Long-term Acoustic Assessment of Bats on Big Sheep Creek in the Tendoy Mountains of Southwest Montana and Management Recommendations for Bats

Prepared for:
Beaverhead-Deerlodge National Forest

and

Dillon Field Office of the Bureau of Land Management

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Montana Natural Heritage Program
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EXECUTIVE SUMMARY

Montana's bat populations face a wide array of conservation issues, including loss of roosting sites, elimination of prey species, collision or drowning hazards at sites where they forage, drink, and mate, and a lack of baseline information on distribution and habitat use that is available to resource managers. In recent years, concerns have focused on fatalities at wind turbine facilities and those resulting from White-nose Syndrome (WNS). WNS has killed an estimated 5.7 to 6.7 million bats in eastern North America and 600,000 to 888,000 bats are estimated to have been killed at wind energy facilities across the United States in 2012 alone. These and other sources of mortality may be having significant impacts on bat populations because bats are long-lived and have only one or two young per year. Given these concerns, a long term acoustic detector was installed on Big Sheep Creek in the Tendoy Mountains in southwest Montana to gather baseline information on bats. This was one of the first ultrasonic acoustic detectors installed in what grew to become a regional network of detectors deployed over multiple years to document activity patterns of bats across Montana, and portions of northern Idaho, and the western Dakotas.

The overarching objectives of this project were to gather multiple years of year-round baseline information on: (1) bat species composition and activity levels; (2) timing of species immergence to and emergence from hibernacula for non-migratory bat species; (3) timing of migrations by tree roosting migratory species that have been documented as having the highest levels of mortality from collisions with wind turbines; and (4) correlates of bat activity such as wind speed, temperature, precipitation, barometric pressure, and moon illumination.

We recorded bat echolocation calls from sunset to sunrise nightly with an SM2Bat+ detector/recorder mounted above Big Sheep Creek between 31 January 2012 and 24 October 2014. A total of 12,269 bat call sequences were recorded over 10,716 hours of monitoring, with 14.5 percent being auto-identified to species by Sonobat 3.0 or Kaleidoscope Pro 2.0 software.

Six species were definitively confirmed by hand review using the bat call characteristic identification guidelines in Montana's Bat and White-Nose Syndrome Surveillance Plan and Protocols: Big Brown Bat (*Eptesicus fuscus*), Silver-haired Bat (*Lasionycteris noctivagans*), Hoary Bat (*Lasiurus cinereus*), Western Small-footed Myotis (*Myotis ciliolabrum*), Long-eared Myotis (*Myotis evotis*), and Little Brown Myotis (*Myotis lucifugus*). In addition, there were several call sequences recorded during the study that fit definitive characteristics of Yuma Myotis (*Myotis yumanensis*) calls. However, because this region is outside the range where the species has been documented with mist net captures, we believe it is best to regard all of these sequences as only potentially Yuma Myotis calls until there is genetic confirmation of the species in the region. While their presence could not be confirmed by this study, Townsend's Big-eared Bat and California Myotis should also both be regarded as potentially present in the Tendoy Mountains given their documented presence in adjacent areas of southwestern Montana. Finally, despite being

detected in the Tendoy Mountains previously, Long-legged Myotis could not be confirmed by this study and should be regarded as present, but with a low likelihood of acoustic detection.

We documented the six species definitively detected in 20 monthly time periods in which there had been no previous documentation of their presence in the region, including three-month expansions in documented activity periods for both Big Brown Bat and Long-eared Myotis, a five-month expansion for Silver-haired Bat, a one-month expansion for Hoary Bat, and four-month expansions for both Western Small-footed Myotis and Little Brown Myotis.

Patterns of bat activity recorded at the Big Sheep Creek acoustic monitoring station were consistent with overall average bat activity patterns recorded across the regional network of acoustic detectors. Activity was very limited, < 1 pass per night on average, between November and February. However, at least some bat activity was documented every month but January in at least one of the study years. Average nightly bat passes began to increase each year in mid to late April, reached a maximum of 56 to 65 bat passes per night between July and September after young became flighted and during migration and swarming, and were greatly reduced again by mid-October.

During the active season (April to October), some level of bat activity was evident throughout most of the nighttime hours. However, there was a major pulse of activity in the first hour after sunset and the vast majority of activity occurred during the first two to three hours after sunset. This may be a result of relatively cold nighttime temperatures at this relatively high elevation site.

Throughout the study maximum background and bat pass temperatures recorded at the detector closely approximated one another. However, average and minimum bat pass temperatures recorded at the detector were consistently much higher than average and minimum background temperatures; monthly averages ranged from 3 to 13.3°C higher and monthly minimums ranged from 1.3 to 24.2°C higher. Thus, bats consistently restricted their activity to warmer time periods from the range of background temperatures that were available to them.

A clear relationship between bat activity patterns at the detector and wind speed recorded at the Harkness weather station was hampered by the 20.1 kilometers separating the two stations. This data indicated that bats are more active at wind speeds of 3 to 7 meters per second than would be expected if bat activity was randomly distributed across all wind speeds available to them. A more reliable measure of bats responses to wind speeds may be evident in data spanning the entire detector network. This data shows bat activity as greater than expected at random for wind speeds less than 3 meters per second. Across the network, wind speeds less than 3 meters per second accounted for 73 percent of bat passes and wind speeds less than 6 meters per second accounted for 95 percent of bat passes.

Nearly 80 percent of bat activity was associated with little to no change (-1 to +1 millibars) in hourly barometric pressure recorded at the Dillon Airport, located 74.4 kilometers to the north-northeast of the acoustic detector.

However, bat activity was greater than would be expected in the negative pressure change classes down to -3 millibars of change per hour and was less than expected with neutral or positive changes up to 1 to 2 millibars per hour than if bat activity were randomly distributed across the background pressure change classes that were recorded. Across the detector network, 72 percent of bat activity was associated with little to no change (-1 to +1 millibars) in hourly barometric pressure. However, bat activity was greater than expected during negative changes (-1 to -3 millibars) in hourly barometric pressure and was less than expected with neutral or positive changes (1 to 2 millibars) in hourly barometric pressure than if it were randomly distributed across background pressure change classes.

Bat activity at the Big Sheep detector and at detectors across the regional network was distributed at random relative to background hours associated with and without precipitation at the nearest weather stations. This may simply be a result of the facts that: (1) nighttime precipitation events are relatively rare; (2) weather stations are often somewhat distant from the acoustic detectors; and (3) precipitation was coded in hourly bins while bats are capable of flight within minutes after the passage of a storm front. Thus, bat activity recorded at the Big Sheep Creek detector and many of the acoustic detectors across the network may be relatively meaningless with regard to precipitation events recorded at distant weather stations.

