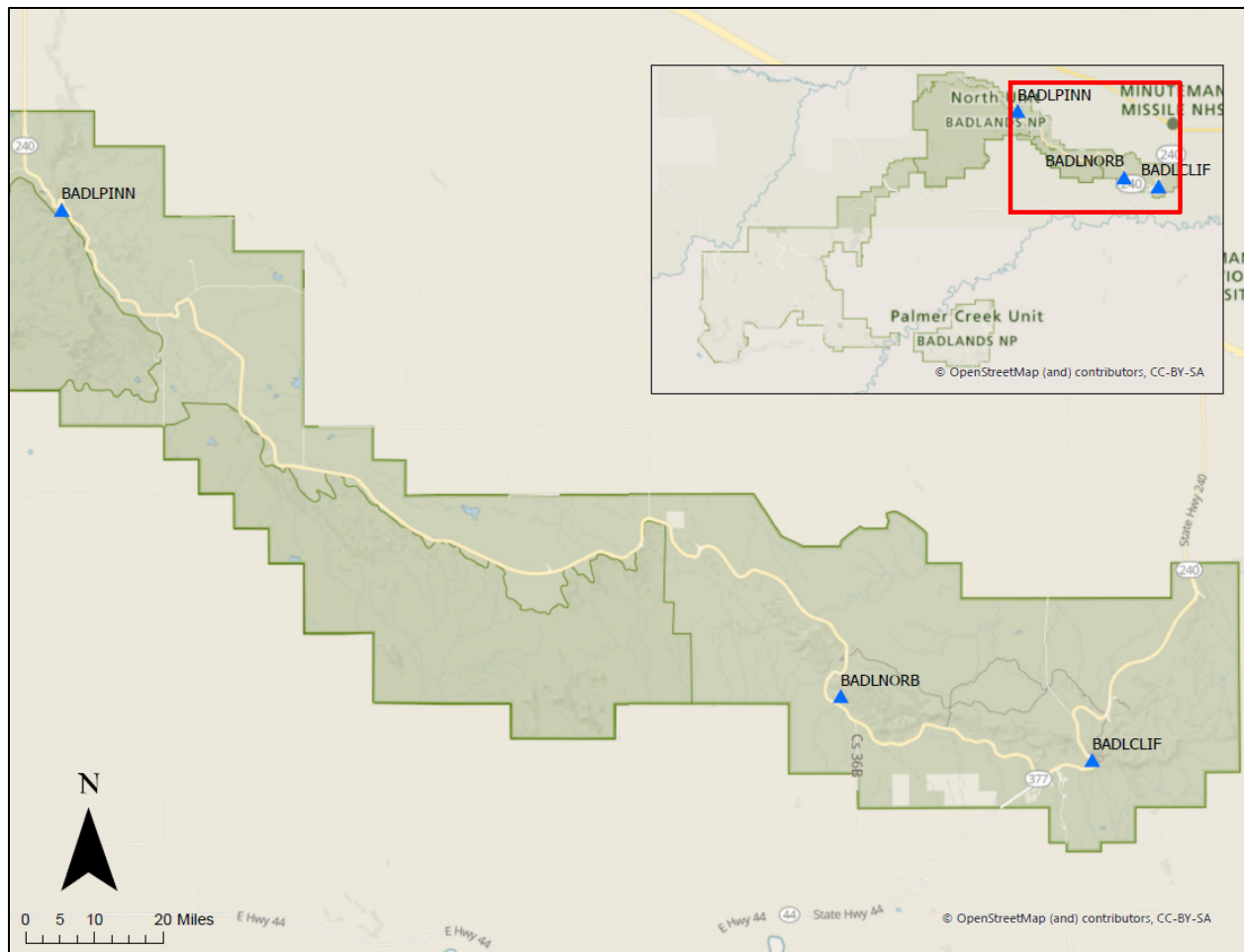


Figure 3. Detector deployment locations at Badlands National Park.

Devils Tower National Monument

DETO is best known for the large tower of columnar igneous rock at its center and the large boulder field surrounding it, though other unique geologic features such as red sedimentary cliffs and sandstone are present throughout the park. Ecosystems of note include many open areas of mixed-grass prairie, ponderosa pine forest, several spring-fed streams, and the floodplain formed by the Belle Fourche River which runs through the southeastern corner of the park. Three acoustic detector deployment sites were chosen at DETO (Figure 4, Appendix A) for a total of 105 survey nights. Sites were chosen based on both proximity to water sources and areas where capture surveys had been conducted in prior years.

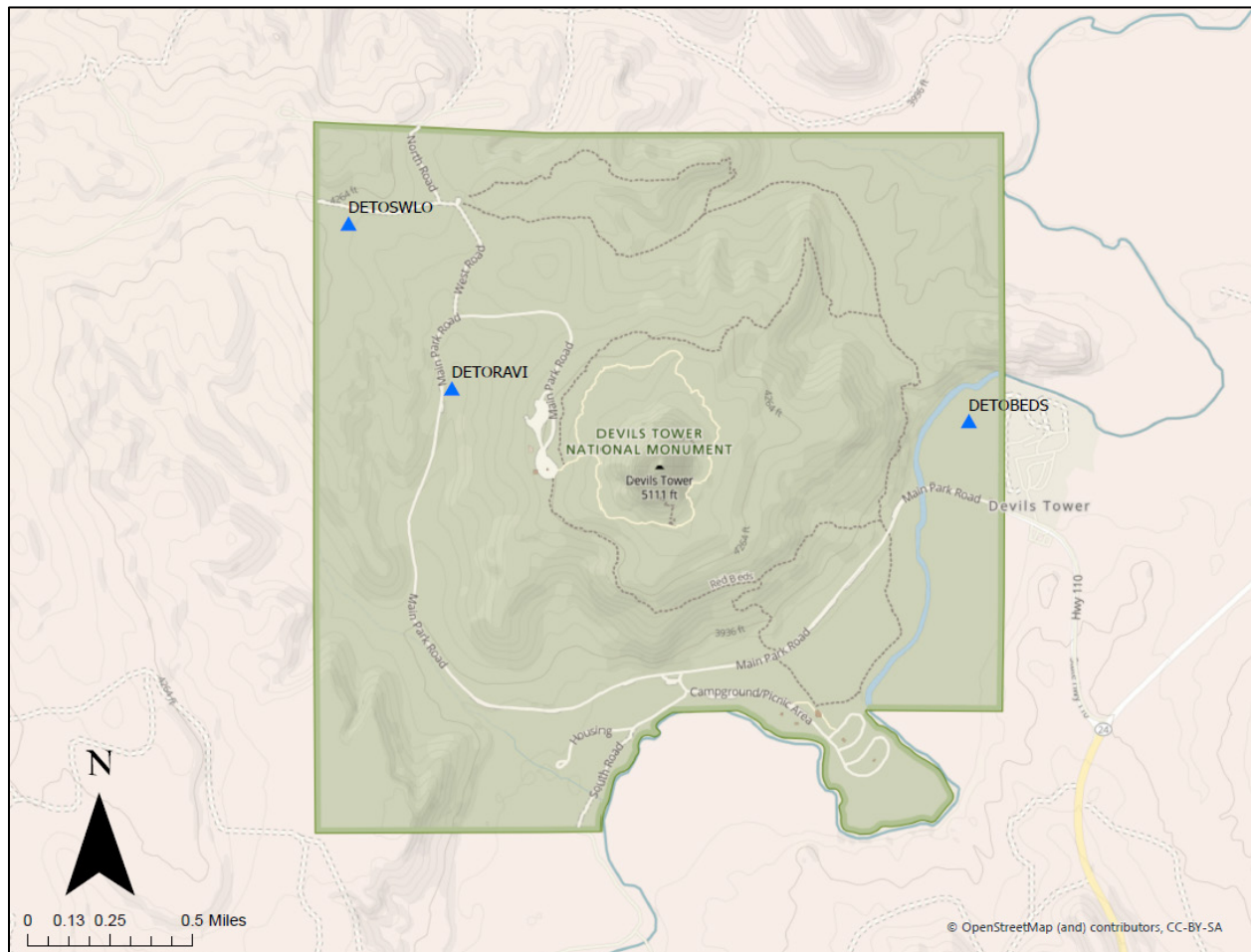


Figure 4. Detector deployment locations at Devils Tower National Monument.

Wind Cave National Park

WICA gets its name as host of one of the longest caves in the world, with its unique feature of “breathing” as atmospheric pressure equalizes between the cave and outside air. It is also the largest park within the Black Hills, at nearly 34,000 acres. As one of several large caves in the region, Wind Cave serves as a key hibernation site for bats. WICA is composed primarily of mixed-grass prairie, with scattered areas of ponderosa pine forest, riparian habitat, and rocky canyons. One detector was deployed at the natural entrance to the cave (Figure 5, Appendix A) where bats are known to enter and exit, for a total of 48 survey nights.

