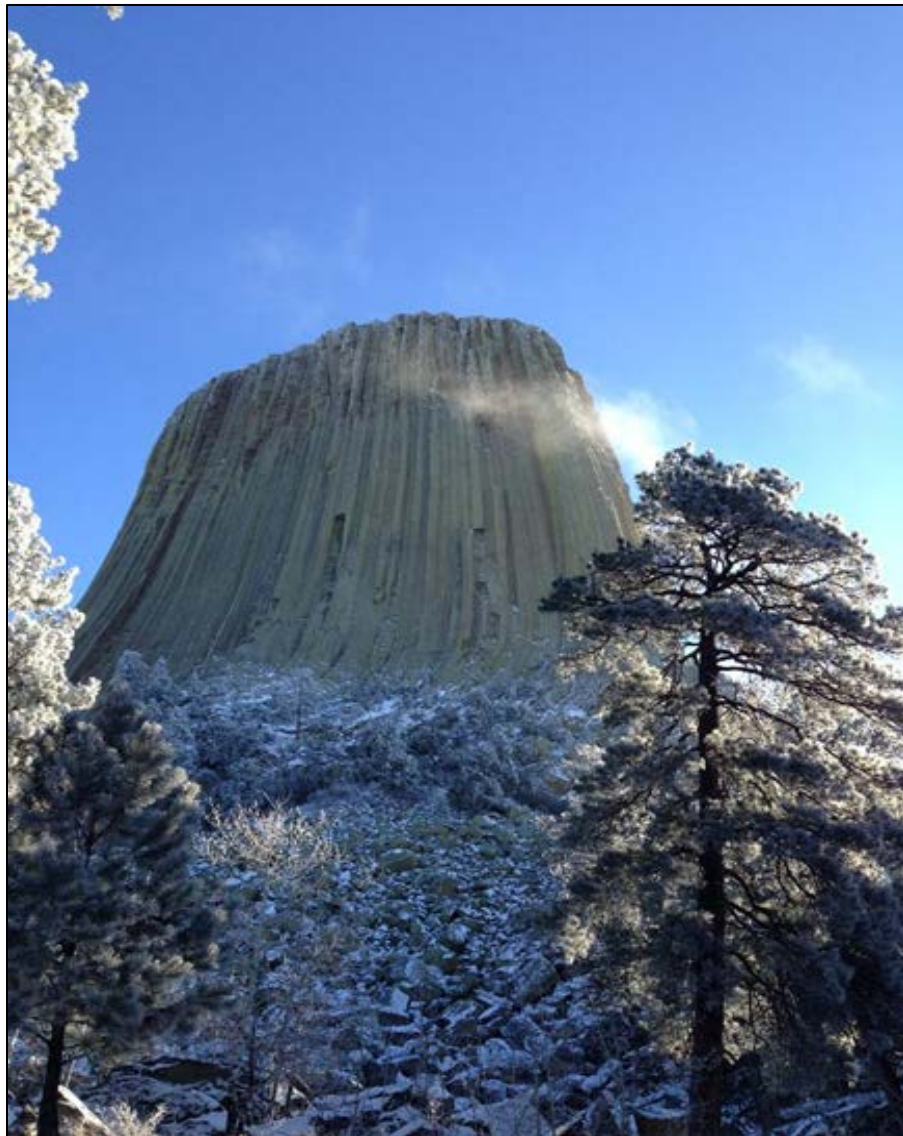




# Winter Bat Activity in a Landscape without Traditional Hibernacula

Natural Resource Report NPS/DETO/NRR—2018/1654



**ON THE COVER**

Winter at Devils Tower

Image credit Ryan Manuel

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# Winter Bat Activity in a Landscape without Traditional Hibernacula

Natural Resource Report NPS/DETO/NRR—2018/1654

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Fort Collins, Colorado

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## Abstract

Prior to 2014, bat research at Devils Tower National Monument (DETO) focused on bats present during the summer months. Biologists at DETO assumed local bats were strictly summer residents due to the presumed lack of typical habitat features associated with bat hibernation, such as caves and mines. This lack of traditional hibernacula features at DETO discouraged staff and research cooperators from studying winter bat populations. Despite the earlier assumption that bats were unlikely to hibernate on the monument, DETO documented significant winter bat activity through passive winter acoustic monitoring. This study is the first study at DETO that documents such activity. Across the northwestern United States, existing research indicates that traditional western hibernacula, such as caves and mines, support small numbers of bats (Hendricks 2012). By contrast, in the Eastern and Midwestern U.S., it is common for some caves and mines to be used by hundreds or even thousands of bats (Tuttle 1991). Where most western bat species overwinter is not well understood or documented. Inspired by both curiosity and the acknowledgement of winter bat activity in the nearby Black Hills Ecosystem, DETO biologists asked a simple question, “Are bats here during the winter, and if they are not, when do they migrate away from the monument?”

The threat of the devastating fungal infestation causing the bat disease known as white-nose syndrome (WNS) looms over every landscape that is currently presumed WNS-free, such as DETO. To better understand winter occupancy and behavior of bats at DETO, we carried out passive acoustic monitoring and emergence surveys. Acoustic detectors were deployed from mid-September 2015 to May 2016. Data from both the fall and spring were included in this report, because those periods are typically associated with important bat life events, such as swarming and mating during fall, and females gathering at maternity sites during spring (Schaik et al. 2015; Frick et al. 2010). Bats call not only to acoustically orient (echolocation), but also in social contexts; bat detectors used for detecting species presence and activity can also record social calls and bursts of activity if they occur in any season (Pflazer and Kusch 2003). Bursts of acoustic activity and social calling at a site can indicate that site is important to overwintering bats. Through this work we sought to determine if bats were present throughout the winter and, if so, characterize what types of activity were ‘typical’ for DETO. Throughout this study, we observed the greatest activity during the fall from September to mid-October, and during spring emergence in mid to late April. Throughout the entire study, we recorded a variety of complex social calls and possible feeding buzzes at varying times during the night. Most of the bat activity occurred shortly after sunset. Some of the activity during the coldest months, December through February, was rather intriguing--we recorded nearly 150 bat passes per site per month, indicating a fair amount of activity. We documented a variety of species during the winter months, identified as November through March, including several species of *Myotis*, as well as *Eptesicus fuscus* and *Lasionycteris noctivagans*. Based on the winter acoustic data, we believe that bats are hibernating in the Tower rock feature and/or the talus boulder field during the winter months.

## Acknowledgments

This research would not be possible without the support and guidance of Rene Ohms, who has spent hours reviewing my documents and data interpretations. Rene was also a key player in acquiring the funds necessary to carry out this project as well as my position. During April 2017, I presented the data in this report to members of the Western Bat Working Group. My attendance would not have been possible without help from the Dixie Pierson Scholarship I received. I would like to thank the Dixie Pierson committee team for being so generous. I would also like to thank Michelle Verant, Julie Reeves, Ian Abernathy, Isabel Ashton, Dan Licht and several individuals associated with the Western Bat Working Group who provided me with advice on weird bat calls and data interpretations. I also want to thank Devils Tower Resource Management volunteers and staff, Tim Demers, Kathleen Callow, Sarah Reynolds, Matt Heinz, Colin Schmidt, Mike Hittle, Daniel Gregorich, Cheyenne Love, Rebecca Martin and Megan Chapman for helping me deploy detectors, data entry, exchange SD cards and sit out in freezing temperatures waiting for bats to fly by. Thank you my peer reviewers, Brendan Moynahan, Paul Cryan, and Jenny Barnett for providing vital insight and support. I will always be grateful for the great people at Devils Tower maintenance who helped me trouble-shoot power problems and structure design.

## List of Terms and Small Glossary

- 1) Species Codes (note that some results have species groupings)
  - a. COTO: *Corynorhinus townsendii*, Townsend's Big-eared Bat
  - b. EPFU: *Eptesicus fuscus*, Big Brown Bat
  - c. LANO: *Lasionycteris noctivagans* Silver-haired Bat
  - d. LACI: *Lasiurus cinereus*, Hoary Bat
  - e. MYCI: *Myotis ciliolabrum*, Western small-footed Myotis
  - f. MYEV: *Myotis evotis*, Western Long-eared Myotis
  - g. MYLU: *Myotis lucifugus*, Little Brown Bat
  - h. MYTH: *Myotis thysanodes*, Fringed Myotis
  - i. MYVO: *Myotis volans*, Hairy-winged Myotis
  - j. MYSE: *Myotis septentrionalis*, Northern long-eared Myotis
  - k. LABO: *Lasiurus borealis*, Eastern Red Bat
  - l. EPFU/LANO: Overlap species ID between two species
  - m. LowF: LACI/LANO overlap of low frequency species
  - n. Myotis40: MYSE, MYCI, MYLU, MYVO overlap ID
  - o. Myotis30: MYEV/MYTH overlap ID
- 2) DETO: Devils Tower National Monument
- 3) RAWS: Remote Automatic Weather Stations, which is a network of automated weather stations ran by federal agencies to observe potential wildfire conditions
- 4) WNS: White-nose syndrome

# Introduction

The history of bat work at Devils Tower (DETO) began with a few mist-netting sessions during the 1990's (Geluso 2017). A few decades later in 2010-2011, the University of Wyoming conducted a summer species inventory (Griscom and Keinath 2011). Recently, from 2014-15, DETO began its first monument-wide acoustic surveys, which continue today. All of the bat work that has been done serves as critical background and baseline data on DETO bat species presence, activity levels, and behavior. After thorough inventories and mist netting sessions, DETO staff and research cooperators confirmed that 11 species of bats occupy the monument, including two species with eastern affinities, *Lasiurus borealis* and the threatened *Myotis septentrionalis*. The results from these studies are critical pieces of information that can help manage white-nose syndrome (WNS) if and when it arrives at DETO.