Patterns in the percent of hours with bat activity generally tracked patterns in the background percent of hours associated with various moon conditions. However, bat activity was much greater than would be expected during the full moon when it was above the horizon and at illumination levels of 0.8 to 1.0 when it was below the horizon than if bat activity had been randomly distributed across the various background moon illumination categories available. Across the regional network of bat detectors, an opposite pattern in bat activity was evident with progressively greater bat activity than would be expected at random when moon illuminations were less than 0.5 and progressively less bat activity than would be expected at random when moon illuminations were greater than 0.5. The Big Sheep Creek moon illumination results might, therefore, at first appear to be discordant with patterns across the region detector network. However, when one takes into account the fact that the Big Sheep Creek detector’s microphone is mounted on a small cliff near the bottom of a canyon that would stay shaded from moon illumination unless the moon is directly overhead, it seems that the pattern observed at this detector is likely the exception that proves the rule that bats are shifting activity toward times or places that have lower moon illumination levels.

Identification of individual species activity patterns was hindered by relatively low and potentially inconsistent rates of auto-identification of call sequences to species. Thus, activity patterns for species from auto-identified call sequences should be regarded as speculative due to a variety of issues that might cause auto-identifications to be inaccurate and/or inconsistent. Of the four species for which there is at least some justification for showing potential patterns of documented activity from auto-identified call sequences, there were three main patterns evident in average nightly passes per week. First, recorded activity for all these species was reduced in 2013 and 2014 relative to what it was in 2012, apparently as a result of the loss in sensitivity of the microphone. Second, in 2012, Big Brown Bat, Western Small-footed Myotis, and Little Brown Myotis all had reduced activity through early June with less than one pass per night on average, higher levels of activity through early September or October with one to up to twenty-three passes per night on average, and then reduced activity with less than one pass per night on average during the winter of 2012-2013. Third, in contrast to the other species, recorded Silver-haired Bat activity began relatively early, lasted relatively late into the year, and had no major peaks or troughs.

The above measures of overall bat activity near the detector, hand confirmed presence of individual species by month, and hand confirmed minimum temperatures associated with bat passes of individual species are all stable metrics upon which management recommendations can be made. However, patterns of activity of individual species resulting from automated analyses should be used with a great deal of caution due to low rates of species assignment and low or uncertain rates of accuracy of those assignments. Furthermore, it should be noted that bat activity measured during this study was made by a microphone on a 9-10 foot mast at the top of a small cliff and may not have adequately sampled the activity of high flying bats such as the Hoary Bat and Silver-haired Bat, which have suffered high rates of mortality at wind turbines across North America.

The following management recommendations are based on information gathered during this study, literature and documentation in Montana's animal point observation database on the roosting habits and habitats of Montana's bat species (Appendix C, MTNHP 2016), compilations of literature on the impacts of wind turbines on bats (Table 1, Appendix A, see especially Schuster et al. 2015), and new voluntary best management practices adopted by the American Wind Energy Association.

Management recommendations include: (1) protecting potential natural roost sites by conserving large diameter trees (especially snags with loose bark), rock outcrops, cliff crevices, and caves; (2) maintaining accessibility for underground mine entrances that bats may be using as summer or winter roosts; (3) reducing structural complexity of vegetation (e.g., short stature grasslands) and availability of standing waters that might provide drinking opportunities for bats near wind turbines or other human structures that might represent a threat to bats or where bats are undesired; (4) if wind turbines are installed in the region, set turbine cut-in speeds to $\geq$ 6.0 m/sec between April and October – especially important in July during peak bat activity when young are newly flighted, and August, September, and October when migratory species are passing through and local bats are swarming and breeding; (5) feather wind turbine blades, or making them parallel to wind direction, when wind speeds are <6 m/sec so that they rotate at fewer than 1-3 revolutions per minute between April and October; and (6) install bat houses on warm south and west facing walls of human structures to provide summer roosting habitat while avoiding bat use of internal portions of the structures.

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INTRODUCTION

Montana's bat populations face a wide array of conservation issues, including loss of roosting sites, elimination of prey species, collision or drowning hazards at sites where they forage, drink, and mate, and a lack of baseline information on distribution and habitat use that is available to resource managers. In recent years, concerns have focused on fatalities at wind turbine facilities and those resulting from White-nose Syndrome (WNS) (Table 1). The large increases in mortality posed by these threats are especially significant to bat populations because bats are long-lived and have only 1 or 2 young per year (Barclay and Harder 2003).

WIND TURBINE IMPACTS

Bat fatalities are widespread at wind energy facilities across the United States with 600,000 to 888,000 fatalities estimated in 2012 alone (Hayes 2013, Smallwood 2013). The widespread nature of these fatalities coupled with low fecundities of bats raise concerns that wind turbines may be having significant impacts on bat populations (Barclay and Harder 2003, Kunz et al. 2007, Arnett et al. 2008). Of North America's 45 documented bat species, mortalities from wind turbines have been documented in 11 and 5 of them potentially occur in the Tendoy Mountains for at least a portion of the year (Tables 1 & 2; Kunz et al. 2007, Arnett et al. 2008). Of these species, mortality rates have been highest (≥ 75% of mortalities) in tree roosting migratory species such as the Hoary Bat (Lasiurus cinereus) and Silver-haired Bat (*Lasionycteris noctivagans*) (Kunz et al. 2007, Arnett et al. 2008, Arnett et al. 2011). Thus, if wind turbines were to be installed in the region, the majority of mortalities would be expected to be associated with these two migratory tree roosting species during migratory events. However, resident bats may also be impacted (Poulton and Erickson 2010) and impacts may occur even during the winter (Lausen and Barclay 2006, this study).