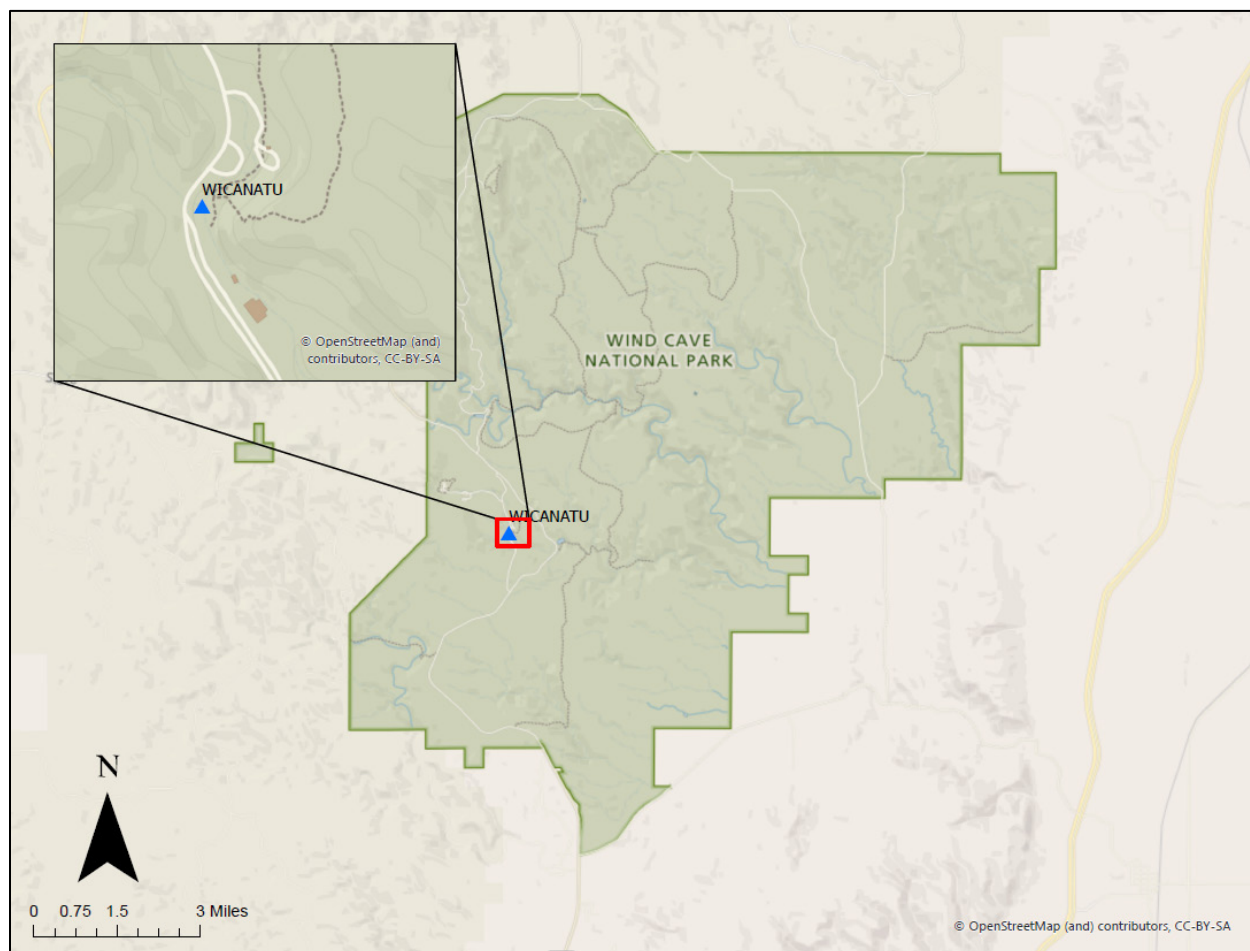


Figure 5. Natural entrance detector deployment site at Wind Cave National Park.

Acoustic Detector Deployment

Wildlife Acoustics SM4BAT-FS detectors (firmware version 2.4.0) equipped with SMM-U2 microphones were utilized at all deployment sites. Detectors were set to run either from 30 minutes prior to sunset to 30 minutes following sunrise (MORU, BADL) or set to run continuously day and night (WICA, DETO) based on management interest. All other detector settings were based on NABat recommendations for Wildlife Acoustics SM4BAT-FS detectors (Reichert et al. 2017, Appendix B). Microphones were mounted facing up as per Wildlife Acoustics User Guide

recommendation, at 2-2.5 meters above ground level on tripod-supported poles. Close proximity to clutter (e.g. branches, snags, live trees, tall boulders) was minimized where possible to ensure recordings of high-quality search-phase calls. All detectors were equipped with 12V batteries supplying external power. Due to a lower call volume in the winter months, each SM4BAT-FS detector was equipped with only one 64GB or 128GB SD card at a time. On average, detectors were checked every 2-4 weeks to retrieve data from SD cards and to ensure batteries and equipment were operational.

iButton Hygrochron (DS1923) temperature and humidity loggers were affixed to detectors at some deployment sites, particularly where conditions varied significantly from nearby weather stations. iButton loggers were programmed to record temperature and humidity every hour on the hour. For all other sites, hourly data from the nearest Remote Automatic Weather Station (RAWS) was used to correlate hourly weather conditions with bat activity. RAWS data was downloaded from the RAWS USA Climate Archive (<https://raws.dri.edu>). See Appendix A for weather data sources used for each deployment site.

Call Analysis with SonoBat 4.4.5

Data was downloaded approximately every 2-4 weeks from acoustic detectors and analyzed using SonoBat 4.4.5. Data was first run through SonoBat Data Wizard's Batch File Scrubber using NABat recommendations (Reichert et al. 2018, Appendix B) for settings. Scrubbed bat call files were then processed through the SonoBatch function for auto-identification of species. For this process, the "Black Hills" classifier was used for data from MORU, WICA, and BADL, while the "Northeastern Wyoming" classifier was used for data from DETO. NABat recommendations for SonoBatch settings were followed for this process as well. Following SonoBatch classification, all calls were manually vetted, using the SonoVet function to view call characteristics, compare reference files, append manual IDs and add any additional notes. As the primary goal of this study was to determine species presence or absence within each park unit, all calls were classified to species where possible and either as low-frequency (LoF) or high-frequency (HiF) where species could not be confidently determined. Calls that were not discernable as either a low-frequency or high-frequency species, and those which contained calls from multiple species in a single recording were classified as "Other". Noise files missed by the Batch File Scrubber were classified as "NOISE" and were excluded from further analysis. These primarily included snowfall noise during large snow events, bird calls for detectors running in the daytime, and sounds of leaves or twigs being disturbed nearby.

Once all files for a given data pull were manually vetted, metadata was appended to all .wav files using SonoBat Data Wizard's "Attribute Files" function. Appended metadata included location information, microphone directional configuration and height, and general project information. Manually vetted call data was exported to a master Excel file (one for each of the four parks surveyed in this project), where weather data were appended. Data was organized in a manner to easily facilitate production of summary tables and figures.

Results and Discussion

Bat activity was documented through the duration of the survey months, from mid-October to the start of February. Across all parks, the most frequently identified calls were those belonging to silver-haired bats (*Lasionycteris noctivagans*), hoary bats (*Lasiurus cinereus*), and big brown bats (*Eptesicus fuscus*). Calls from a total of 11 species were documented during the duration of the study (Table 1). The only species not documented from any site was the Tricolored bat (*Perimyotis subflavus*), however, as this species has only been recently documented in the region, it is not included in SonoBat's Black Hills or Northeastern Wyoming classifier packages thus making their calls easier to overlook in manual review. Echolocation calls were recorded at temperatures as low as 2°F though this was uncommon, and activity was generally infrequent at temperatures below 20°F. Note that temperature graphs do not account for the lower frequency of warm nights experienced in the winter months, and caution should be taken in interpolating trends above temperatures where activity levels peak.

Table 1. Total counts of species classifications for each park. Refer to Terms and Codes (page vii) for clarification of park codes and species codes. See Appendix C for complete classification breakdown by each monitoring site.

Park Code	Coto	Epfu	Labo	Laci	Lano	Myci	Myev	Mylu	Myth	Myvo	Myse
MORU	20	463	17	1014	2704	210	1	55	78	2	0
BADL	4	37	3	28	120	58	0	19	0	0	0
WICA	0	0	0	1	1	0	0	0	0	0	2
DETO	0	4	0	2	7	0	0	1	0	0	0

Mount Rushmore National Memorial

Surveys at MORU occurred from October 14th through January 30th, with a total of 10,381 bat calls recorded during the study. More than half of all calls recorded at MORU occurred from the MORUMIMA site (Figure 6), making this the area of greatest winter bat activity. Calls from a total of 10 species (Appendix C) were documented in the park, though only one call from the western long-eared bat (*Myotis evotis*) and two calls from the long-legged bat (*Myotis volans*) were confidently identified. In general, activity levels appeared to follow temperature trends, with the most activity occurring on warmer nights (Figure 7). Activity levels peaked shortly after sunset, around 6 PM (Figure 8, Figure 9). Species activity and total activity by temperature are shown in Figures 10 and 11, respectively.