WNS is a disease in hibernating bats, caused by the invasive fungus *Pseudogymnoascus destructans*. The fungus infects the cold skin of bats during hibernation and the disease is named for the white coloration around the muzzle and other parts of the body where fungal growth on the skin can be particularly noticeable at certain times of year (USGS 2016). This fungus is widely believed to have killed millions of bats. In March 2016, WNS made a 1,300 mile jump from its last known location of eastern Nebraska to Washington (Lorch et al. 2016). This illustrates the unpredictability of the disease's movement and the strong possibility that humans may inadvertently be mediating the transmission of the fungus on their clothing and gear. Recently, Ballman et al. (2017) reported that *P. destructans* persisted on bats during the summer, and therefore that bats assisted in the transmission of infectious fungal particles among cave environments. The WNS fungus is not only transferrable from bats to other bats and nearby cave sites, but also to human clothing and survey equipment. Research conducted prior to this study indicated that the fungus did not spread during the summer, and transmission of the fungus occurred primarily in the winter. This new discovery highlights the need for further research in fungal ecology, transmission, and reevaluation of existing decontamination methods.

The WNS fungus survives and flourishes in traditional hibernacula sites such as in caves and mines, but little is known about how the fungus survives in environments outside of traditional hibernacula sites (Verant et al. 2018). Until recently, DETO staff presumed WNS would minimally impact local bat populations, because there are no caves or mines within the monument. Furthermore, it was long assumed that summer bat populations at DETO migrated to nearby private and public lands to overwinter in caves, mines, or buildings (Griscom and Keinath 2011; Hendricks 2012). Although there are no known caves or mines at DETO, shoulder season or potentially indicative swarming bat activity was recorded during fall acoustic monitoring in 2014. This discovery exposed the need for a more thorough and long-term monitoring effort to learn if bats could be hibernating in rock crevices. In addition to monitoring the winter hibernation months, November to March, we wanted to monitor spring emergence and migration, which we believe occurs in April and May.

Primary objectives of this research were to (1) determine whether bats were consistently present at DETO and utilizing the Tower during the winter, (2) to document species present during winter

months, (3) learn about winter activity and behavior, and (4) determine the activity that occurs prior to hibernation during the fall and spring. Results would directly inform resource managers and assist in better management practices. For example, if the park found acoustic bat activity during the winter, resource managers would need to move forward to identify the hibernacula. Locating hibernacula is critical for management of bat species and is the only means for successful visitor management in hibernacula areas.

## Study Site

All surveyed areas occurred within DETO. DETO is federal land used by outdoor recreationalists that is managed by the Department of Interior, National Park Service. There are a few main habitat types around DETO--rocky boulder field and Tower formation, bottomland, riparian corridor, ponderosa pine/bur oak forests, and open grasslands. The boulder field spans 13 acres and is of an unknown depth. The Tower formation stands 264 m above the landscape, is 1.6 km wide at the base, and tapers at the summit to 61m by 122m. The average precipitation falling around DETO is 43 cm, based on Remote Automatic Weather Stations (RAWS) weather data recorded within the monument.

During 2014, acoustic bat monitoring occurred from July to late October at three locations. The detectors recorded bat echolocation calls through the end of October. This data collection effort prompted the initial investigation into possible overwintering bat species at DETO. We initially documented a few species present during October, including *E. fuscus*, *L. noctivagans*, and species of *Myotis*.

After our initial observations in the fall of 2014, we tried to infer locations where bats may be overwintering within the monument. To aid in the site selection, we conducted emergence surveys during the fall to help us identify bat 'hot spots.' See map of selected sites in Figure 1. From our observations, we deployed winter detectors along the west and south areas of the boulder field.

More specifically, Site 16's natural features included an edge habitat within the western boulder field and Ponderosa Pine/Bur Oak forest. Elevation at this site was 1335m. The other monitoring site, Site 17, was also near the Tower with a similar elevation of 1328m. Site 17 was further away from the Tower than site 16, and was located along a grassy hill. Nearby natural features included a ponderosa pine forest, boulder fields, Tower feature and some sandstone cliffs.

# Devils Tower National Monument 2015-16 Winter Acoustic & Emergence Sites

Intermountain Region  
National Park Service

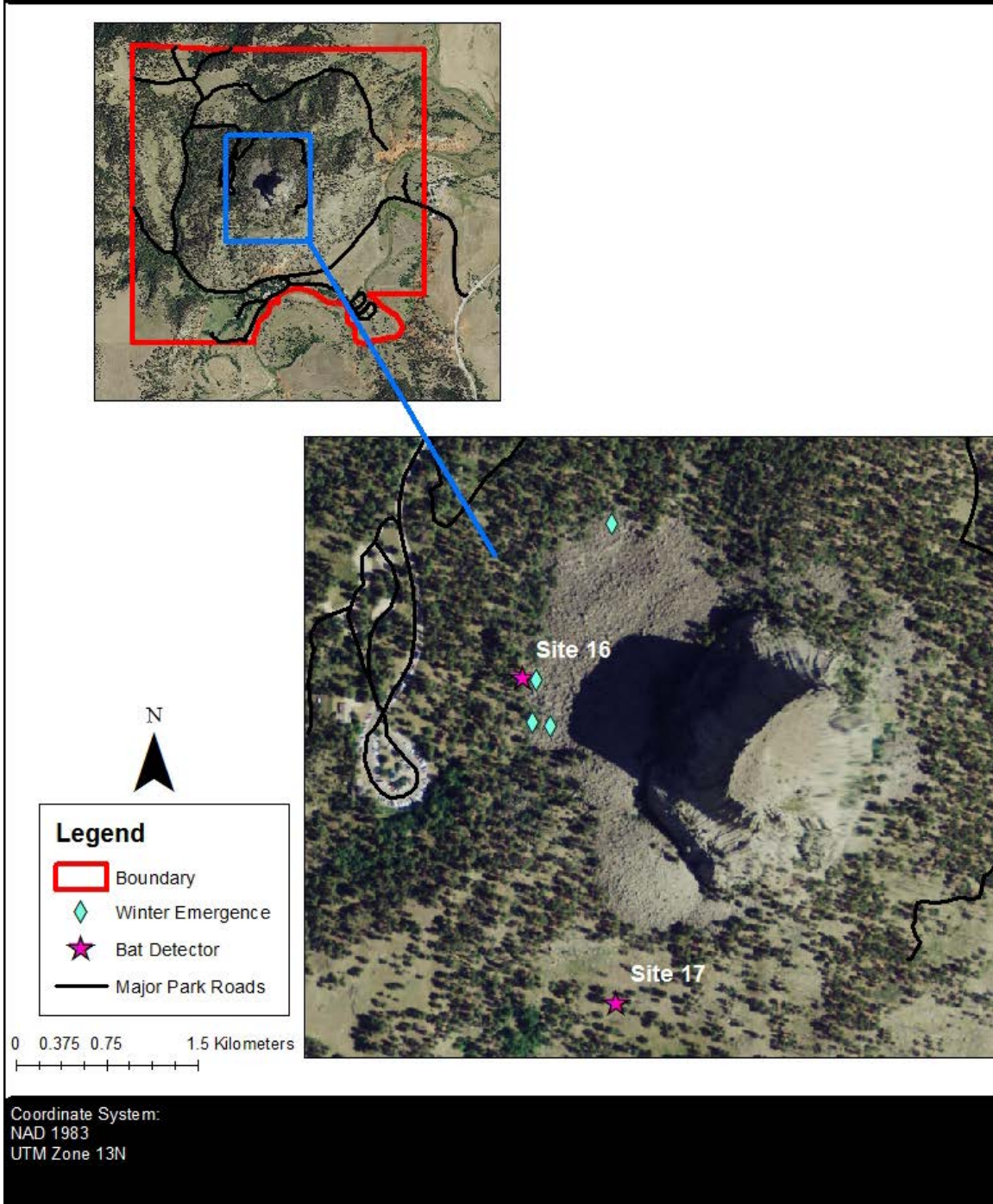


**Figure 1.** Study site for winter bat acoustic and emergence monitoring at Devils Tower, winters of 2015-2016.

## Methods

We used acoustic bat surveys as a non-invasive method to conduct continuous monitoring of bat activity. Passive acoustic detectors minimize the stress a bat may experience from mist netting or through handling, especially during times of year when bats are less active (Kunz and Parsons 2009). Furthermore, the data from acoustic detectors allow insight into varying levels of bat activity over a period of time. One limitation of passive detectors is that they record data without an accompanying observer documenting the number of bats flying by (abundance). To get more coverage of potential bat flight and activity, hand held-detectors operated in real time, assisted in surveying for important bat areas. Such cues can help during the planning process for long-term deployment of acoustic recording devices or monitoring with other research methods.