WHITE-NOSE SYNDROME IMPACTS

Since 2006, White-Nose Syndrome, resulting from the cold adapted fungus *Pseudogymnoascus destructans*, has killed an estimated 5.7 to 6.7 million bats in eastern North America (Blehert et al. 2008, Lorch et al. 2011, USFWS News Release January 17, 2012, Minnis and Lindner 2013). As a result, the extinction of Little Brown Myotis (*Myotis lucifugus*) is predicted in eastern North America by 2026 (Frick et al. 2010), Little Brown Myotis, Northern Myotis (*M. septentrionalis*), and Tri-colored Bat (*Perimyotis subflavus*) were emergency listed as Endangered under Canada's Species at Risk Act (COSEWIC 2012), Little Brown Myotis has been petitioned for emergency listing under the United States Endangered Species Act (Kunz and Reichard 2010), and Northern Myotis has been listed as Threatened under the United States Endangered Species Act across its range, including nine eastern Montana counties (USFWS 2015). *P. destructans* has progressed westward to states along the Mississippi River corridor as well as the Province of Ontario, Canada, has caused WNS in at least three species documented in Montana, has been detected in other species that may serve as local or regional vectors, and seems likely to affect other Montana species due to the close relatedness of species that have been impacted (Table 1, Blehert et al. 2011, Heffernan 2014).

ACOUSTIC MONITORING NETWORK

Starting in the fall of 2011, various federal, state, and tribal partners began deploying SM2Bat, SM2Bat+, and SM3Bat ultrasonic detector/recorders to gather year-round baseline information on bat activity in various localities across Montana. During 2012, individual efforts began to coalesce into a regional network of detectors to address most bat species known to occur in Montana (Figure 1, Table 1, Maxell 2015). Most of the recordings from this array are being processed, analyzed, and archived at the Montana Natural Heritage Program.

PROJECT NEED

Previous acoustic and mist net sampling for bats in southwestern Montana has been limited to single nights of sampling between late June and early September and no overwintering has been documented for bats in the Tendoy Mountains. Thus, the region lacked baseline data on year-round patterns of bat activity that could be used to inform resource management plans or individual projects.

SPECIES POTENTIALLY PRESENT

Of Montana’s 15 known bat species, 8 had been documented in the vicinity of the Tendoy Mountains prior to 2012: Big Brown Bat (*Eptesicus fuscus*), Silver-haired Bat (*Lasionycteris noctivagans*), Hoary Bat (*Lasiurus cinereus*), California Myotis (*Myotis californicus*), Western Small-footed Myotis (*Myotis ciliolabrum*), Long-eared Myotis (*Myotis evotis*), and Little Brown Myotis (*Myotis lucifugus*) (Table 2). Two additional species are potentially present in the Tendoy Mountains as indicated by their presence in the surrounding region: Townsend’s Big-eared Bat (*Corynorhinus townsendii*) and Yuma Myotis *(Myotis yumanensis*) (Table 2).

OBJECTIVES

The major goals of this project were to: (1) gather baseline information on bat species composition and activity levels on Big Sheep Creek year round for 2-3 years; (2) identify timing of species immergence to and emergence from hibernacula for non-migratory bat species; (3) identify timing of migrations by tree roosting migratory species that have been documented as having the highest levels of mortality from collisions with wind turbines; and (4) identify relationships between bat activity and wind speed, temperature, precipitation, barometric pressure, and moon illumination.

METHODS

BAT DETECTOR DEPLOYMENT

The Tendoy Mountains were assessed for a location on public land with: (1) open water for as much of the year as possible; (2) rock outcrops and trees that might be used as roosts by bats; (3) southern solar exposure that would allow a solar panel to charge a battery even during the winter; (4) year-round access without too much travel by foot; and (5) a low likelihood of vandalism. An area along Big Sheep Creek met these criteria and on the afternoon of 31 January 2012 a Song Meter SM2Bat+ detector/recorder (Wildlife Acoustics Inc., Maynard, MA) was deployed adjacent to the stream with the microphone at the top of a small cliff at the edge of the stream and the detector/recorder, battery, and solar panel approximately 50-meters up the slope to the north of the creek (Table 3, Figures 1-3). Overall, this detector was fully operational for a total of 930 nights and 10,716 hours between 31 January 2012 and 24 October 2014 (Table 3).

The SM2Bat+ detector/recorder was deployed, monitored, and maintained with the equipment, supplies, settings, and protocols listed in Montana's Bat and White-Nose Syndrome Surveillance Plan and Protocols 2012-2016 (Maxell 2015).

A variety of factors influence the detection of a bat echolocation call and the quality of the resulting recording. These include sensitivity of the individual microphone, temperature, humidity, wind speed, and frequency, amplitude, distance, and directionality of echolocation calls emitted by bats (Parsons and Szewczak 2009, Agranat 2014). The energy of sounds spreading in all directions diminishes by one fourth for every doubling of distance because the surface area of a sphere is related to the square of its radius. Furthermore, higher frequency sounds are diminished over shorter distances because of atmospheric absorption (Parsons and Szewczak 2009, Agranat 2014). Testing of the SMX-US microphones used in this study indicates that bats emitting frequencies in the range of 20 kHz should be detected at distances of 24 to 33 meters from the microphone while those emitting frequencies in the range of 40 kHz should be detected at distances of 18 to 22 meters (Agranat 2014). These distances are the radii of the relevant spheres of detection around microphones when they are at full sensitivity. However, we know that sensitivity varied over time by an unknown magnitude as a result of precipitation and freezing events, some of which permanently reduced the sensitivity of microphones (Table 3).

DATA MANAGEMENT & CALL ANALYSES

Acoustic file recordings, in both original WAC and processed WAV formats, are stored in the Montana Bat Call Library which is housed on a series of 15-20 Terabyte Drobo 5D and 5N storage arrays at the Montana State Library as well as a secondary offsite location to protect against catastrophic loss. Acoustic analysis results, temperature files, weather station data, and solar and lunar data were all processed and combined within SQL database tables in accordance with the general work flow pattern for data management and analysis outlined in the text and in Appendices 8-10 of Maxell (2015). Bat call sequences were analyzed with the goal of definitively identifying individual species presence by month and individual species' minimum temperatures of activity in accordance with the Echolocation Call Characteristics of Montana Bats and Montana Bat Call Identification materials in Appendices 6 and 7 of Montana's Bat and White-Nose Syndrome Surveillance Plan and Protocols 2012-2016 (Maxell 2015).

WEATHER STATION DATA

Weather station data were downloaded using the Mesowest application programming interface as outlined in Appendix 9 of Maxell (2015). Temperature, wind speed, and precipitation data were downloaded from the Harkness weather station (44.465, -112.95194) which is located 20.1 kilometers southwest of the detector/recorder. Temperature, wind speed, and precipitation data were available for 94.6%, 94.6%, and 94.5% of the hours of detector deployment, respectively. Barometric pressure data were downloaded from the Dillon Airport weather station (45.2575, -112.55444) which is located 74.4 kilometers north-northeast of the detector/recorder. Barometric pressure data was available for 97.4% of the hours of detector deployment.