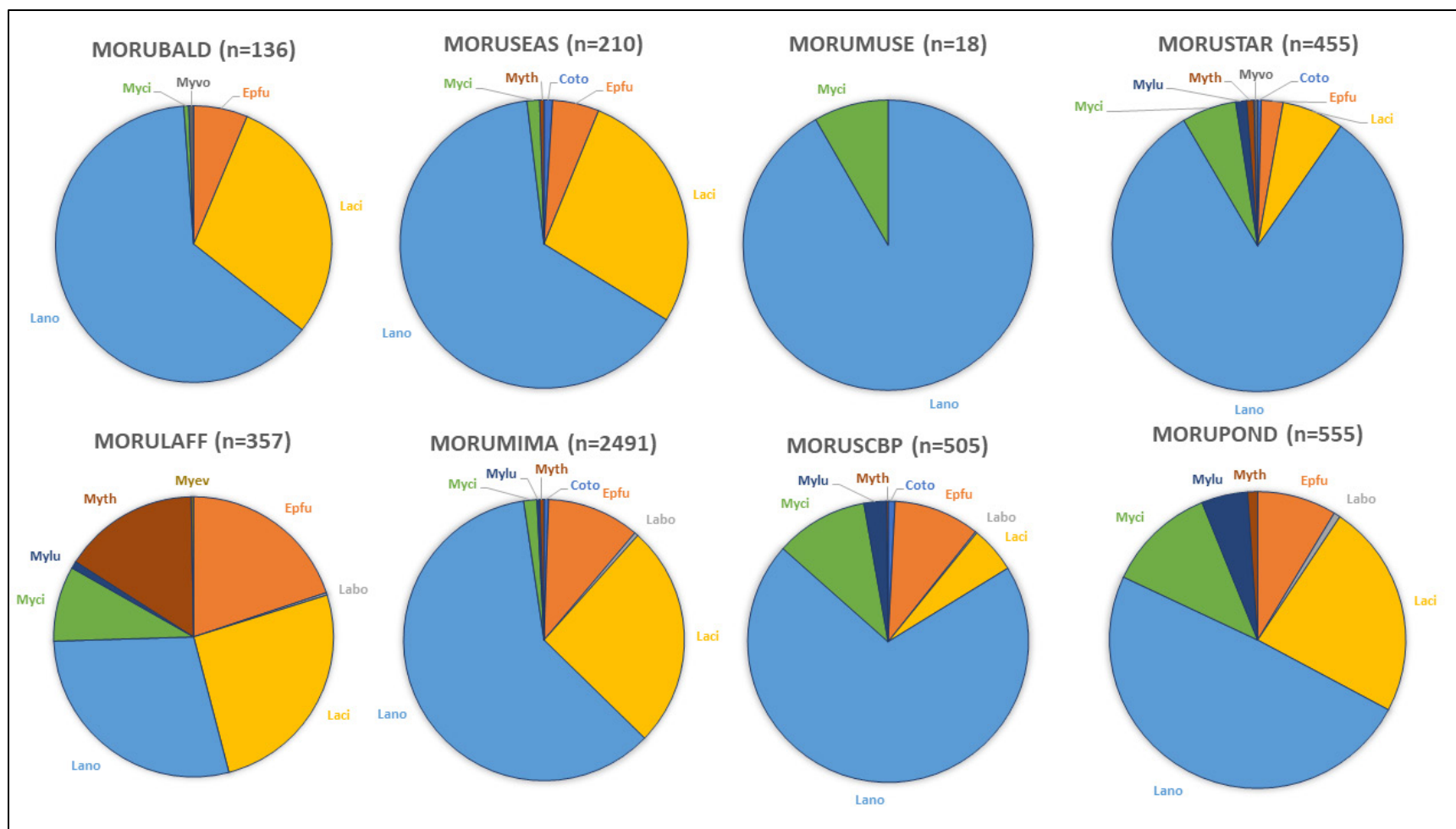


Figure 6. Relative frequency of species classifications for each monitoring site at MORU.

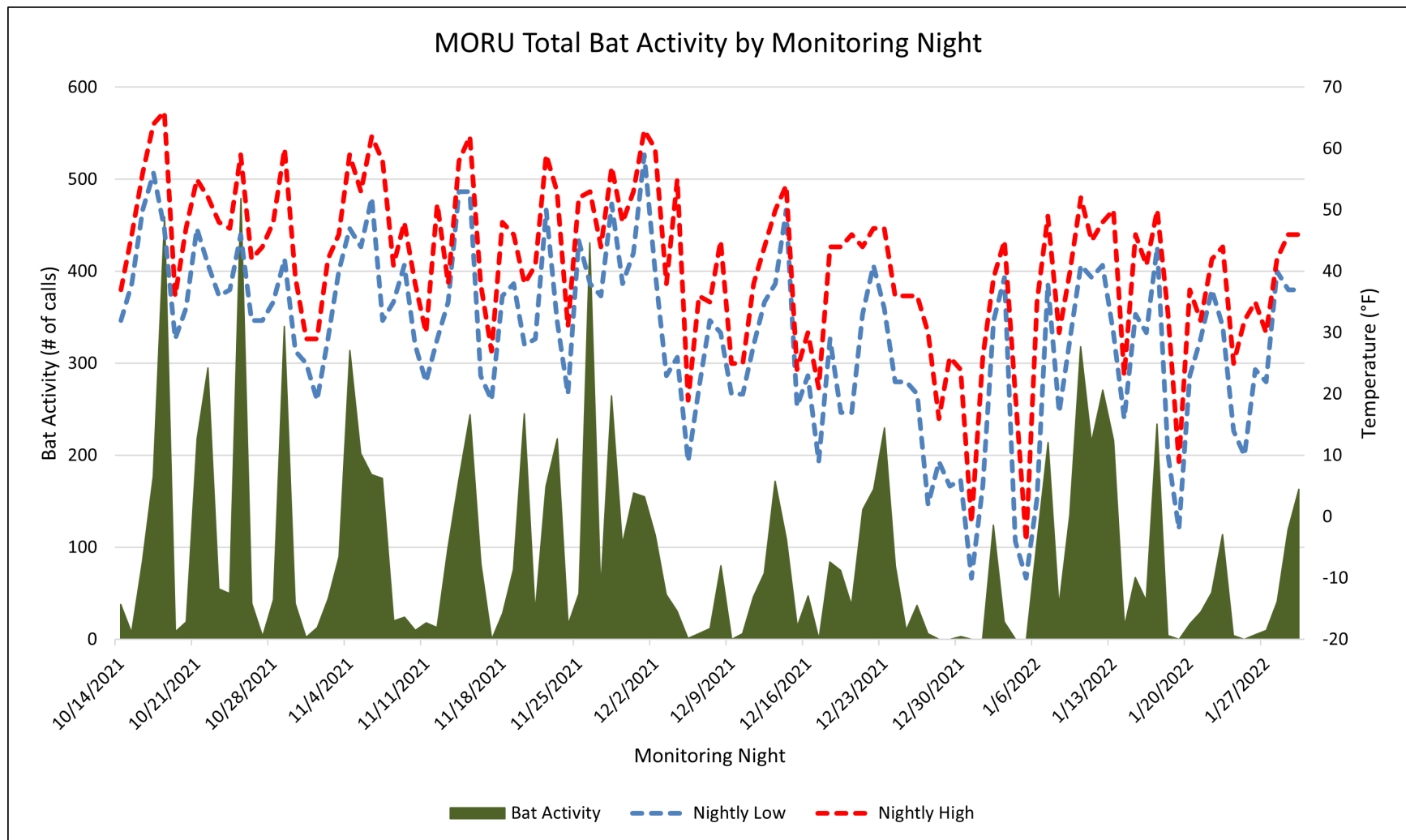


Figure 7. Total bat activity on each monitoring night at MORU compared to nightly (4PM-7AM) low and high temperatures.

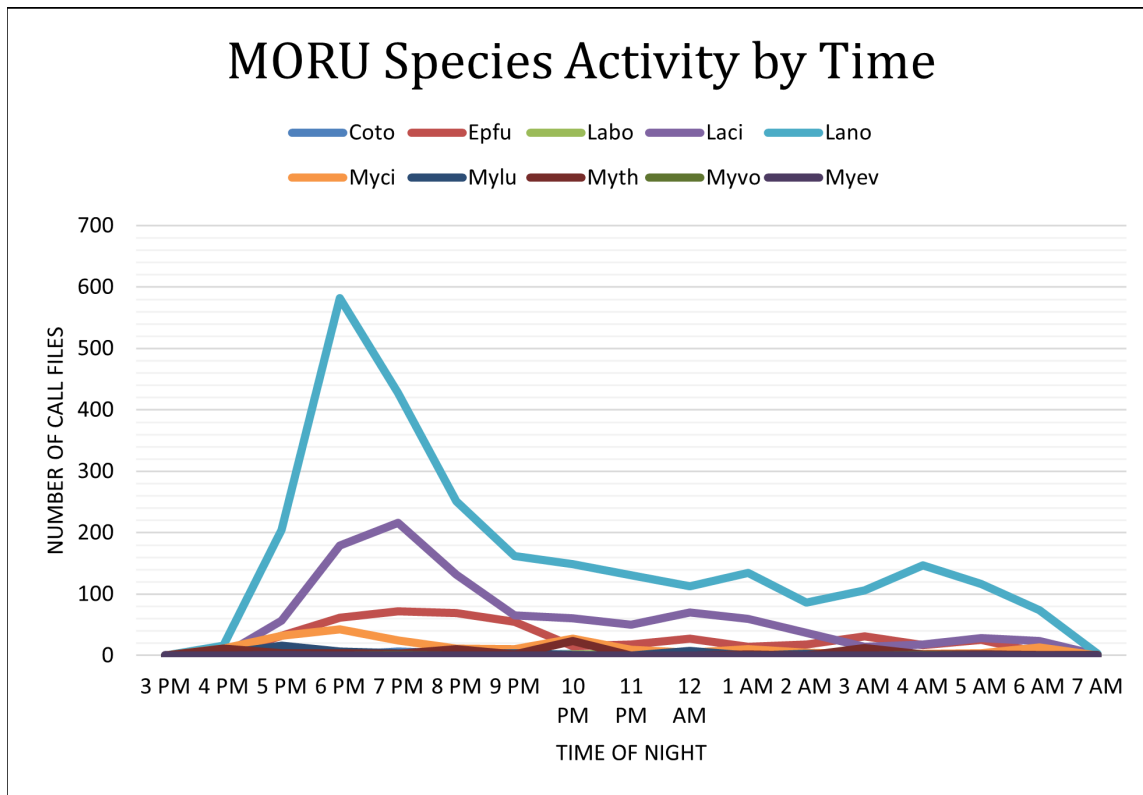


Figure 8. Activity levels of each species documented at MORU by time of night.