### Equipment and Software

We used Wildlife Acoustic's *SM3BAT* bat detector for passive monitoring, and Wildlife Acoustic's *EM Touch* and Elekon *Batscanner* detectors for real time, hand-held detector monitoring. Although the *Batscanner* does not record data as the *EM Touch* does, the *Batscanner* provided quick digital readings of frequency detections. For all recorded passive acoustic bat data we used Wildlife Acoustic's SM3-U1 ultrasonic microphones. We recorded full-spectrum bat acoustic data in ".wav" format.

We used 12V deep cycle batteries (Duracell Ultra AGM Power Sport, Duracell, Bethel, CT) equipped with a solar panel (SunWize 40W, SunWize, Philomath, OR) and LVD charge controller (SunSaver 10-L Solar Controller 12V, Morningstar Corp, Newton, PA). Recording units required 32 GB SD cards, spilt-loom tubing, connecting wires for microphones, a 3-meter conduit pipe and rebar for mounting the detector, and Garmin GPS receivers.

The setup for each of the passive detector sites included a 3-m piece of PVC electrical conduit piping with an elbow connector for attaching a microphone. To secure the microphone, we used a combination of wire and screws.



**Figure 2.** Photograph illustrating microphone attachment. Note that this microphone is a newer model than what was used for this study. Prior models had holes at the base that could be screwed into the connector piece.

The conduit pipe that housed the detector had a U-bolt attached to it with a piece of wood where the detector rested. We staged the battery and solar panel next to the detector to secure the unit. We oriented the microphones to face the Tower feature and talus slopes but at an angle so that they did not record echoes from sound bouncing off of the rocks.



**Figure 3.** Example of the acoustic monitoring equipment deployed at DETO.

### Programming Details

Before deploying the equipment in the field, we used the SM3 configurator v. 1.2.6 software to program SD cards before importing programs into the SM3Bat units. This helped reduce any deployment issues.

Using the SM3BAT configurator software, we programmed the latitude and longitude for DETO as well as the current time zone (MST -7 during the summer and MST -6 after observance of daylights saving in the fall). We also imported our detector recording settings into the software program to speed up detector deployment.

The screenshot displays the SM3 configurator software interface with 16 numbered settings. Each setting consists of a button, a dropdown menu, and input fields for two channels (CH 0 and CH 1).

| Setting Number | Setting Name | CH 0            | CH 1            |
|----------------|--------------|-----------------|-----------------|
| 1              | HPF          | 1 kHz           | Off             |
| 2              | GAIN         | Specify 12.0 dB | Automatic       |
| 3              | FS           | WAV Format      | AUTO            |
| 4              | ZC           | OFF             | DIV 8           |
| 5              | FRQMIN       | Specify 8 kHz   | Specify 16 kHz  |
| 6              | FRQMAX       | Specify 192 kHz | Specify 192 kHz |
| 7              | DMIN         | Specify 1.5 ms  | Specify 1.5 ms  |
| 8              | DMAX         | Off             | Off             |
| 9              | TRGLVL       | Specify 12 dB   | Automatic       |
| 10             | TRGWIN       | 3.0 s           | 3.0 s           |
| 11             | TRGMAX       | Specify 10.0 s  | Specify 15.0 s  |
| 12             | REPEAT       |                 |                 |
| 13             | AT SSET      | - 00 : 00 : 30  |                 |
| 14             | REPEAT       |                 |                 |
| 15             | RECORD       | 01 : 00 : 00    |                 |
| 16             | UNTCOUNT     | Forever         |                 |

**Figure 4.** Description of the acoustic monitoring program used during the winter study at DETO as programmed from the Wildlife Acoustic's SM3 Configurator software. The specific recording settings complied with current setting standards of the equipment used during the time of deployment.

In addition to considering the specific setting needs for the winter bat acoustic monitoring project, DETO staff complied with NABAT survey standards throughout the planning process. With the recently released NABAT plan, the sites selected for the 2015 winter study, known as site numbers

16 and 17, will be renamed in the future to Site 16- DETO\_522364, and Site 17- DETO\_522453 to remain consistent with the naming methods used at DETO in our bat monitoring protocol.

We placed detectors along the boulder field that spans across the western and southwestern sides of the Tower. We believe that bats could potentially roost in any of the deep cracks and crevices within the Tower and boulder field. Other non-traditional hibernacula with similar characteristics have been located by radio tracking bats during fall and winter in other parts of the world such, as in Norway (Michaelsen et al. 2013), Colorado (Neubaum et al. 2006), and Alaska (Blejwas 2016).

We selected the location of Site 16 as part of this study because a few bats were observed flying in this area during an emergence survey prior to the detector deployment. There are also large, prominent boulders in this area.

We selected Site 17 because we assumed that the southern side of the Tower may be more active with bats than other sides due to greater solar exposure. We also wanted to include a site that was some distance from the Tower proper, to discover if bats fly outward from the boulder field. During additional emergence surveys in other cardinal directions out from the Tower (i.e., north and east), we did not observe many bats, so these areas were not considered. We deployed detectors at both selected sites, 16 and 17, September 16, 2015 through April 30, 2016 to provide breadth and coverage during our survey effort.



**Figure 5.** The views looking southwest (left) and south (right) of Site 16.



**Figure 6.** The views looking south (left) and north (right) of Site 17.

### ***Acoustic Bat Processing and Data Analysis Methods***

A trained wildlife technician analyzed acoustic data using Sonobat MT Plains v. 3.2.1. Resulting species identifications were based solely on acoustic analysis, and definitive confirmation of species presence requires mist net captures to supplement acoustic surveys (Adams 2013). The acoustic analysis results of this project include groupings of a couple of species for several of the recorded calls. Species groupings occur for a variety of reasons. First, the call sequence may duplicate other similar frequency ranged species, making it difficult to accurately and confidently identify a call sequence to a species. Secondly, the call sequence may show characterizations of a feeding, social or approach call which can distort the typical characteristics of a species, and cause the call to look like a wider range of species (Murray et al. 2001). Thirdly, environmental or recording conditions may further obscure the quality of a call, and thus reduce the confidence of species identification. Inversions, precipitation, and surface echoes may all contribute to the distortion (Pettersson 2002; Stilz and Schnitzler 2012). EPFU/LANO identification groupings result because the two species often echolocate with similar call parameters. Diagnostic features that separate the two species include long, flat echolocations of LANO, and pulses above 65 kHz for EPFU (Szewczak et al. 2011a, 2011b). Other species groupings in this report, such as *Myotis*40 include similar species such as MYSE, MYCI, MYLU, and MYVO. *Myotis*30 species also sometimes overlap in their characteristics, mostly due to environmental or recording situations. These species of 30 kHz *Myotis* include MYTH and MYEV. Lastly, some recorded calls of lower frequency bats aren't identifiable

due to the noise or other quality limitations in the call, but it is clear to the analyzer that the call is from a low frequency bat. We labeled these parameters as LowF.

### ***Passive Acoustic Data***

We scrubbed all passive acoustic data through the Sonobat Batch Scrubber 5.4 with settings at medium, to include signals from 5-20 kHz. Proceeding scrubbing, each data file attributed to the site name, UTM, datum, microphone type and orientation, detector deployment details, personnel involved, dates recorded, equipment and firmware used, dates deployed, and power source. We ‘sonobatched’ the data with Sonobat MT Plains 3.2.1 and applied the following settings: 10 calls to consider per file, .80 acceptable call quality, .20 bat pass tallying, and .90 decision threshold to classify the bat calls. All species identifications went through the process of using Sonobat’s auto-classification followed by hand-vetted using guidance from the *Eastern and Western Echolocation Call Characteristics* key produced by Humboldt State University Bat Lab (Szewczak et al. 2011a, 2011b). The classification of a bat pass included calls >2ms in this study.