SOLAR AND LUNAR DATA

Solar and lunar data were calculated for all hours of detector deployment using the Python package ephem (3.7.6.0), which uses well-established numeric routines to produce high-precision astronomy computations (see Appendix 10 of Maxell 2015). The underlying code produces results nearly identical to data available from the U.S. Naval Observatory (Astronomical Applications Department). Precise times for sunrise, sunset, moonrise, moonset, and percent illumination at the detector were calculated based on latitude, longitude, and date. It should be noted that local topography is not incorporated into any of these calculations. Therefore, the exact timing of these events on the ground may differ slightly from those produced by this model, but should typically be within a few minutes unless local terrain differs greatly from the modeled horizon (e.g. if the site is at the bottom of a canyon).

Results

TOTAL VOLUME OF BAT PASSES AND AUTO-IDENTIFICATION RATES

Between 31 January 2012 and 24 October 2014, a total of 12,269 bat call sequences were recorded, with 14.5 percent (monthly range 0.0 to 56.5 percent) auto-identified to species by Sonobat 3.0 or Kaleidoscope Pro 2.0 software. Overall rates of auto-identification were significantly lower than the regional network average of 23.7 percent for many months of the study (Table 4, Figure 4). The overall low auto-identification rates may be a result of microphone placement relative to the typical flight corridor of bats along this particular section of Big Sheep Creek (Figure 3). The microphone was placed at the top of a cliff and it is possible that bats flying close to the water were at the outer margin of the microphone's ability to detect complete diagnostic call sequences (Maxell 2015). It is also possible that a decline in microphone sensitivity after the spring of 2013, likely due to rain events, hampered recording fully diagnostic call sequences (Tables 3 & 4, Figure 5, Maxell 2015).

SPECIES PRESENT & ACTIVITY PERIODS

Of the call sequences auto-identified to species, more than 600 were fully reviewed by hand. Of the 107 months with calls auto-identified to ten different species, 62 months (58 percent) were confirmed by hand review for six species (Table 5). Big Brown Bat, Silver-haired Bat, Hoary Bat, Western Small-footed Myotis, Long-eared Myotis, and Little Brown Myotis had relatively high rates of monthly hand confirmation (43.8 to 100 percent) (Table 5). Despite having auto-identified call sequences and potentially being present in the region, Townsend's Big-eared Bat and California Myotis could not be confirmed with a definitive call sequence (Tables 2 & 5, Maxell 2015). Townsend's Big-eared Bat has not been previously documented in the region with either mist net or acoustic surveys and California Myotis has only been documented with a single acoustic record (Table 2, MTNHP 2016). We believe that both of these species should be regarded as potentially present in the Tendoy Mountains because of previous documentation in nearby areas of southwestern Montana (Table 2, MTNHP 2016). We also classified two call sequences that were auto-identified as Yuma Myotis as probable and two other sequences met all the definitive characteristics of Yuma Myotis. However, because this region is outside the range where the species has been documented with mist net captures, we believe it is best to regard all of these sequences as only potentially Yuma Myotis until there is genetic confirmation of the species in the region (Table 2, MTNHP 2016). Long-legged Myotis has been confirmed in the Tendoy Mountains previously and a number of call sequences were auto-identified as this species. However, none of these call sequences met the definitive characteristics to confirm this species' presence. We therefore feel that this species should be regarded as present in the Tendoy Mountains with a low likelihood of acoustic detection (Tables 2 & 6, MTNHP 2016, Maxell 2015).

We documented the six species definitively detected in 20 monthly time periods in which there had been no previous documentation of their presence in the region, including three-month expansions in documented activity periods for both Big Brown Bat and Long-eared Myotis, a five-month expansion for Silver-haired Bat, a one-month expansion for Hoary Bat, and four-month expansions for both Western Small-footed Myotis and Little Brown Myotis (Table 6).

As compared to the regional network of acoustic detectors, most of the species definitively confirmed at the Big Sheep detector had reduced (three to seven month) periods of confirmed activity and there was little to no confirmation of species and limited bat activity in general between November and February (Tables 7 & 8). Limited detection during these colder time periods may indicate that many species that are year-round residents in Montana either move away from this high elevation region during these colder months or have local winter roosts that are somewhat distant from the location of the acoustic monitoring station and do not often travel far enough during winter rehydration flights to be detected.

GENERAL PATTERNS OF BAT ACTIVITY

The patterns of activity recorded at the Big Sheep Creek acoustic monitoring station were consistent with overall average bat activity patterns recorded across the regional network of acoustic detectors (Table 8, Figures 5-7). Bat activity was very limited, < 1 pass per night on average, between November and February. However, at least some bat activity was documented every month but January in at least one of the study years (Tables 6-8, Figures 5 & 6). Average nightly bat passes began to increase each year in mid to late April, reached a maximum of 56 to 65 bat passes per night between July and September after young became flighted and during migration and swarming, and were greatly reduced again by mid-October (Table 8, Figures 5 & 6, Parsons et al. 2003). While active season patterns were similar across the study, the average number of nightly passes recorded during the 2012 active season was greater than what was recorded in the 2013 and 2014 active seasons, apparently as a result of the loss in microphone sensitivity (Tables 3 & 8, Figures 5 & 6).

TIMING OF BAT ACTIVITY

During the active season (April to October), some level of bat activity was evident throughout most of the nighttime hours. However, there was a major pulse of activity in the first hour after sunset and the vast majority of activity occurred during the first two to three hours after sunset (Figure 9a). This may be a result of relatively cold nighttime temperatures at this relatively high elevation site. This hypothesis is supported by the fact that fewer nighttime hours had activity during the colder months of April and October and activity was further reduced during these months in later nighttime hours (Figure 9a). Similarly, during the inactive season (November to April), bat activity was almost solely limited to the first two to three hours after sunset (Figure 9b).

TEMPERATURE & BAT ACTIVITY

Nightly average bat pass temperatures recorded at the detector ranged from 6.4 to 19.4°C during the active season and 3.0 to 8.5°C during the inactive season (Table 9). Throughout the study maximum background and bat pass temperatures recorded at the detector closely approximated one another (Table 9). However, average and minimum bat pass temperatures recorded at the detector were consistently much higher than average and minimum background temperatures; monthly averages ranged from 3 to 13.3°C higher and monthly minimums ranged from 1.3 to 24.2°C higher (Table 9, Figure 10). Similarly, the distribution of temperatures recorded at the Harkness weather station, located 20.1

kilometers to the southwest of the detector, that were associated with bat passes was significantly higher than the distribution of background temperatures (Figure 11). Thus, bats consistently restricted their activity to warmer time periods from the range of background temperatures that were available to them. This same pattern holds across the entire detector network with more than 99 percent of bat activity restricted to temperatures above freezing and 97 percent of bat activity restricted to temperatures above 5°C (Figure 12).