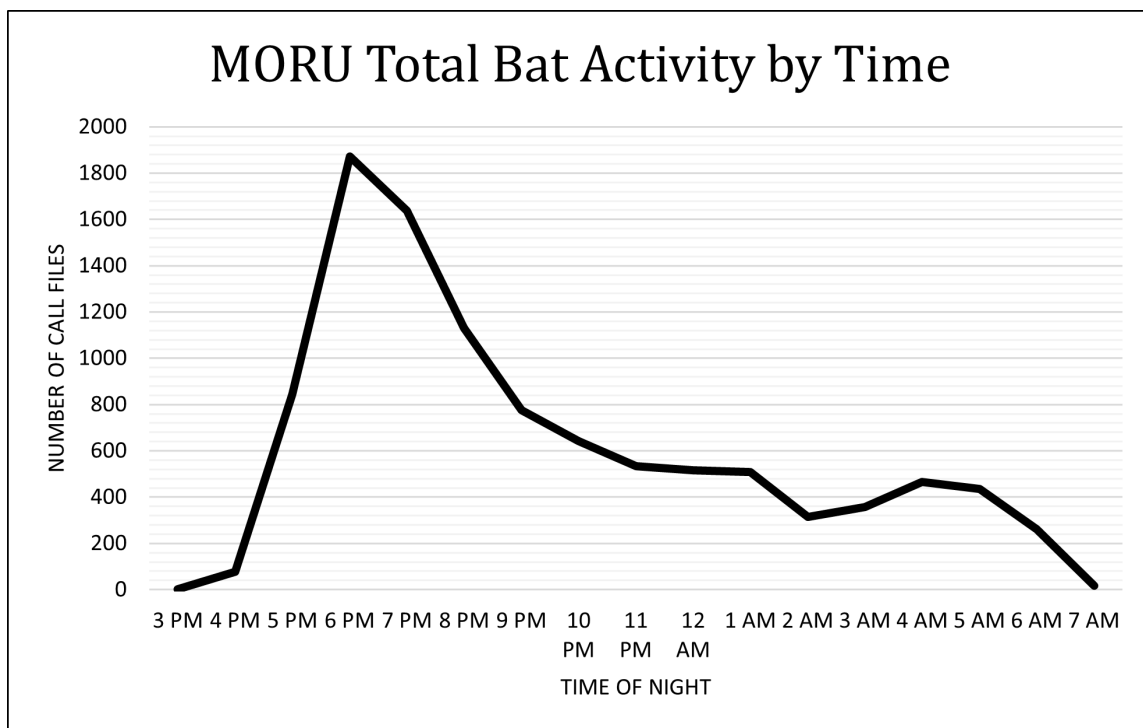


Figure 9. Total bat activity levels at MORU by time of night.

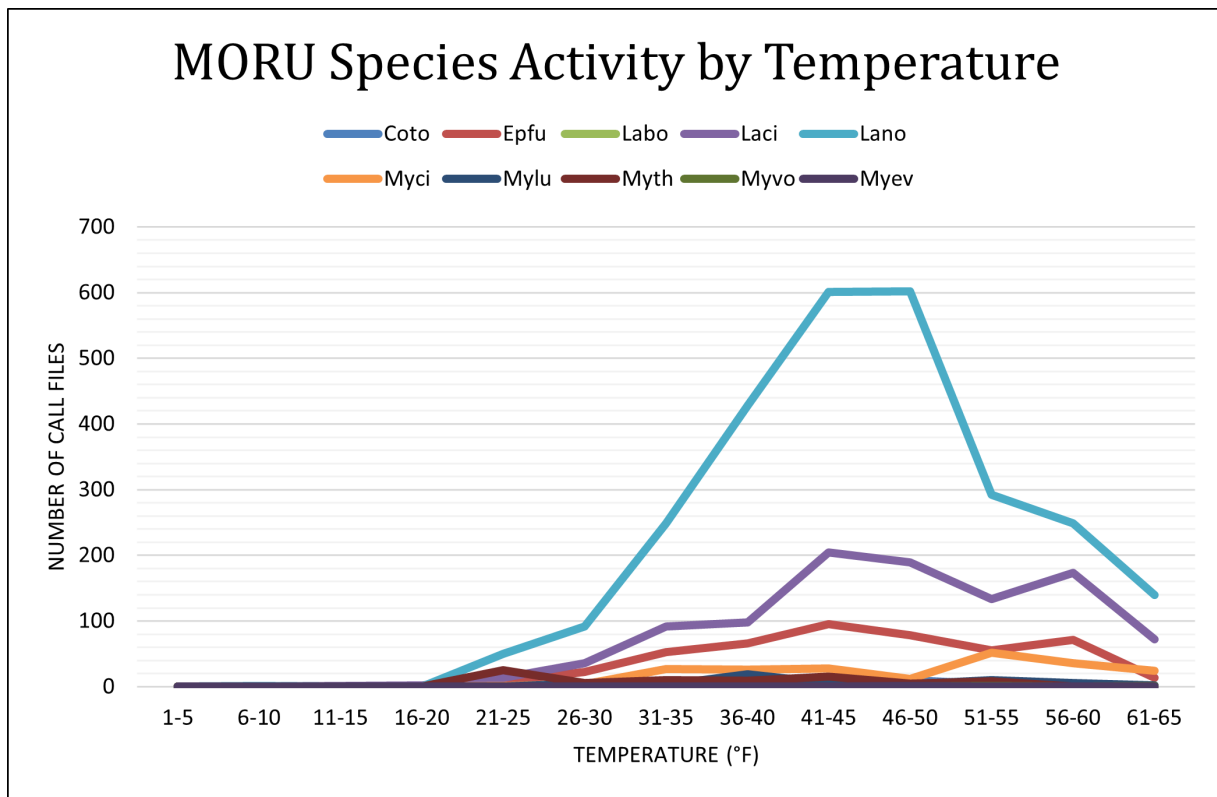


Figure 10. Activity levels of each species documented at MORU by temperature.

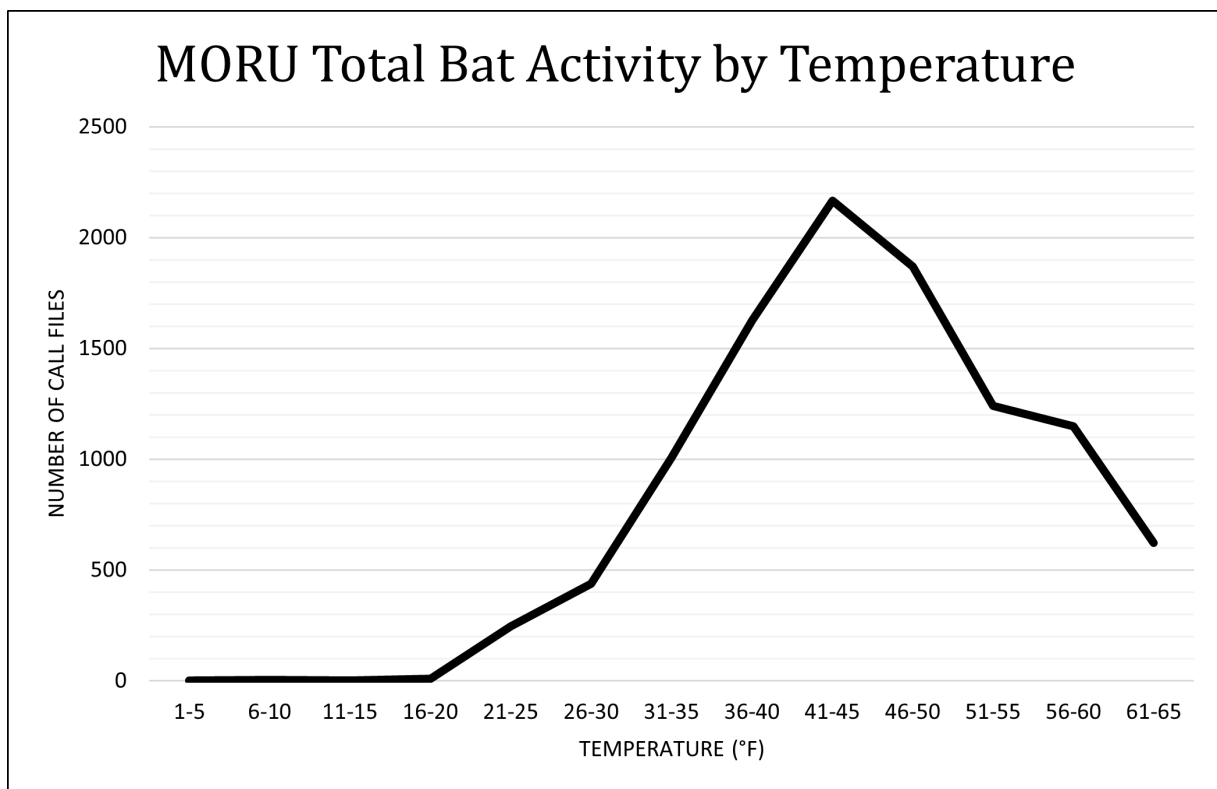


Figure 11. Total bat activity levels at MORU by temperature.