### ***Hand-held Detector Acoustic Data***

We scrubbed all raw data using Sonobat Batch Scrubber 5.4 with settings at medium, to include signals from 5-20 kHz. We decided not to attribute the data after scrubbing, due to the few recorded files. However, we attributed the data on April 4, 2016 because we recorded several bat calls. For those files, the Sonobat SM2 Attributer attributed the bat calls and appended the following information to each file name: Site name, trail name and length or UTM, moon cycle, minimum temperature for the night, personnel, dates recorded, equipment and firmware used, and habitat type. Afterwards, we ‘sonobatched’ the data with Sonobat MT Plains 3.2.1 with the following settings: 10 calls to consider per file, .80 acceptable call quality, .20 bat pass tallying, .90 decision threshold to classify the bat calls. Guidance towards identified species occurred through Sonobat’s auto-classification and then hand-vetted species confirmations through the *Eastern and Western Echolocation Call Characteristics* key produced by Humboldt State University Bat Lab (Szewczak et al. 2011a, 2011b). The designation and characterization of a bat pass in this study included calls >2 ms (Vonhof 2006).

### ***Hand-held Detectors and Emergence***

During new moon and warmer days during the winter, we completed four emergence surveys (2/9, 2/10, 3/10 and 4/4 of 2016). We presumed that by selecting the darkest and warmest nights we would increase the probability of observing a bat in flight, since the areas around the Tower are fairly open and leave a bat vulnerable to predation.

Most emergence surveys occurred along the southwestern edge of the boulder fields. Survey locations include those found in Figure 1. Surveyors sat in these locations approximately 30 minutes before sunset and scanned the area until an hour after sunset. We visually scanned the sky for bats and used night vision binoculars and infrared cameras to aid in seeing bats as the sky became darker.

During emergence surveys, we sat out after sunset at locations near the bat detectors, in hopes of seeing a bat in flight. Not only did we want to document and confirm and winter flight, but we also wanted to count the number of bats we observed flying, and from what location. Equipment used for

these surveys included binoculars (Nikon Monarch 10x 42, Nikon, Melville, NY), active bat detectors, night vision binoculars (ANVIS AN/ANS model, Department of Defense Military Surplus, USA), and thermal cameras (FLIR TS model 19 mm lens, FLIR, Goleta, CA and 'Close Combat Thermal Targeting sight' by Raytheon, Waltham, MA).

### **Weather Data Collection**

We obtained weather data from a RAWS weather station located within the monument property, but it is 155 meters lower in elevation than the study sites. The RAWS weather station collected a variety of hourly weather data, but we used only the data for temperature. For this report, we averaged the temperature for each hour from sunset to sunrise to represent a single temperature reading for a night. We averaged these daily temperatures for each month to portray the average temperature observed in a month.

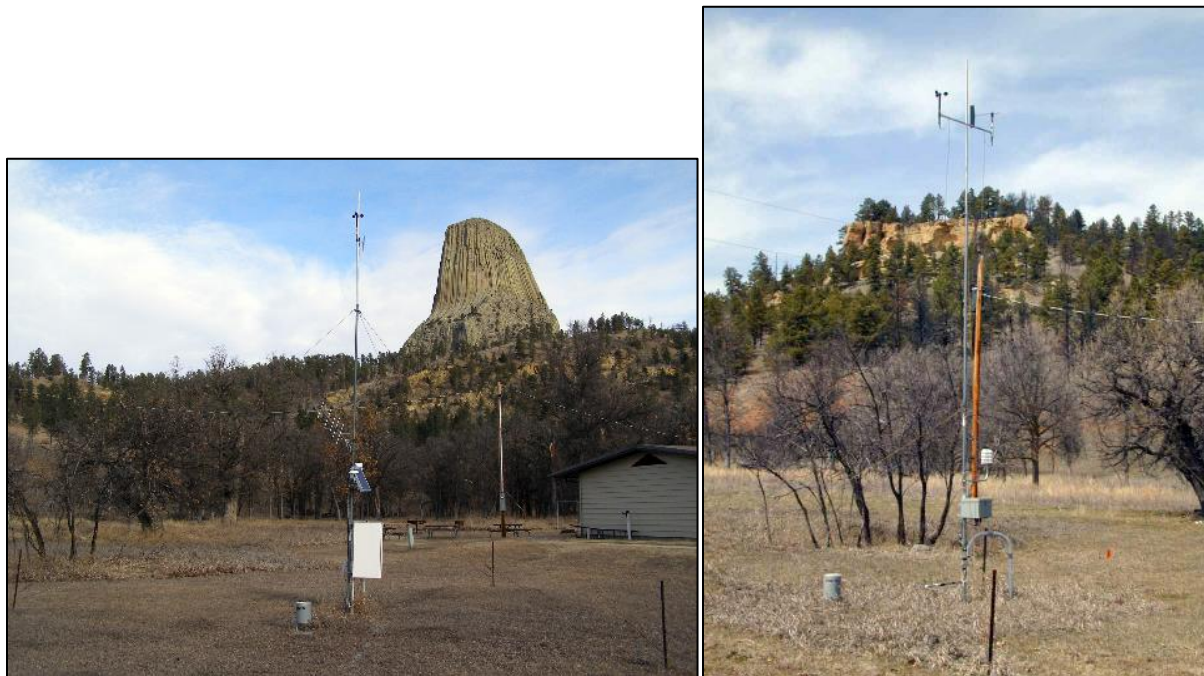


**Figure 7.** Location of the RAWS weather station looking north (left) and west (right).

## Results

### Weather Data

This project was originally designed to include weather data from a RAWS weather station to evaluate trends between species activity and temperature. At the time of the project, there did not seem to be any issues utilizing the available data until the monitoring project continued into year two during 2016-2017. High variability in temperature trends among sampling sites in the weather data became apparent when newly used on-site temperature loggers highlighted clear differences. After a few months of weather collection in 2016, we compared the new temperature logger data with the RAWS weather data and the variability among sites we assumed would be similar was very striking (Figure 8, page 14).

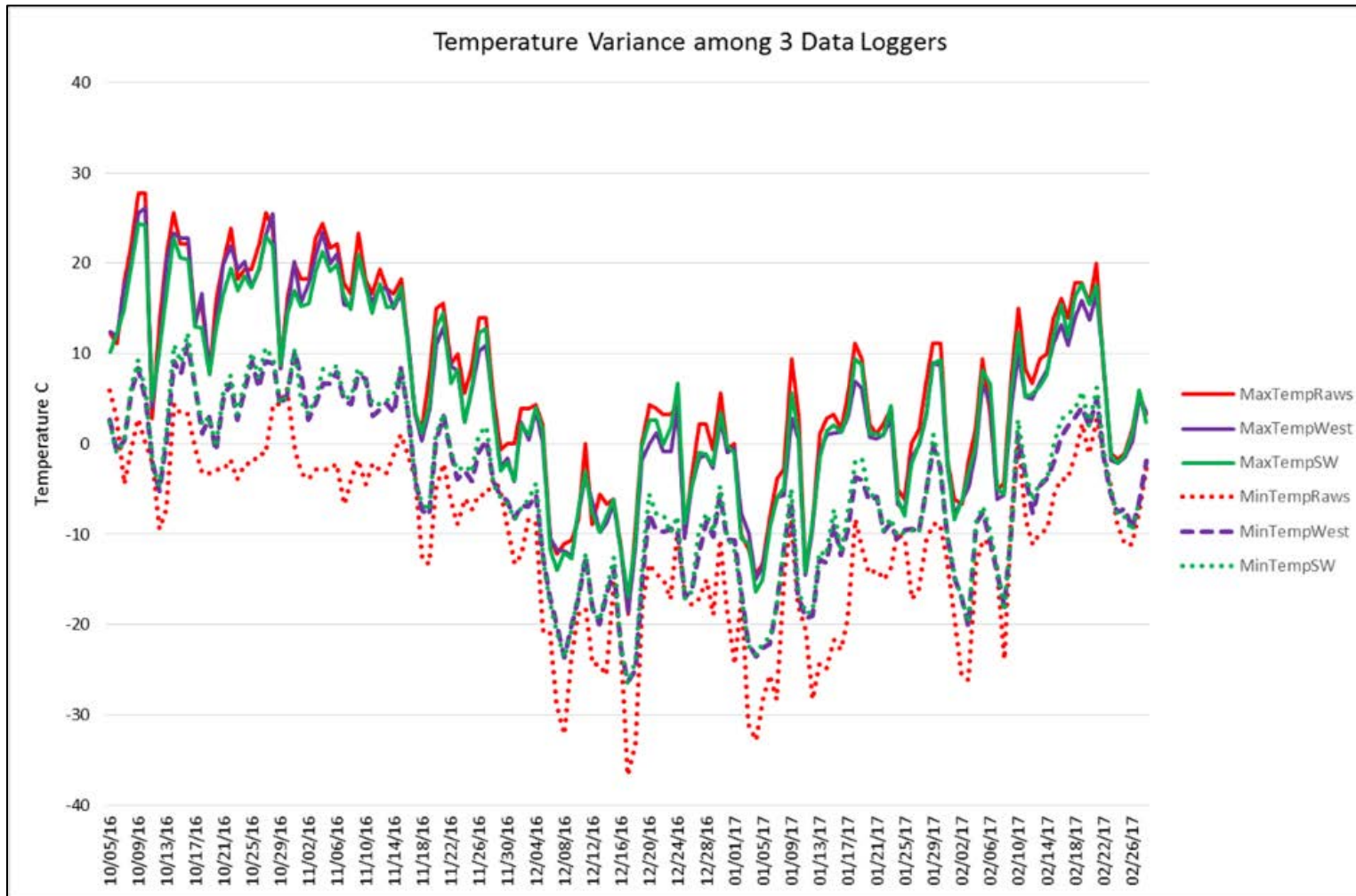


**Figure 8.** Weather data comparisons of the minimum and maximum temperatures from three data loggers, including the RAWs weather station, site named “TempRaw”, and two HOBO Pro-V data loggers, named “TempSW,” and “TempWest,” that were located on the west and southwestern detector sites.