Monthly minimum bat pass temperatures confirmed for individual species ranged from 2.2 to 19.3°C for Big Brown Bat, 4.4 to 19.9°C for Hoary Bat, 3.1 to 19.6°C for Silver-haired Bat, 6.2 to 19.9°C for Western Small-footed Bat, 6.7 to 22.9°C for Long-eared Myotis, and 8.5 to 20.3°C for Little Brown Myotis (Tables 10 & 11, Appendix B). The minimum bat pass temperatures recorded for individual species at the Big Sheep Creek acoustic detector were 5 to 11.3°C higher than have been recorded on other detectors across the region network to-date (Table 11, Appendix B). This possibly indicates that roost sites for most species are somewhat distant from the detector location and that bats may not be flying far from their roost sites during colder weather conditions in this relatively harsh high elevation landscape.

WIND SPEED & BAT ACTIVITY

Bat activity patterns in relation to wind speed recorded at the Harkness weather station, located 20.1 kilometers to the southwest of the acoustic detector, indicate that bats are more active at wind speeds of 3 to 7 meters per second than would be expected if bat activity was randomly distributed across all wind speeds available to them. Furthermore, only a tiny fraction of activity was associated with wind speeds of 10 meters per second or more (Figure 13). There were also clearly unlikely associations in the Harkness weather station data with some bat activity associated with wind speeds of up to 17 meters per second, more than 5 percent of passes associated with wind speeds greater than 8 meters per second, and less bat activity than would be expected at random for wind speeds at or below 2 meters per second (Figure 13). These seemingly anomalous results are likely due to the large distance between the Harkness weather station and the acoustic detector on Big Sheep Creek.

Across the entire detector network, bat activity was greater than expected at random for wind speeds less than 3 meters per second (Figure 14). Wind speeds less than 3 meters per second accounted for 73 percent of bat passes and wind speeds less than 6 meters per second accounted for 95 percent of bat passes (Figure 14). Given the relatively large distance between some bat detectors and weather stations (e.g., the Big Sheep Creek detector and Harkness weather station), it seems likely that, if anything, bats probably restrict their flight to even lower wind speeds than the associations in Figures 13 & 14 indicate.

BAROMETRIC PRESSURE & ACTIVITY

Nearly 80 percent of bat activity was associated with little to no change (-1 to +1 millibars) in hourly barometric pressure recorded at the Dillon Airport, located 74.4 kilometers to the north-northeast of the acoustic detector. However, bat activity was greater than would be expected in the negative pressure change classes down to -3 millibars of change per hour and was less than expected with neutral or positive changes up to 1 to 2 millibars per hour than if bat activity were randomly distributed across the background pressure change classes that were recorded (Figure 15).

This same pattern is evident across the detector network (Figure 16). Approximately 72 percent of bat activity across the network was associated with little to no change (-1 to +1 millibars) in hourly barometric pressure. However, bat activity was greater than expected during negative hourly changes (-1 to -3 millibars) and is less than expected with neutral or positive hourly changes (1 to 2 millibars) than if it were randomly distributed across background pressure change classes (Figure 16).

PRECIPITATION & BAT ACTIVITY

Bat activity was distributed at random relative to background hours associated with and without precipitation (Figure 17). This may simply be a result of the facts that: (1) nighttime precipitation events in the Tendoy Mountains are rare with only 1 percent of nighttime hours associated with precipitation at the Harkness weather station; (2) the Harkness weather station is approximately 20.1 kilometers from the bat detector, and (3) precipitation was coded in hourly bins while bats are capable of flight within minutes after the passage of a storm front. Thus, bat activity recorded at the acoustic detector on Big Sheep Creek may be relatively meaningless with regard to precipitation events recorded at the Harkness weather station.

Across the acoustic detector network, bat activity was slightly more during hours with precipitation than would be expected if bat activity was randomly distributed between hours with and without precipitation (Figure 18). Again, because hourly precipitation events are rare, the weather stations were often somewhat distant from the acoustic detectors, and because precipitation was coded in hourly bins while bats are capable of flight within minutes after the passage of a storm front, patterns of bat activity relative to recorded precipitation events at weather stations may not be all that meaningful.

MOONLIGHT & BAT ACTIVITY

Patterns in the percent of hours with bat activity generally tracked patterns in the background percent of hours associated with various moon conditions (Figure 19). However, bat activity was much greater than would be expected during the full moon when it was above the horizon and at illumination levels of 0.8 to 1.0 when it was below the horizon than if bat activity had been randomly distributed across the various background moon illumination categories. The only other category with much greater bat activity than would be expected at random was the 0.1 illumination category when the moon was above the horizon (Figure 19). All other categories had bat activity levels as would be expected at random or below what would be expected at random.

Across the regional network of bat detectors, an opposite pattern in bat activity was evident with progressively greater bat activity than would be expected at random when moon illuminations were less than 0.5 and progressively less bat activity than would be expected at random when moon illuminations were greater than 0.5 (Figure 20). The importance of moon illumination to bat activity across the regional detector network is further demonstrated by the increase in the magnitude of increased bat activity relative to expected at illuminations less than 0.5 when the moon is below the horizon as compared to when it is above the horizon. Similarly, the decrease in the magnitude of the decreased bat activity relative to expected at illuminations greater than 0.5 when the moon is below the horizon as compared to when it is above the horizon, also strongly supports the consistent importance of moon illumination to overall bat activity across the regional detector network.

The Big Sheep Creek moon illumination results might, therefore, at first appear to be discordant with patterns across the region detector network. However, when one takes into account the fact that the Big Sheep Creek detector's microphone is mounted on a small cliff near the bottom of a canyon that would stay shaded from moon illumination unless the moon is directly overhead, it seems that the pattern observed at this detector is likely the exception that proves the rule that bats are shifting activity toward times or places that have lower illumination levels.

SPECIES ACTIVITY PATTERNS

Identification of individual species activity patterns was hindered by relatively low and potentially inconsistent rates of auto-identification of call sequences to species (Table 4, Maxell 2015). Only Big Brown Bat, Silver-haired Bat, Western Small-footed Myotis, and Little Brown Myotis had relatively high rates of confirmation of monthly presence (Table 5) and enough calls auto-identified to examine trends. Call sequences of known species identity in the Montana Bat Call Library have also had relatively high accuracy rates (>50 percent correct auto-identification rates) for these species. However, activity patterns for these species from auto-identified call sequences should still be regarded as speculative due to a variety of issues that might cause auto-identifications to be inaccurate and/or inconsistent (Maxell 2015).