Badlands National Park

Surveys at BADL occurred from January 4th through January 31st, with a total of 692 bat calls recorded during the study. Most activity occurred at the BADLNORB site (Figure 12), which was also the only site where Townsend's big-eared bat (*Corynorhinus townsendii*) calls were documented. In total, calls from 7 species were documented at BADL during the study (Appendix C). In general, activity levels appeared to follow temperature trends, with the most activity occurring on warmer nights (Figure 13). Activity levels peaked around sunset, at approximately 5 PM (Figure 14, Figure 15). Species activity and total activity by temperature are shown in Figures 16 and 17, respectively.

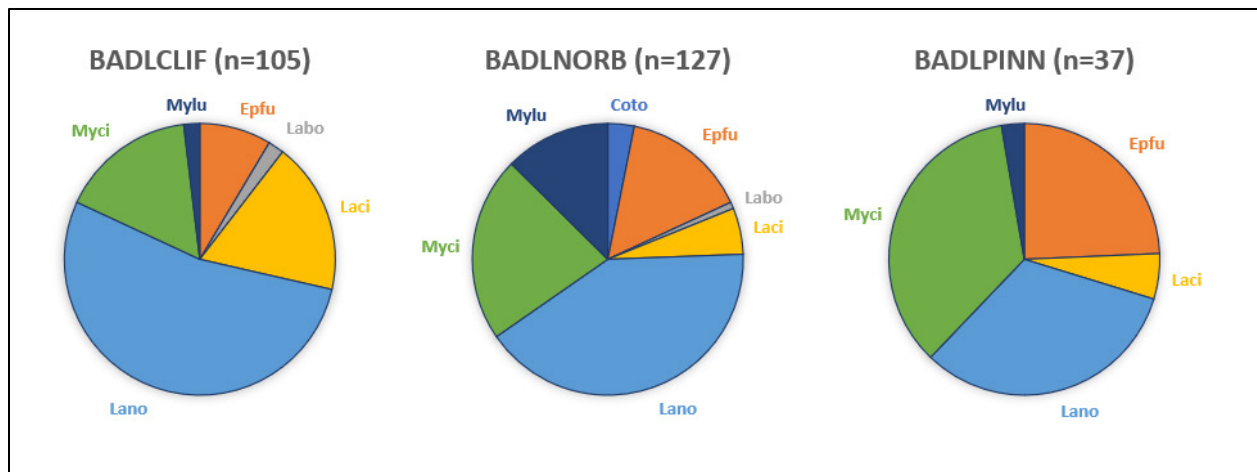


Figure 12. Relative frequencies of species classifications for each monitoring site at BADL.

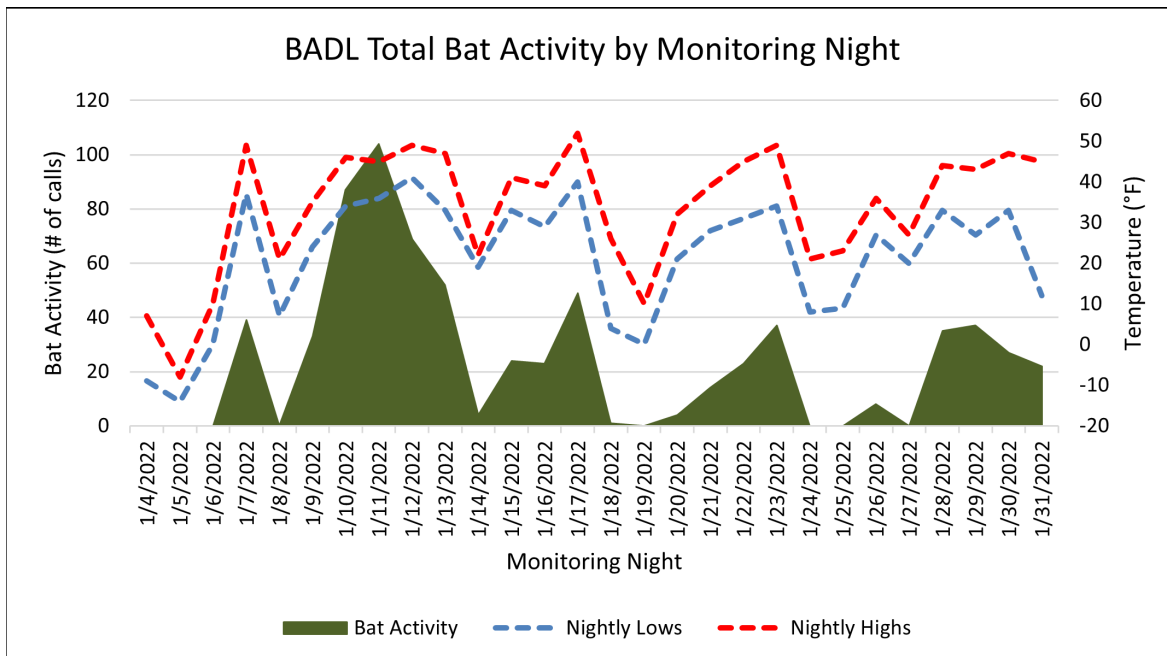


Figure 13. Total bat activity on each monitoring night at BADL compared to nightly (4PM-7AM) low and high temperatures.

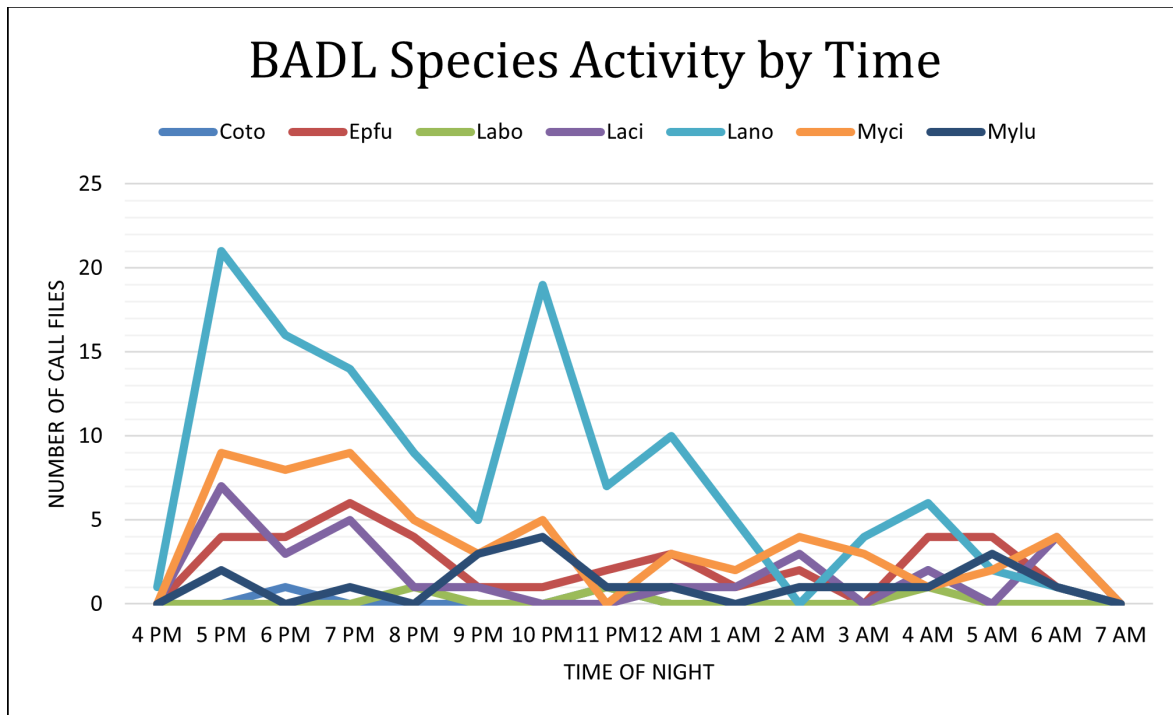


Figure 14. Activity levels of each species documented at BADL by time of night.