## Acoustic Data and Equipment

We recorded over 7,000 bat passes over the six-month sampling period. Throughout this period, the bat detector at Site 16 periodically lost power. The dates of power loss at Site 16 included 12/15/2015-12/18/2015; 12/29/2015-1/3/2016; 1/14/2016-2/2/2016; 3/2/2016-3/8/2016; and 4/25/2016-4/28/2016. Site 17 proved to be a reliable site and experienced no loss in power. Site 16's primary cause of power failure included inadequate sunlight for charging the solar panel.

Despite the loss of power at Site 16, the site still recorded more bat passes than at Site 17. During the pre-hibernation swarming and spring emergence periods, in September, October and April, Site 16 recorded significantly more bat passes than at Site 17. However Site 17 recorded more bat passes during December and January. We observed less bat activity during periods with colder temperatures at both sites.

During winter (November-March), we recorded a total of 762 total bat passes between the two sites. Although the monthly species counts differed between the two sites, both sites recorded a total of 381 bat passes each from November to March.

Out of the 381 bat passes recorded during winter at site 16, 70% of the species recorded were classified as EPFU/LANO, followed by 23% LANO, 5% Myotis40, and at or below 1 % were MYCI, EPFU, and LOWF. Actual totals for these recorded calls included: 20 Myotis40, 1 LowF, 86 LANO, 4 EPFU, 268 EPFU/LANO, and 2 MYCI.

Out of total 381 bat passes recorded during winter at site 17, 55% of the species recorded were classified as EPFU/LANO, followed by 35% LANO, 9% Myotis40 and at or below 1% were LOWF, MYCI, and COTO. Actual total recorded calls included: 36 Myotis40, 1 LowF, 133 LANO, 209 EPFU/LANO, and 1 MYCI.

The most active bat species in flight November through March was EPFU/LANO, followed by LANO. Bat activity for all species declined shortly after sunset, but activity remained variable throughout the night.

Peak bat activity for each month occurred shortly after sunset (Figure 12). We found that a few months had variable activity patterns. Calls recorded during February, November, and December all showed a second peak of activity later in the night.

We recorded higher levels of sunset activity in some months compared to other hours of the night. In September, both sites recorded 49% of bat passes around sunset. Additional months had similar results, such as 43% of the activity occurring after sunset in October. Acoustic data from the remaining months suggested less than half of the bat activity occurred after sunset. Several of these observations interestingly coincided with the coldest months, 13% in November, 23% in December, 20% in January, 21% in February, 33% in March, and 32% in April.

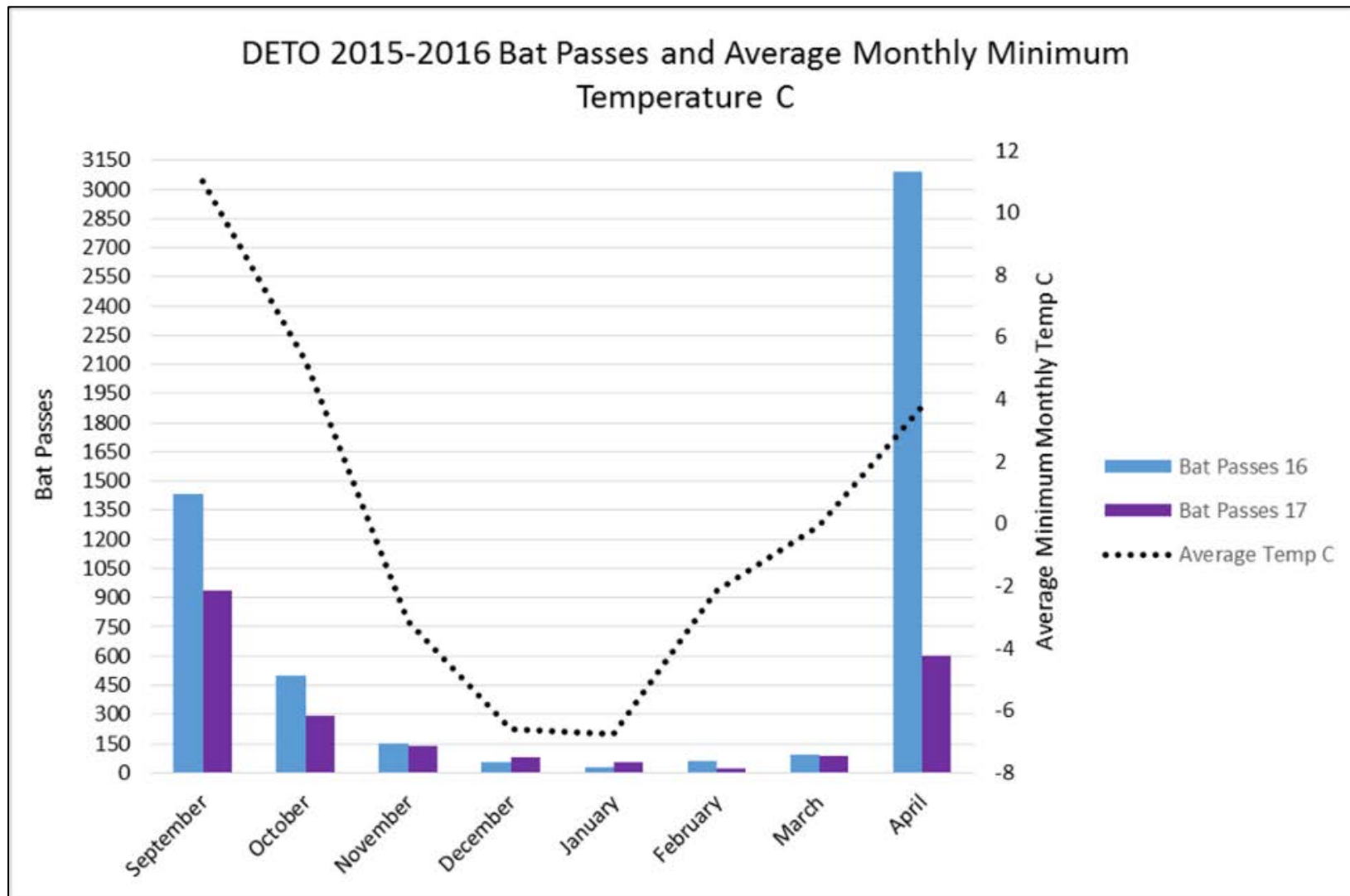


**Figure 9.** Chart illustrating the number of detected bat passes per month per site (bars, left y-axis) and mean minimum monthly temperature (dotted line, right y-axis).