Of the four species for which there is at least some justification for showing potential patterns of documented activity from auto-identified call sequences, there were three main patterns evident in average nightly passes per week (Figures 21 through 24). First, recorded activity for all these species was reduced in 2013 and 2014 relative to what it was in 2012, apparently as a result of the loss in sensitivity of the microphone. Second, in 2012, Big Brown Bat, Western Small-footed Myotis, and Little Brown Myotis all had reduced activity through early June with less than one pass per night on average, higher levels of activity through early September or October with one to up to twenty-three passes per night on average, and then reduced activity with less than one pass per night on average during the winter of 2012-2013. Third, in contrast to the other species, recorded Silver-haired Bat activity began relatively early, lasted relatively late into the year, and had no major peaks or troughs.

AVAILABILITY OF DATA SUMMARIES

The latest tabular and chart data summaries for bat activity patterns in association with time, weather, and other correlates for detectors across the regional network of ultrasonic acoustic monitoring stations are available by request from the Montana Natural Heritage Program through an Excel workbook. Pivot tables and charts in topical worksheets in this workbook can be filtered to produce the latest data summaries for one or more sites, time periods, and species.

As confirmations of individual species monthly presence and minimum temperatures of activity are made, this information is added to the animal point observation database at the Montana Natural Heritage Program and is available to agency biologists and resource managers for regional and project-level planning online in the context of a variety of map information through the MapViewer web application http://mtnhp.org/mapviewer/

Management Recommendations

The above measures of overall bat activity near the detector, hand confirmed presence of individual species by month, and hand confirmed minimum temperatures associated with bat passes of individual species are all stable metrics upon which management recommendations can be made. However, patterns of activity of individual species resulting from automated analyses should be used with a great deal of caution due to low rates of species assignment and low or uncertain rates of accuracy of those assignments. Furthermore, it should be noted that bat activity measured during this study was made by a microphone on a 9-10 foot mast at the top of a small cliff and may not have adequately sampled the activity of high flying bats such as the Hoary Bat and Silver-haired Bat, which together with the Eastern Red Bat are the three species that have suffered approximately 75% of the documented mortalities associated with wind turbines across North America (Kunz et al. 2007). Thus, the following management recommendations avoid use of activity patterns of individual species as determined by automated analyses and instead rely on results of hand confirmed analyses, general patterns of bat activity that were recorded at the study site, and results of published studies of wind turbine impacts on bat species.

The following management recommendations are based on information gathered during this study, literature and documentation in Montana's animal point observation database on the roosting habits and habitats of Montana's bat species (Appendix C, MTNHP 2016), compilations of literature on the impacts of wind turbines on bats (Table 1, Appendix A, see especially Schuster et al. 2015), and new voluntary best management practices adopted by the American Wind Energy Association (AWEA 2015).

Management recommendations include: (1) protecting potential natural roost sites by conserving large diameter trees (especially snags with loose bark), rock outcrops, cliff crevices, and caves (Appendix C); (2) maintaining accessibility for underground mine entrances that bats may be using as summer or winter roosts; (3) reducing structural complexity of vegetation (e.g., short stature grasslands) and availability of standing waters that might provide drinking opportunities for bats near wind turbines or other human structures that might represent a threat to bats or where bats are undesired; (4) if wind turbines are installed in the region, set turbine cut-in speeds to ≥ 6.0 m/sec between April and October – especially important in July during peak bat activity when young are newly flighted, and August, September, and October when migratory species are passing through and local bats are swarming and breeding; (5) feather wind turbine blades, or making them parallel to wind direction, when wind speeds are <6 m/sec so that they rotate at fewer than 1-3 revolutions per minute between April and October; and (6) install bat houses on warm south and west facing walls of human structures to provide summer roosting habitat while avoiding bat use of internal portions of the structures.

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Table 1. Montana bat species, conservation status, and known or potential concerns from WNS and wind turbine facilities.

Species	Conservation Status	Species known to be affected by White-Nose Syndrome / *P. destructans*	Species known to be subject to mortality at wind turbines*
Pallid Bat (*Antrozous pallidus*) = ANPA	G5 S3, MT SOC, BLM Sensitive, USFS Sensitive	No connection known at this time.	No mortalities documented in literature.
Townsend's Big-eared Bat (*Corynorhinus townsendii*) = COTO	G34 S3, MT SOC, BLM Sensitive, USFS Sensitive	Detected, but no diagnostic sign of WNS (USFWS 2014). Potential winter roost vector.	No mortalities documented in literature.
Big Brown Bat (*Eptesicus fuscus*) = EPFU	G5 S4	Blehert et al. 2008, Langwig et al. 2012, 2014, Frank et al. 2014.	Johnson et al. 2004; Kunz et al. 2007; Arnett et al. 2008, 2011.
Spotted Bat (*Euderma maculatum*) = EUMA	G4 S3, MT SOC, BLM Sensitive, USFS Sensitive	No connection known at this time.	No mortalities documented in literature.
Silver-haired Bat (*Lasionycteris noctivagans*) = LANO	G5 S4, Potential MT SOC	Detected, but no diagnostic sign of WNS (Bernard et al. 2015, USFWS 2014). Potential regional migratory vector.	Johnson et al. 2004; Kunz et al. 2007; Arnett et al. 2008, 2011; Baerwald et al. 2009; Poulton and Erickson 2010.
Eastern Red Bat (*Lasiurus borealis*) = LABO	G5 SU, Potential MT PSOC	Detected, but no diagnostic sign of WNS (Bernard et al. 2015, USFWS 2014). Potential regional migratory vector.	Kunz et al. 2007; Arnett et al. 2008, 2011.
Hoary Bat (*Lasiurus cinereus*) = LACI	G5 S3, MT SOC	No connection known at this time.	Johnson et al. 2004; Kunz et al. 2007; Arnett et al. 2008, 2011; Baerwald et al. 2009; Poulton and Erickson 2010.
California Myotis (*Myotis californicus*) = MYCA	G5 S4	Close relatedness to *M. leibii* indicates possible susceptibility (Agnarsson et al. 2011, Langwig et al. 2012)	No mortalities documented in literature.
Western Small-footed Myotis (*Myotis ciliolabrum*) = MYCI	G5 S4	Relatively close relatedness to *M. lucifugus* indicates possible susceptibility (Frick et al. 2010, Agnarsson et al. 2011)	No mortalities documented in literature.
Long-eared Myotis (*Myotis evotis*) = MYEV	G5 S4 BLM Sensitive	Close relatedness to *M. sodalis* indicates possible susceptibility (Agnarsson et al. 2011, Langwig et al. 2012)	Kunz et al. 2007
Little Brown Myotis (*Myotis lucifugus*) = MYLU	G3 S3, MT SOC	Blehert et al. 2008, Frick et al. 2010, Lorch et al. 2011, Warnecke et al. 2012, Johnson et al. 2014, Langwig et al. 2012, 2014.	Johnson et al. 2004; Kunz et al. 2007; Arnett et al. 2008, 2011.
Northern Myotis (*Myotis septentrionalis*) = MYSE	G1G3 SU, BLM Special Status, USFS Threatened, USFWS Listed Threatened	Blehert et al. 2008, Langwig et al. 2012, 2014, USFWS 2015.	Kunz et al. 2007; Arnett et al. 2008
Fringed Myotis (*Myotis thysanodes*) = MYTH	G4 S3, MT SOC, BLM Sensitive	Relatively close relatedness to *M. lucifugus* indicates possible susceptibility (Frick et al. 2010, Agnarsson et al. 2011)	No mortalities documented in literature.
Long-legged Myotis (*Myotis volans*) = MYVO	G5 S4 BLM Sensitive	Close relatedness to *M. sodalis* indicates possible susceptibility (Agnarsson et al. 2011, Langwig et al. 2012)	No mortalities documented in literature.
Yuma Myotis (Myotis yumanensis) = MYYU	G5 S3S4, Potential MT SOC	Relatively close relatedness to *M. grisescens* indicates possible susceptibility (Agnarsson et al. 2011, USFWS 2014)	No mortalities documented in literature.