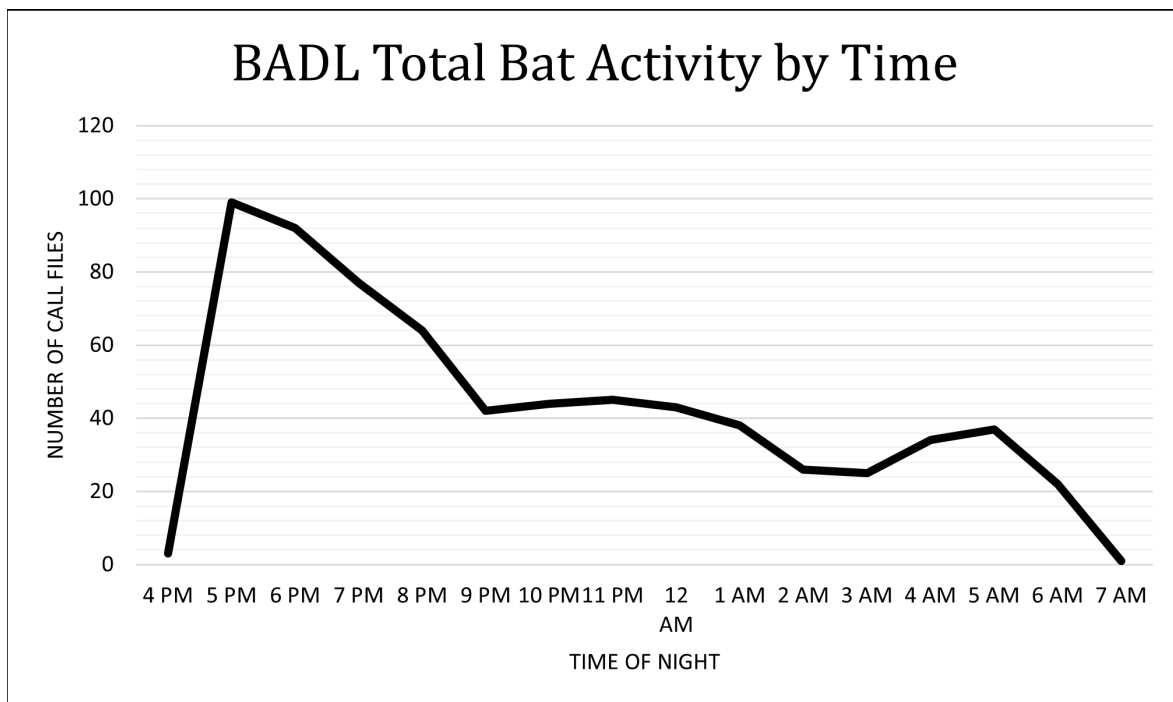


Figure 15. Total bat activity levels at BADL by time of night.

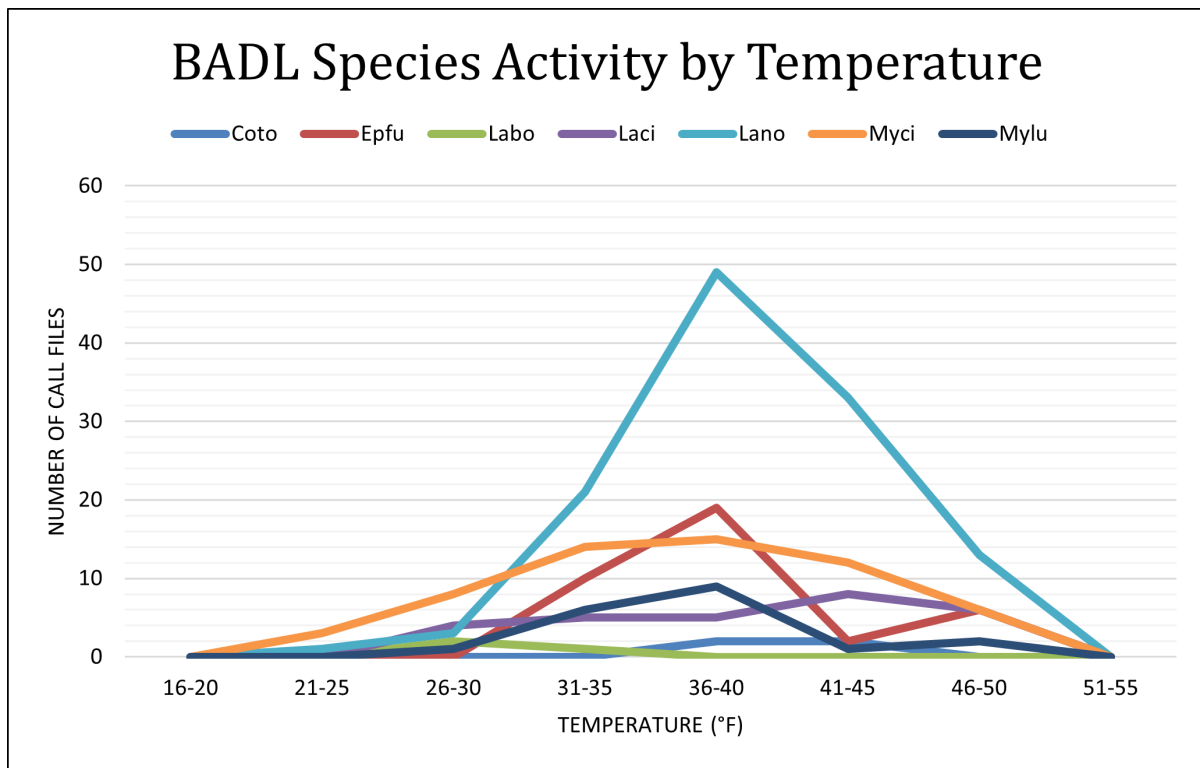


Figure 16. Activity levels of each species documented at BADL by temperature.

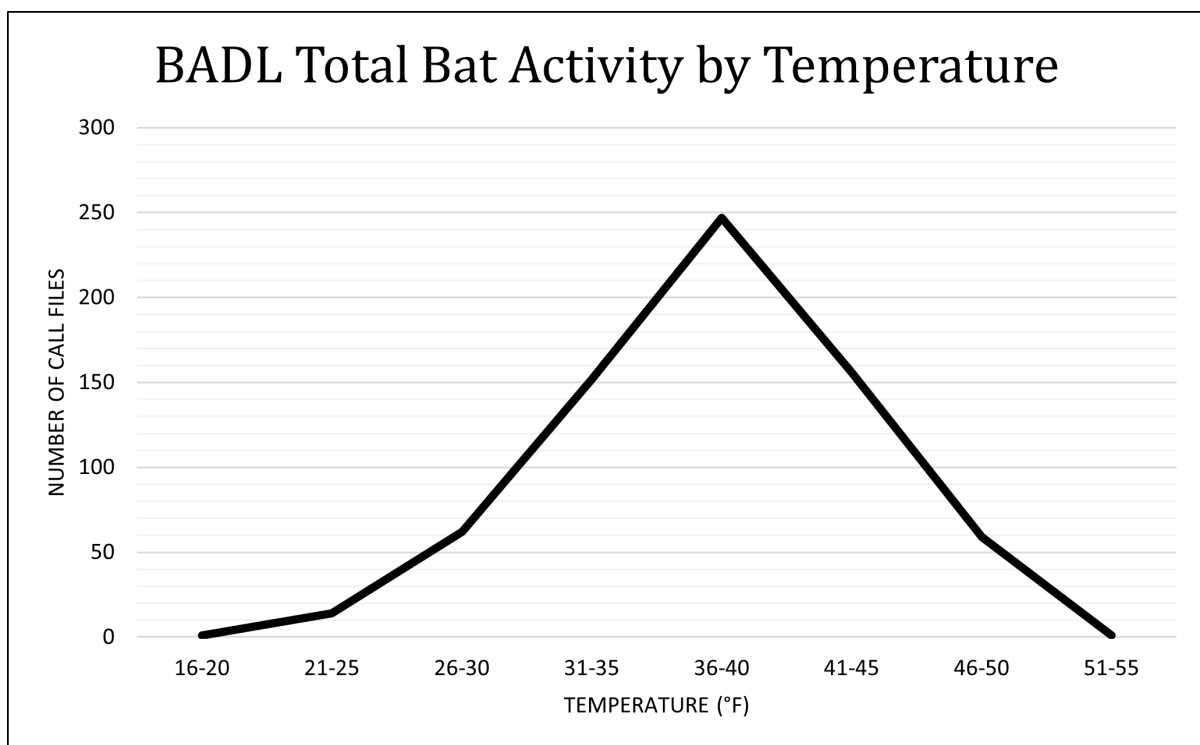


Figure 17. Total bat activity levels at BADL by temperature.

Devils Tower National Monument

Surveys at DETO occurred from November 17th to approximately December 28th, with a total of 45 bat calls recorded during the study. Of the three monitoring sites chosen, over half of the calls recorded occurred at the DETORAVI site. In total, calls from 4 species were identified at DETO during the study (Appendix C, Figure 18). Issues with data collection occurred at DETO due to premature battery failure, timestamp reset, and excess generation of noise files due to the continuous recording mode employed at this park. This resulted in an inability to graph trends in monitoring night, time, or temperature after December 5th (Figure 19), though only two additional calls were recorded beyond this point.