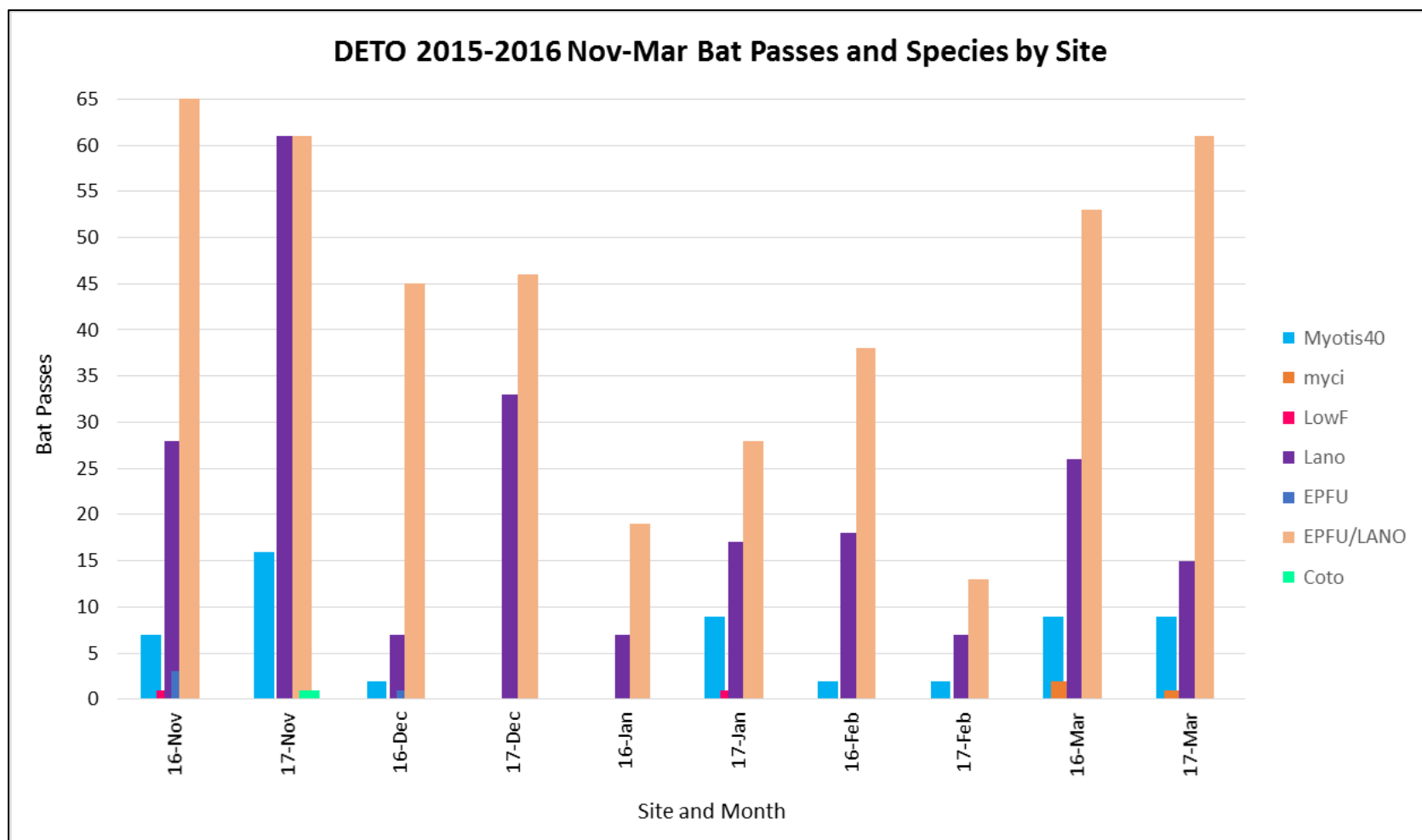


**Figure 10.** Breakdown of the total number of bat passes recorded each month per site during the winter period, November through March.

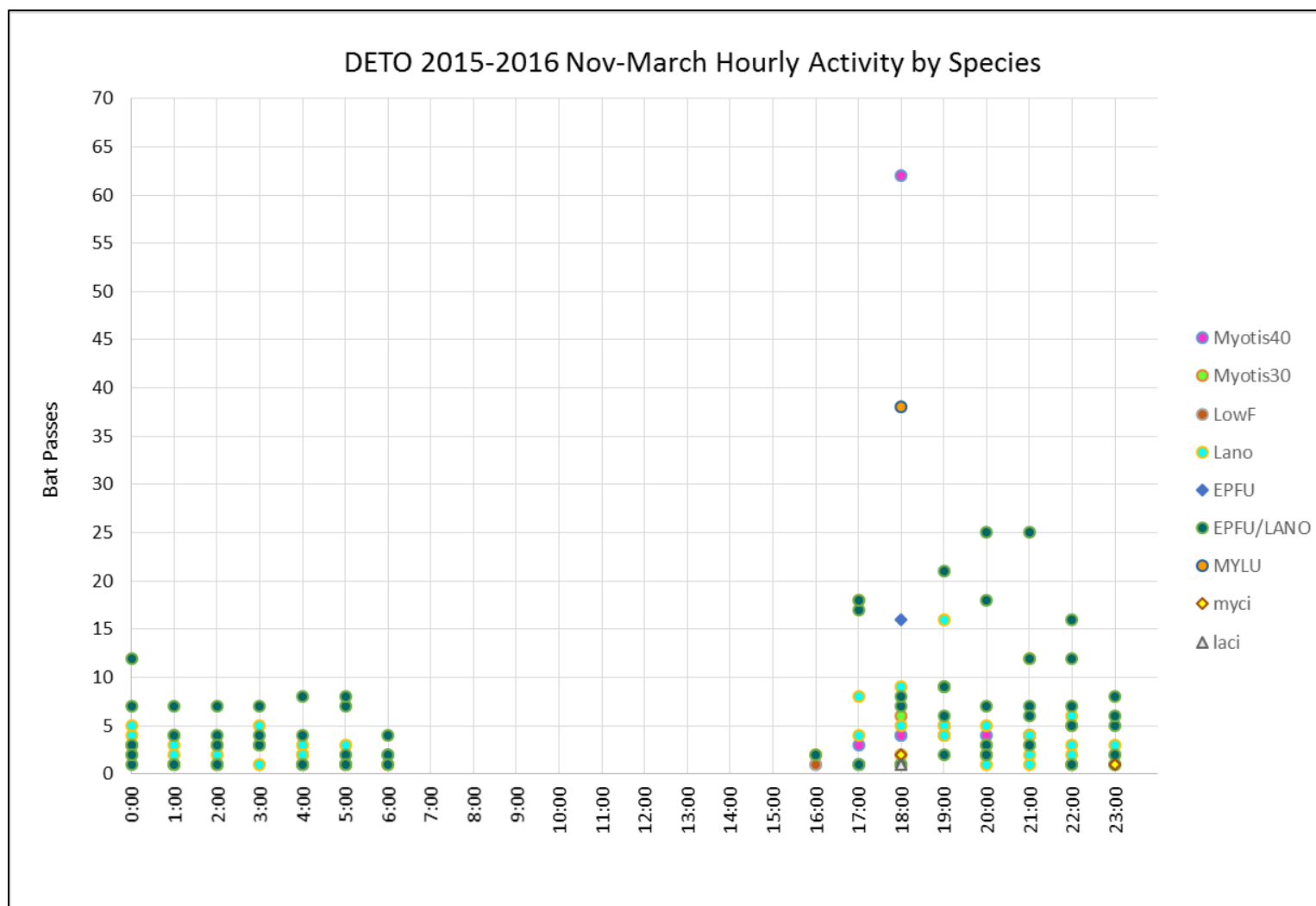


**Figure 11.** Hour of day when each bat species was recorded during acoustic sampling efforts from November through March. Each dot represents the sum of the bat passes recorded for the cumulative monthly hours for each species. For example, at 0:00, EPFU/LANOs were recorded at 0:00 for the months of November through March, equaling 5 dots.