*Unidentified Myotis species mortalities have also been reported at the Judith Gap Wind Farm (Poulton and Erickson 2010).

Table 2. Bat species present or potentially present in the Tendoy Mountains prior to and during this study.

Species	Previous Documentation During Active Season [1]	Documented Periods of Activity During this Study	Documented or Potential Use of Hibernacula in Region
Townsend's Big-eared Bat (*Corynorhinus townsendii*) [2]	Not documented. Potential.	Possible [2]	Not documented. Potential.
Big Brown Bat (*Eptesicus fuscus*)	5 acoustic and 3 mist net records in June and August	June through October	Not documented. Potential.
Silver-haired Bat (*Lasionycteris noctivagans*)	12 acoustic records in June, July, August, and September	March through November	Believed until recently to be migratory, but acoustic evidence counters this.
Hoary Bat (*Lasiurus cinereus*)	7 acoustic and 1 mist net record in June, July, and August	July through September	Migratory
California Myotis (*Myotis californicus*) [3]	1 acoustic record in August	Not confirmed [3]	Not documented. Potential.
Western Small-footed Myotis (*Myotis ciliolabrum*)	10 acoustic and 1 mist net records in June, July, and August	March through September	Not documented. Potential.
Long-eared Myotis (*Myotis evotis*)	9 acoustic and 3 mist net records in June, July, and August	May through October	Not documented. Potential.
Little Brown Myotis (*Myotis lucifugus*)	19 acoustic and 5 mist net records in June, July, and August	April through October	Not documented. Potential.
Long-legged Myotis (*Myotis volans*) [4]	1 acoustic and 1 mist net record in June and August	Not confirmed [4]	Not documented. Potential.
Yuma Myotis (*Myotis yumanensis*) [5]	Not documented. Potential.	Possible [5]	Not documented. Potential.

[1] Records between April 1 and October 31 in the point observation database at the Montana Natural Heritage Program dating prior to 2012.

[2] Species is relatively quiet and often does not create fully definitive echolocation call recordings on bat detectors.

[3] Several call sequences were auto-identified as California Myotis. However, these call sequences lacked the definitive characteristics necessary to confirm the species presence. The species presence in the region is currently based on a single call sequence recorded in 2006. Mist net capture and morphological verification is needed.

[4] Several call sequences were auto-identified as Long-legged Myotis. However, these call sequences lacked the definitive characteristics necessary to confirm the species presence.

[5] We classified two call sequences that were auto-identified as Yuma Myotis as probable and two other sequences meet all the definitive characteristics of Yuma Myotis. However, because this region is outside the range where the species has been documented with mist net captures, we plan to regard all of these sequences as potentially Yuma Myotis until there is genetic confirmation of the species in the region.

Table 3. Deployment history of SM2 Bat+ detector/recorder on Big Sheep Creek.

Service Date	Comments
1/31/2012	Deployed detector in Big Sheep Creek drainage with microphone just above the creek at Latitude = 44.61183 and Longitude = -112.80327 and detector/recorder and solar panel/battery at Latitude = 44.612056 and Longitude = -112.80361
2/21/2012	Detector/recorder and microphones were checked and data were downloaded.
3/5/2012	Detector/recorder and microphones were checked and data were downloaded.
3/12/2012	Detector/recorder and microphones were checked and data were downloaded.
5/10/2012	Detector/recorder and microphones were checked and data were downloaded. Temperature data from 11 April and 9 May was accidentally discarded.
6/25/2012	Detector/recorder and microphones were checked and data were downloaded.
7/18/2012	Detector/recorder and microphones were checked and data were downloaded.
9/20/2012	Detector/recorder and microphones were checked and data were downloaded.
10/23/2012	Detector/recorder and microphones were checked and data were downloaded.
11/21/2012	Detector/recorder and microphones were checked and data were downloaded.
2/12/2013	Detector/recorder and microphones were checked and data were downloaded.
6/12/2013	Detector/recorder and microphones were checked and data were downloaded. Microphone had lost sensitivity relative to 2012 and was operating at reduced sensitivity after this point.
9/6/2013	Detector/recorder and microphones were checked and data were downloaded. Microphone had reduced sensitivity.
3/13/2014	Detector/recorder and microphones were checked and data were downloaded. Microphone had reduced sensitivity.
6/23/2014	Detector/recorder and microphones were checked and data were downloaded. Microphone had reduced sensitivity.
7/11/2014	Detector/recorder and microphones were checked. Temperature and acoustic data was not gathered between 26 June and 10 July due to the theft of the solar panel and loss of charge in the battery. A fully charged battery was reinstalled on this service date, but the solar panel was not replaced. Microphone had reduced sensitivity.
8/14/2014	Detector/recorder and microphones were checked and data were downloaded. Microphone had reduced sensitivity.
10/6/2014	The battery was swapped out on this date. Battery power had fallen below the threshold for powering the detector on 15 August and no temperature or acoustic data was gathered between then and 5 October. Microphone had reduced sensitivity.
1/6/2015	The entire detector/recorder system was decommissioned on this service date. The microphone had greatly reduced sensitivity and only 3 call sequences were recorded in October before the battery died on 25 October, 2014 which effectively ended the study.