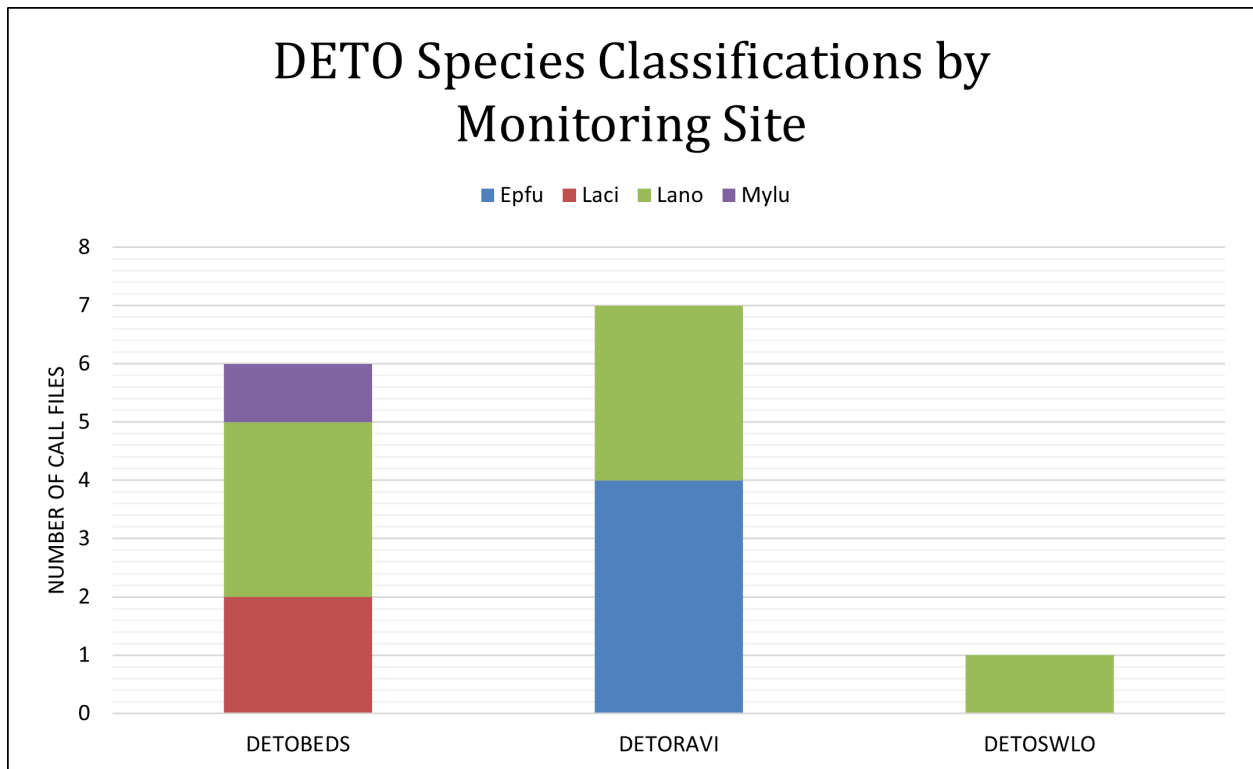


Figure 18. Total species classifications for each monitoring site at DETO.

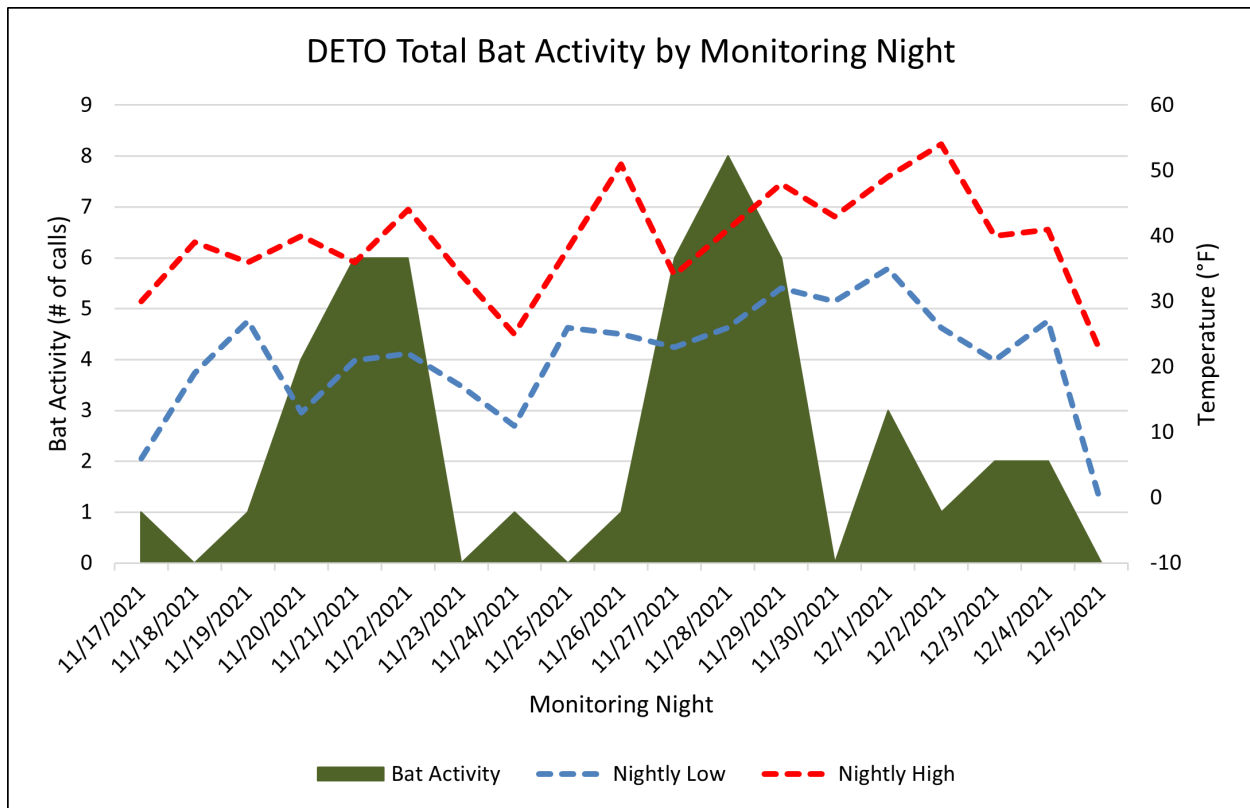


Figure 19. Total bat activity at DETO through the night of December 5th compared to nightly (4PM-7AM) low and high temperatures.

Wind Cave National Park

Surveys at WICA occurred from November 8th to approximately December 25th, with a total of 17 bat calls recorded during the study. In total, calls from 3 species (hoary bats, silver-haired bats, and northern long-eared bats) were identified at WICA during the study (Appendix C). Most calls could not be confidently identified to species. This was the only park surveyed during this study where northern long-eared bat calls were identified. As with DETO, we experienced issues with data collection due to premature battery failure, timestamp reset, and excess generation of noise files due to the continuous recording mode employed at this park. This resulted in an inability to graph trends in monitoring night, time, or temperature after December 13th (Figure 20).

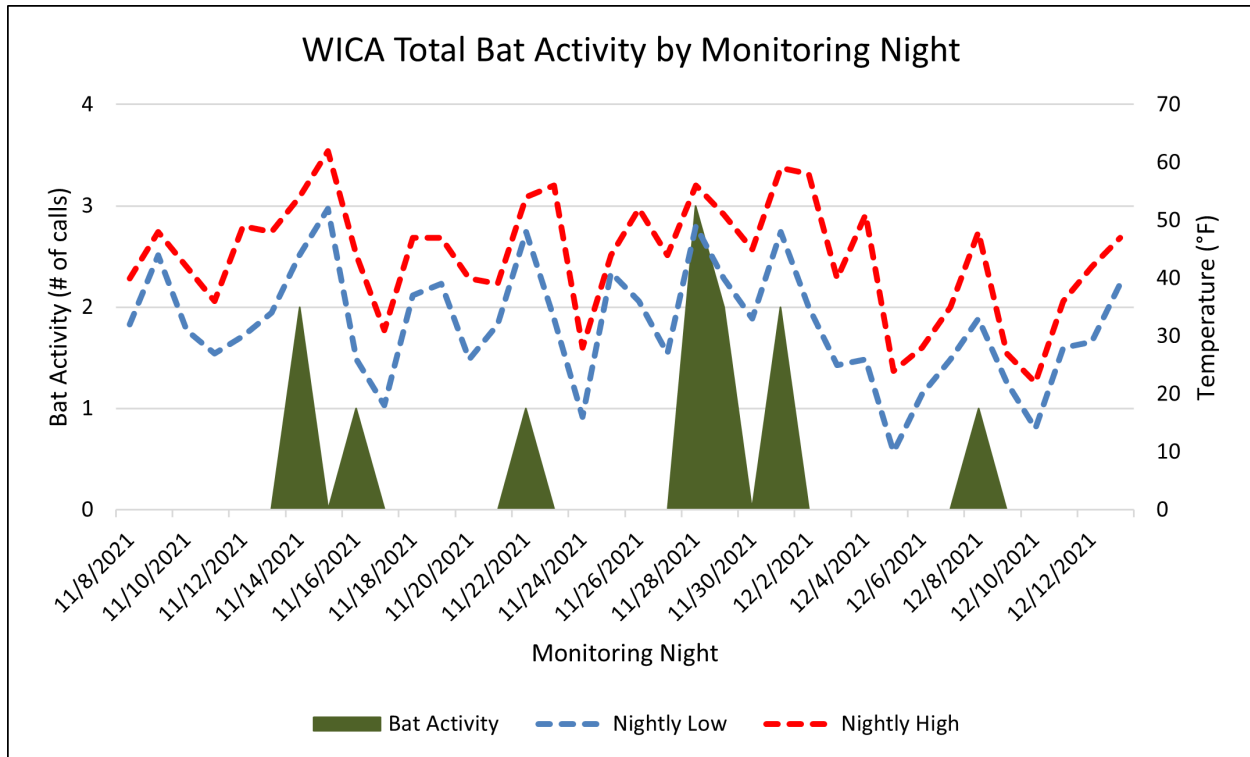


Figure 20. Total bat activity at WICA through the night of December 13th compared to nightly (4PM-7AM) low and high temperatures.