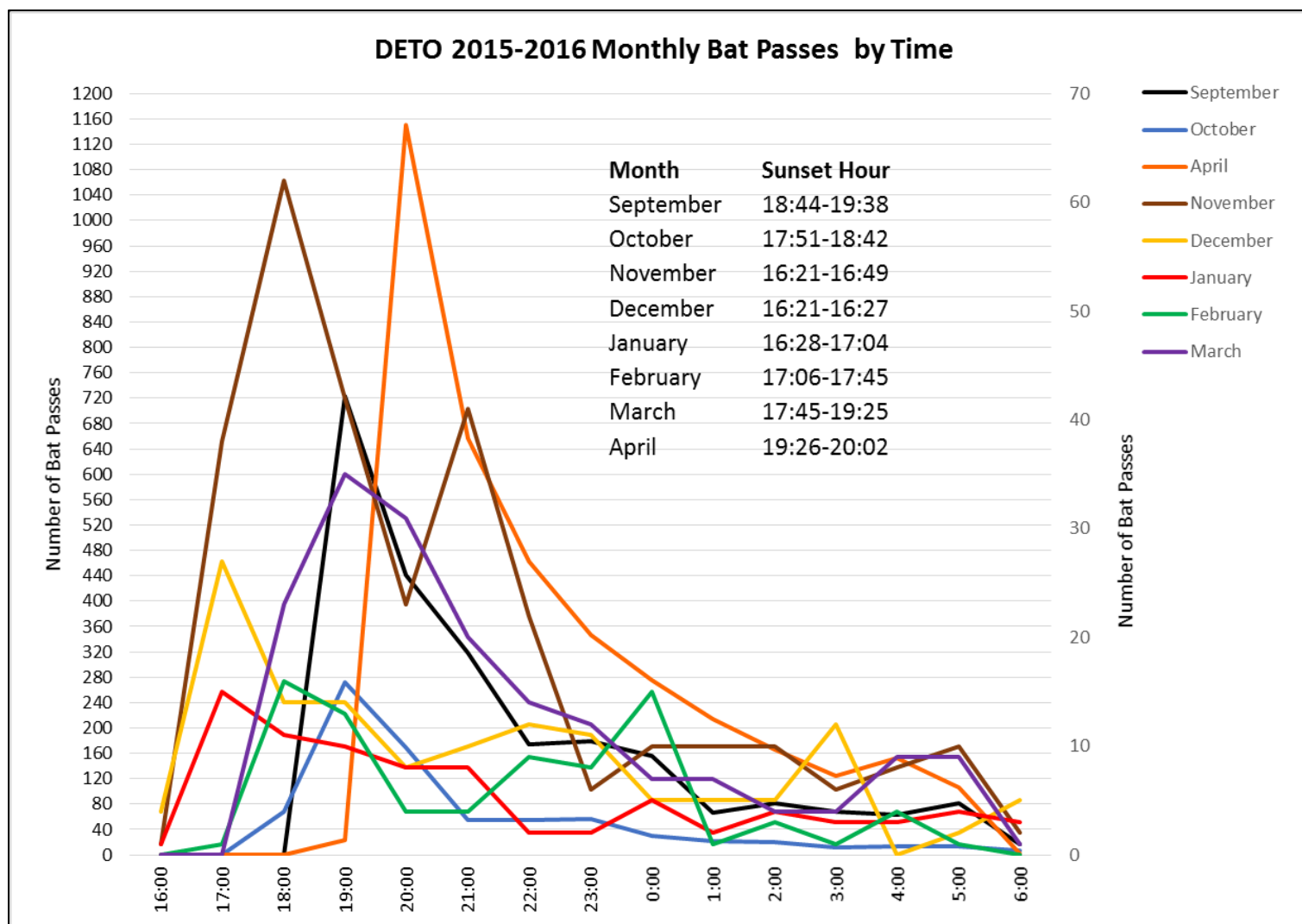


**Figure 12.** Each line on the chart above correlates to the monthly tally of bat passes recorded per hour for the combined sites.

## Emergence Surveys and Active Detector Use

During emergence surveys, we did not observe any bats flying, although we did hear and record bat calls on hand-held bat detectors. Unfortunately, the quality of the EMTouch recordings did not allow us to accurately identify and therefore confirm species based on call characteristics. The frequencies recorded included 26-kHz species during February, and several 26-kHz, *Myotis30*, and *Myotis40* species during April. We observed several bats flying around the boulder field in April.

**Table 1.** Results from emergence surveys

| Emergence Survey Date | Sunset Time | Time Bat Observed | Temperature C, Survey Start/End | Relative Humidity %, Survey Start/End | Precipitation Survey Start/End | Survey Wind speed (mph) Start/End |
|-----------------------|-------------|-------------------|---------------------------------|---------------------------------------|--------------------------------|-----------------------------------|
| 2/9/2016              | 17:18       | 18:17             | 9 / 7                           | 37 / 47                               | None                           | 2 / 2                             |
| 2/10/2016             | 17:19       | 17:57             | 10 / 8                          | 29 / 29                               | None                           | 4 / 4-6                           |
| 3/10/2016             | 17:54       | None observed     | 9 / 7                           | 21 / 26                               | None                           | 1 / 1                             |
| 4/4/2016              | 19:29       | 19:57             | 19 / 16                         | 22 / 25                               | None                           | 2 / 1.4                           |

# Discussion

## Equipment and Weather

The winter weather around Devils Tower proved to be a challenging environment to record bat data. Something we did not anticipate included the discovery of high micro-climate variability around the Tower feature, most likely due to the rocks absorbing and retaining heat. From the Figure 8 weather data, we can infer that the RAWS weather station experienced colder temperatures at night. At the detector sites, data loggers showed that similar temperatures persisted during the day as the RAWS, but nightly temperatures stayed warmer at the detector sites than at the RAWS location. Due to this extreme temperature variability in the available weather data, we concluded that using hourly temperature readings from the RAWS weather station might not be an accurate predictor of bat flight at other areas around DETO and that monthly average temperatures might be more helpful for interpreting the data.

The power loss at Site 16 continued throughout the winter and caused constant frustration. Missing periods of data during a study is a significant loss to a biologist. The solar panel's angle, surrounding topography, and limited daylight hindered the detector's power supply. To eliminate some of the challenges with the solar panel, we decided to directly connect external batteries to the detector. Unfortunately, the small 12V batteries did not perform well during extremely cold weather. Staff were not available to keep up with the battery exchanges that were needed to keep the detector functioning. Unlike Site 16, the ample sunlight at Site 17 was sufficient for reliably keeping the battery charged and the detector running. The frequent power issues with Site 16 led us to relocate the site a few meters away from the original recording location during the winter of 2016-2017 to ensure consistent recording periods within a similar recording environment to the prior year. The relocation to a more open area allowed solar power generation to keep the detector running.

Snow presented additional challenges with detector performance, piling on top of the solar panels and limiting the panel's ability to charge the detector. Therefore, we required staff to brush off snow after weather events. Similarly, the microphones from Wildlife Acoustics did not perform well in cold and snowy conditions. Over the course of the survey, we noticed a decline in the performance and sensitivity of the microphones. We believe that the microphones did not stand up to harsh winter conditions. Individuals interested in repeating this study need to have extra microphones available and to frequently inspect microphones and recording quality.

## Emergence Surveys

We learned that the visual surveys we carried out were an unreliable means to locate bats emerging from the boulder field or the Tower. The scope and size of the Tower and boulder field made it difficult for surveyors to locate bats. The sample size used for the survey counts was small and therefore, no real meaningful trends could be inferred from these surveys. Rather, the emergence surveys can be helpful in identifying flyways that are helpful when determining suitable mist netting areas.

## Acoustic Analysis and Non-traditional Hibernacula

The overarching result from this study is that we consistently recorded bat activity around the Tower feature during the winter, and shortly after sunset at a location without caves or mines. During the study, we recorded well over 7,000 bat passes in files requiring 65 GB of storage. We did not anticipate collecting so much data.

We also recorded bats emerging shortly after sunset. It is known that sunset time influences bat activity. Bats often have two peaks of activity, one at dusk and one near dawn (Fenton and Simmons 2014). The data collected at DETO supports this behavioral observation due to the number of recordings made by remote detectors that were within an hour after sunset, as well as calls recorded using other survey methods.

Although most bat calls were recorded shortly after sunset, bat activity sometimes continued late into the night. Reasons for winter bat flight remains a mystery. Many variables may drive a bat to arouse during the winter. Some bats fly to excrete bodily wastes outside their hibernacula (Baumber et al. 1971). Another speculation is that bats may fly to find water. The drier climate in the west may drive the bats as those found at DETO to take flight to find water (Ben-Hamo and Muñoz-Garcia 2013). A study from Burton and Reichman (1999), hypothesized that bats may alter the timing of torpor to prevent disease. Bats may arouse during warmer winter nights to seek and consume insects (Avery 1985). Some species of bats may opportunistically mate through the winter, as some studies confirmed presence of sperm in both males and females (Crichton and Krutzsch 2000). A recent study by Klüg-Baerwald et al. (2016) discovered that some species arouse during the winter due to changes in barometric pressure, wind speeds, and temperature as a means to conserve energy. All of these are interesting possibilities for DETO to explore as a possible driver of winter bat flight.

Some biologists interpret winter bat flight incorrectly and associate winter activity as a clear sign of WNS. WNS cannot be confirmed solely by winter flight activity. A more valid indicator that may suggest WNS presence is observing bats flying during the daytime in freezing temperatures, or clustering near hibernacula entrances (USGS 2016). However, the only sound method to test for WNS is through diagnosis of appropriate tissue samples for the presence and/or characteristic lesions caused by *P. destructans* at a qualified laboratory.

The winter flight activity proposed a significant challenge to this study, as well as to other studies that seek to identify non-traditional hibernacula, is specifying the point at which we declare a species a winter resident. It is also difficult to label the timing of primary bat activity periods at DETO—swarming, spring emergence, and migration in an area outside of a predictable cave environment. We based our identification of seasons based on activity recorded in the years following this data, since the trends in activity were similar.

The data gathered during the months of September, October, and April indicated high levels of activity as well as species diversity (Figure 9), details that can be difficult to tease out from migration activity, fall swarming, and spring emergence events. We do feel that during these months hibernation is unlikely, and thus we did not include them as winter months. We observed that these months also experienced favorable weather patterns and therefore we questioned the timing of

migration verses simply favorable weather conditions for bats to be out foraging for insects. During the remaining months, consequentially the coldest months, bat activity remained fairly constant, and thus suggest that most bats are in torpor and emerging for brief moments during this period.

One benefit of utilizing more than one acoustic monitoring site is that it allowed us to compare species detections between sites. If a species was detected at both sites, it increased our confidence that the species could be a winter resident. It is important to note the variance of species activity and occurrence between our sites throughout the winter. During December, there were more species recorded at Site 16 than at Site 17, and more species recorded at Site 17 in January than at Site 16. The data indicates variability among sites by bats throughout the survey period, but do not inform us as to why this was the case. Interestingly, acoustic activity of some species declined throughout the survey period, such as EPFU/LANO, and other species were inconsistently recorded, such as the LANO and *Myotis*40 groups.

Results from this study need to be interpreted as suggested species presences. Confirmation of species are best validated through mist-netting, since there is overlap among many species in call characteristics used to identify them through acoustic analysis (Adams 2013). The results in this report are presented with this important caveat. There is significant overlap between the call characteristics LANO and EPFU, as well as the species of *Myotis*. Although there were no recordings of other, low frequency species, such as COTO, during the winter we recorded some COTO calls in November and in April, suggesting the species may also reside at DETO over the winter.

The detection of LANO at DETO during the winter is intriguing. We interpret the LANO species identification due to several recordings of flat  $\geq 25$  kHz calls with little or no slope. The duration of these calls were fairly long, between 9-12 ms. Although poorly understood, a few cases at other northern locations in the U.S. documented LANO presence during the winter. A study in Washington documented LANO foraging during the winter (Falxa 2007). In Yellowstone National Park, Johnson et al. (2017) tracked radio-tagged LANO during the autumn to rock crevices, and acoustically recorded them throughout the winter. Other examples in the U.S. include a LANO roosting in a farm house in Michigan on January 23, 1977 (Gosling 1977). In British Columbia, there are a few records of LANO occupying the area during the winter. Most of the observed bats roosted in trees during the winter, but one roosted in a mine (Nagorsen et al. 1993). Other research in Canada documented LANOs either acoustically or located them under bark, rock crevices, and/or mines (Lausen and Hill 2012).

We also documented a few other species than LANO overwintering at DETO. Although there were only a few confirmed EPFU recordings throughout the winter, we believe that it is likely that the species is present during the winter. Several acoustic calls had characteristics consistent with those of EPFU, but the calls did not reach the diagnostic high frequency range of at least 65 kHz that separates the species from LANO in identification algorithms (Szewczak et al. 2011a, 2011b). The *Myotis*40 identified species experienced a lot of overlap between MYLU, MYVO, and MYCI. The environment around the detector sites may play a role in making these calls difficult to differentiate among species by altering the echolocation's characteristics. During the winter, we recorded so few calls from species of *Myotis* that the quality of the available recordings were not sufficient to

confidently confirm to species. Of the calls that were analyzed, interpretations suggested the echolocation calls were made by MYLU and MYCI. The best solution for DETO might be to confirm our preliminary species-presence interpretations through mist netting in March or late November. Those months seem to be the best time to capture winter residents, based on acoustic data. A radio-telemetry project will be initiated to determine winter hibernacula areas and document species presences during 2018-2019.

As previously mentioned, non-traditional hibernacula types like rock crevices are not well understood, especially in the western U.S. Not only is there poor documentation of non-traditional hibernacula types, but there are few observed cases of large colonies of hibernating bats in the western U.S. It is not known where the bulk of western bats overwinter, since few gather in caves and mines. An example that highlights this data gap and the value of locating hibernacula is in Montana. Data from Montana hibernacula surveys indicate that most bats overwintering in Montana are found in groups of 25 or fewer bats (Hendricks 2012).

Throughout the western U.S., researchers and biologists are slowly embracing the idea that hibernacula can occur outside of caves and mines. In Alaska, a radio-telemetry project focused on overwintering MYLU discovered the bats roosting in unusual places—root wads and rock crevices. During the winter, the bat-selected sites proved to be suitable and stable environments for hibernation (Blejwas 2016). Acoustic studies in Nebraska demonstrated that both EPFU and MYSE used limestone and shale cliff faces during the winter (Lemen et al. 2016). During a bat radio-telemetry project in Yellowstone National Park that lasted from August through October over several years, results indicated that the tracked bats remained 3 km from where they were originally tagged, and located in rock crevices (Johnson et al. 2017). Presently, Yellowstone does not know if it has suitable cave environments, but they believe that cliff faces and rocky slopes are possible locations for suitable hibernacula (Johnson et al. 2017). In Norway, radio-tagged bats roosted in rock talus and cliff faces during the winter months (Michaelsen et al. 2013). In Dinosaur Provincial Park in Alberta, Canada, Lausen and Barclay (2006) recorded winter bat calls around the area and also tracked radio-tagged bats to badland-like formations, a feature similar to those found at DETO. Finally, in Colorado, radio-tagged EPFU spent the fall in high-elevation rock talus crevices, alluding to the possibility of an overwintering location (Neubaum et al. 2006). All of these examples support the argument that DETO could have multiple types of hibernacula in a variety of rock crevices—badland-like formations, sandstone cliffs, boulder fields, and large cliff faces.

Other National Parks and public lands across the country may host undocumented hibernacula and may benefit from learning about the DETO experience in this study. Land managers should think outside of the box with bats. There is a gap in understanding where bats hibernate other than in caves or mines in The West. Deploying winter bat detectors is an excellent, non-invasive method for land managers to explore if bats are active in their area. Another critical question is how, and if, *P. destructans* persists in non-traditional hibernacula. It is unknown how *P. destructans* survives outside of caves and mines, and rock crevice micro-climate and environmental conditions are not well understood. When this gap is filled, the knowledge can help develop and implement the best

management practices for bats while balancing the threats of WNS, public recreation, and preserving bat populations.

## Recommendations

Some winter bat research methods are more effective than others. For example, supplementing acoustic monitoring with emergence surveys is not a reliable method to locate a bat emerging from its habitat during winter, unless the landscape is small or bats are known to be within the immediate monitoring area. If emergence surveys continue in the future at DETO, there are some equipment considerations that should be implemented. From a surveyor's perspective, night vision binoculars were the most useful piece of equipment because the heat from the rocks did not obscure the output imagery as the thermal camera did. Only the Tower feature negatively affected the image output from the thermal camera. This did in turn in effect the ability to scan the Tower to see if bats were emerging from it. Unlike the Tower, the boulder field's shape and definition remained visible when viewing with a thermal camera. A night-vision helmet-mounted binocular or monocular would be ideal for emergence surveys, since the night time enhancement features could be indefinitely engaged, thereby enabling continuous surveillance. Finally, a simple suggestion is to commence the survey as soon as the light contrast in the sky disappears. If biologists want to be thorough in their surveys, a high-resolution and/or high-magnification recording thermal camera or night vision camera on a tripod may be the best option for surveying large landscapes.

Another method utilized in the preceding winter of this study that proved useful was deploying temperature loggers with acoustic detectors. Such loggers may provide insight to help identify warm microclimates. Researchers should consider monitoring barometric pressure, relative humidity and dew point, precipitation, and wind speed. Monitoring for moonlight and nightly insect populations is encouraged as another factor potentially influencing bat behavior. Finally, it may be useful to deploy an acoustic detector near open pools of water to determine if bats are visiting them during the winter, looking for potential drinking sources.

Because we initiated this project to determine winter bat use at DETO to help manage WNS if it were to arrive in the park, the park now can move forward with the next steps. Radio-telemetry will be a key future activity for pin-pointing where bats are overwintering. Management challenges that DETO will face will be managing visitors within the area of the Tower feature during the winter months. Throughout the winter on warmer days, a few climbers can be observed climbing on the Tower. There are also usually a few visitors exploring the boulder field during snow-free periods. Depending on the depth and seclusion of bats potentially roosting in rock crevices at DETO, the disturbance potential at both recreational areas might intensify during the fall and early spring as visitation increases. These disturbances over time could negatively impact overwintering bat species.

A study by Boyles and Brack (2009) explored the overwinter survival rates of hibernating bats in areas with human disturbance. They found that locations with long winters and frequent human disturbances could experience lower survival rates than if just one of the negative variables existed. Another study suggested that the effects of human disturbance through sound and light does not affect hibernating MYLU until 2-7.5 hours after the disturbance occurs (Thomas 1995). Human disturbance can be extremely costly for a bat's precious winter fat reserves. Each human disturbance that causes a bat to arouse can cause 108 mg of fat loss, equivalent to 68 days of torpor (Thomas et

al. 1990). The potential impacts of human disturbance on bats if they are hibernating in rock crevices around the Tower is high, especially on warm early spring days or once the snow melts in the boulder fields. The boulder field is more accessible to most visitors due to the lack of required specialized equipment that rock climbing requires. The area that most visitors explore off trail is close to Site 16. Managing this type of environment will be challenging. Strategic and thoughtful planning is required to protect overwintering bats as well as value the visitor's experience. Other land managers in areas with similar hibernacula and visitation will face the same challenges, and therefore should work together to find solutions to monitor and minimize the disturbance of bat overwintering in unusual places. Similarly, land managers who are unsure if bats overwinter in their landscape should design and implement acoustic monitoring projects to determine winter activity before WNS arrives.

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