Literature Cited

- Dunbar, M. B., J. O. Whitaker, and L. W. Robbins. 2007. Winter feeding by bats in Missouri. *Acta Chiropterologica* 9(1):305–310.
- Hammesfahr, A. M., and R. E. Ohms. 2018. Winter bat activity in a landscape without traditional hibernacula. Natural Resource Report. NPS/DETO/NRR—2018/1654. National Park Service, Fort Collins, Colorado.
- Licht, D. S. 2018. Acoustic Surveys of Bats at Northern Great Plains Parks and Preliminary Results from 2014-16. Natural Resource Report NPS/NGPN/NRR—2018/1588. National Park Service, Fort Collins, Colorado.
- Mormann, B. M., and L. W. Robbins. 2007. Winter roosting ecology of eastern red bats in southwest Missouri. *The Journal of Wildlife Management* 71(1):213–217.
- Reeder, D. M., C. L. Frank, G. G. Turner, C. U. Meteyer, A. Kurta, E. R. Britzke, M. E. Vodzak, S. R. Darling, C. W. Stihler, A. C. Hicks, and others. 2012. Frequent arousal from hibernation linked to severity of infection and mortality in bats with white-nose syndrome. *PLoS One* 7(6): e38920.
- Reichert, B., C. Lausen, C. Corben, K. Livengood, J. Szewczak, T. Weller, S. Loeb, R. Rodriguez, E. Britzke, T. Hohoff, and others. 2017. North American Bat Monitoring Program guide to acoustic detectors settings v1.0. U.S. Geological Survey.
- Reichert, B., C. Lausen, S. Loeb, T. Weller, R. Allen, E. Britzke, T. Hohoff, J. Siemers, B. Burkholder, C. Herzog, and M. Verant. 2018. A guide to processing bat acoustic data for the North American Bat Monitoring Program (NABat). U.S. Geological Survey Open-File Report 2018:1068.
- Speakman, J. R., and P. A. Racey. 1989. Hibernation ecology of the pipistrelle bat: energy expenditure, water requirements and mass loss, implications for survival and the function of winter emergence flights. *The Journal of Animal Ecology* 58(3):797–813.

Appendix A. Detector Deployment Site and Weather Source Information

Tables A1–A2 show the detector deployment site data and weather data sources, respectively.

Table A1. Location and site data for each of 15 acoustic detector deployments between all four parks. The first four letters of the Site Name correspond to each park's four-letter park code.

Site Name	Nights Active	Coordinates	Recording Mode	Brief Site Description
MORUMUSE	Oct 15 – Oct 21	43.88222, -103.45133	Set-30 to Rise+30	North-facing slope in pine forest, near water treatment plant
MORUBALD	Oct 18 – Nov 4	43.88699, -103.46007	Set-30 to Rise+30	East-facing slope in clearing of pine forest, adjacent to old hiking trail
MORUSTAR	Oct 18 – Nov 7	43.87359, -103.46148	Set-30 to Rise+30	Steep west-facing slope below Hwy 244, above Starling Basin
MORUMIMA	Oct 14 – Jan 30	43.88129, -103.46200	Set-30 to Rise+30	Clearing between two tall granite cliffs by Hwy 244, near pine snags
MORUSCBP	Oct 14 – Jan 30	43.87786, -103.45885	Set-30 to Rise+30	Talus slope below sculpture, near pine forest edge and paved trail
MORUSEAS	Oct 22 – Jan 30	43.88538, -103.46605	Set-30 to Rise+30	Gully adjacent to South Seas climbing area, in pine and birch forest
MORULAFF	Nov 5 – Jan 30	43.88434, -103.44833	Set-30 to Rise+30	Lafferty Gulch, clearing in pine forest at edge of stream
MORUPOND	Nov 8 – Jan 30 ^A	43.87610, -103.46252	Set-30 to Rise+30	Open grassy area adjacent to old beaver pond within Starling Basin
DETOBEDS	Nov 17 – Dec 28 ^B	44.59189, -104.70155	Continuous	Grassy riparian area by Belle Fourche River, in cottonwood grove
DETORAVI	Nov 17 – Dec 22	44.59291, -104.72428	Continuous	Edge of pine forest, above ravine with stream below
DETOSWLO	Nov 17 – Dec 13 ^B	44.59807, -104.72882	Continuous	Sweat Lodge area, near pine forest edge beside shallow gully
BADLCLIF	Jan 4 – Jan 31	43.75162, -101.93218	Set-30 to Rise+30	Near Cliff Shelf Trail adjacent to Hwy 240, in juniper clearing
BADLNORB	Jan 4 – Jan 31	43.76487, -102.00427	Set-30 to Rise+30	Canyon opening between badlands formations, in sandy area
BADLPINN	Jan 4 – Jan 31	43.86559, -102.22808	Set-30 to Rise+30	East-facing narrow gully adjacent to Hwy 240
WICANATU	Nov 8 – Dec 25 ^B	43.55812, -103.47943	Continuous	West-facing slope across paved trail from Wind Cave natural entrance

^A Data from November 11th excluded from analysis due to equipment being blown over in high winds.

^B End dates approximated from last recording file due to premature battery failure and timestamp reset.

Table A2. Weather data source for each acoustic detector deployment site.

NPS Park Unit	Site Name	Weather Data Source
Mount Rushmore National Memorial	MORUMUSE	MORU RAWS Weather Station
	MORUBALD	MORU RAWS Weather Station
	MORUSTAR	MORU RAWS Weather Station
	MORUMIMA	MORU RAWS Weather Station
	MORUSCBP	MORUSEAS iButton Logger
	MORUSEAS	MORUSEAS iButton Logger
	MORULAFF	MORULAFF iButton Logger
	MORUPOND	MORUPOND iButton Logger
Devils Tower National Monument	DETOBEDS	DETO RAWS Weather Station
	DETORAVI	DETO RAWS Weather Station
	DETOSWLO	DETO RAWS Weather Station
Badlands National Park	BADLCLIF	BADLCLIF iButton Logger
	BADLNORB	BADLNORB iButton Logger
	BADLPINN	BADLPINN iButton Logger
Wind Cave National Park	WICANATU	WICANATU iButton Logger

Appendix B. SM4BAT-FS and SonoBat Settings

Tables B1–B2 show the settings for the SM4BAT-FS and the Sonobat 4.4.5, respectively.

Table B1. Detector configuration settings based on NABat recommendations for Wildlife Acoustics SM4BAT-FS acoustic detectors (Reichert et al. 2017).

Parameter	Setting
Gain	12dB
16k High Filter	On
Sample Rate	256kHz
Min Duration	1.5ms
Max Duration	50ms
Min Trigger Freq	16kHz
Trigger Level	12dB
Trigger Window	2s
Max Length	15s
Date / Time	GARMIN GPS 18x OEM
Location	GARMIN GPS 18x OEM
Sunrise / Set Type	Sunset / Sunrise
Delay Start	N/A
LED Indicator	5 Minutes Only
Advanced	N/A
Schedule	Set-30 to Rise+30 OR Continuous

Table B2. SonoBat 4.4.5 Analysis Settings

Analysis Process	Parameter	Setting
Batch File Scrubber	Acceptable call quality	Medium
	Search frequency	5 kHz and above
SonoBatch	Classifier region	Black Hills OR Northeastern WY
	Filter	Autofilter
	Acceptable call quality	0.8
	Sequence decision threshold	0.9
	Max # of calls to consider per file	16

Appendix C. Total Counts by Park

Tables C1–C4 show the total species counts by site in each park.

Table C1. Total species counts by monitoring site at Mount Rushmore National Memorial.

Site Name	Coto	Epfu	Labo	Laci	Lano	Myci	Myev	Mylu	Myth	Myvo	Myse	LoF	HiF	Other
MORUBALD	0	11	0	51	110	1	0	0	0	1	0	129	6	1
MORUSTAR	1	6	0	17	203	15	0	3	2	1	0	310	144	1
MORUMUSE	0	0	0	0	22	2	0	0	0	0	0	13	5	0
MORUSCBP	4	50	1	27	355	54	0	13	1	0	0	656	117	3
MORUMIMA	13	266	11	639	1504	38	0	8	12	0	0	3225	79	11
MORUSEAS	2	11	0	58	135	3	0	0	1	0	0	247	15	1
MORULAFF	0	71	1	92	102	31	1	3	56	0	0	200	72	0
MORUPOND	0	48	4	130	273	66	0	28	6	0	0	412	168	2

Table C2. Total species counts by monitoring site at Badlands National Park.

Site Name	Coto	Epfu	Labo	Laci	Lano	Myci	Myev	Mylu	Myth	Myvo	Myse	LoF	HiF	Other
BADLCLIF	0	9	2	19	56	17	0	2	0	0	0	100	53	0
BADLNORB	4	19	1	7	52	28	0	16	0	0	0	110	61	2
BADLPINN	0	9	0	2	12	13	0	1	0	0	0	64	33	0

Table C3. Total species counts by monitoring site at Devils Tower National Monument.

Site Name	Coto	Epfu	Labo	Laci	Lano	Myci	Myev	Mylu	Myth	Myvo	Myse	LoF	HiF	Other
DETOBEDS	0	0	0	2	3	0	0	1	0	0	0	2	0	0
DETORAVI	0	4	0	0	3	0	0	0	0	0	0	20	1	0
DETOSWLO	0	0	0	0	1	0	0	0	0	0	0	8	0	0

Table C4. Total species counts at Wind Cave National Park.

Site Name	Coto	Epfu	Labo	Laci	Lano	Myci	Myev	Mylu	Myth	Myvo	Myse	LoF	HiF	Other
WICANATU	0	0	0	1	1	0	0	0	0	0	2	3	10	0

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525