Table 4. Detector status as measured by percent of calls auto-identified to species

Year	Month	Total No. of Calls	No. Calls Classified to Species	% Auto-identified to Species
2012	February	2	1	50.0%
2012	March	31	13	41.9%
2012	April	217	33	15.2%
2012	May	582	58	10.0%
2012	June	1382	230	16.6%
2012	July	1745	382	21.9%
2012	August	2027	463	22.8%
2012	September	1845	161	8.7%
2012	October	832	107	12.9%
2012	November	15	7	46.7%
2012	December	1	0	0.0%
2013	January	0	-	-
2013	February	0	-	-
2013	March	23	13	56.5%
2013	April	102	21	20.6%
2013	May	97	16	16.5%
2013	June [1]	76	0	0.0%
2013	July	335	10	3.0%
2013	August	449	30	6.7%
2013	September	723	82	11.3%
2013	October	896	87	9.7%
2013	November	3	1	33.3%
2013	December	0	-	-
2014	January	0	-	-
2014	February	0	-	-
2014	March	0	-	-
2014	April	47	0	0.0%
2014	May	60	3	5.0%
2014	June [2]	176	4	2.3%
2014	July [2]	453	40	8.8%
2014	August [2]	147	14	9.5%
2014	September [2]	0	-	-
2014	October [2]	3	0	0.0%
		∑ = 12,269	∑ = 1,776	X = 14.5%

[1] Microphone had lost sensitivity after May of 2013.

[2] There were power/charging malfunctions during these time periods as a result of the theft of the solar panel in June of 2014. See comments in Table 3.

Table 5. Monthly rates of hand confirmation from automated analysis results

Species	No. months with automated identification of species	No. months with hand confirmed identification of species	Percent of months automated identification was hand confirmed
Townsend's Big-eared Bat (*Corynorhinus townsendii*) [1]	7	0	0.0%
Big Brown Bat (*Eptesicus fuscus*)	16	7	43.8%
Silver-haired Bat (*Lasionycterus noctivagans*)	16	15	93.8%
Hoary Bat (*Lasiurus cinereus*)	4	4	100.0%
California Myotis (*Myotis californicus*) [2]	6	0	0.0%
Western Small-footed Myotis (*Myotis ciliolabrum*)	18	14	77.8%
Long-eared Myotis (*Myotis evotis*)	7	7	100.0%
Little Brown Myotis (*Myotis lucifugus*)	16	15	93.8%
Long-legged Myotis (*Myotis volans*) [3]	8	0	0.0%
Yuma Myotis (*Myotis yumanensis*) [4]	9	0	0.0%

[1] Species is relatively quiet and often does not create fully definitive echolocation call recordings on bat detectors.

[2] California Myotis calls can overlap with Western Small-footed Myotis, Yuma Myotis, and Little Brown Myotis calls (Maxell 2015). Several call sequences were auto-identified as California Myotis. However, these call sequences lacked the definitive characteristics necessary to confirm the species presence. The species presence in the region is currently based on a single call sequence recorded in 2006. Mist net capture and morphological verification is needed.

[3] Long-legged Myotis calls can overlap with Western Small-footed Myotis, Long-eared Myotis, Little Brown Myotis, and Fringed Myotis calls and rarely have call characteristics recorded that allow them to be definitively identified as Long-legged Myotis (Maxell 2015). Several call sequences were auto-identified as Long-legged Myotis. However, these call sequences lacked the definitive characteristics necessary to confirm the species presence.

[4] Yuma Myotis calls can overlap with Little Brown Myotis and California Myotis calls (Maxell 2015). We classified two call sequences that were auto-identified as Yuma Myotis as probable and two other sequences meet all the definitive characteristics of Yuma Myotis. However, because this region is outside the range where the species has been documented with mist net captures, we plan to regard all of these sequences as potentially Yuma Myotis until there is genetic confirmation of the species in the region.

Table 6. Species definitively detected by month each year of the study[1, 2]

Species	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Big Brown Bat (*Eptesicus fuscus*)						🟦 2012 2014	2012	🟦 2012 2013	2012	2012 2013		
Silver-haired Bat (*Lasionycteris noctivagans*)			2012	2012 2013	2012 2014	🟦 2012	🟦 2012 2014	🟦 2012 2014	🟦 2012 2013	2012 2013	2012	
Hoary Bat (*Lasiurus cinereus*)						🟦	🟦 2012 2014	🟦 2012 2013 2014	2012 2013			
California Myotis (*Myotis californicus*)[3]								🟦				
Western Small-footed Myotis (*Myotis ciliolabrum*)			2013	2013	2012 2013 2014	🟦 2012	🟦 2012 2013 2014	🟦 2012 2013 2014	2012 2013			
Long-eared Myotis (*Myotis evotis*)					2012 2013 2014	🟦 2012 2013 2014	🟦 2012 2013 2014	🟦 2012 2013 2014	2012	2012		
Little Brown Myotis (*Myotis lucifugus*)				2012 2013	2012 2013	🟦 2012	🟦 2013 2014	🟦 2012 2013 2014	2012 2013	2012 2013		
Long-legged Myotis (*Myotis volans*)[4]						🟦		🟦				

[1] Blue cells of table indicate documentation of the species in the region during this month prior to this study

[2] See comments in Table 3 on periods of time when there were detector/recorder, microphone, or power system malfunctions.

[3] California Myotis calls can overlap with Western Small-footed Myotis, Yuma Myotis, and Little Brown Myotis calls (Maxell 2015). Several call sequences were auto-identified as California Myotis. However, these call sequences lacked the definitive characteristics necessary to confirm the species presence. The species presence in the region is currently based on a single call sequence recorded in 2006. Mist net capture and morphological verification is needed.

[4] Long-legged Myotis calls can overlap with Western Small-footed Myotis, Long-eared Myotis, Little Brown Myotis, and Fringed Myotis calls and rarely have call characteristics recorded that allow them to be definitively identified as Long-legged Myotis (Maxell 2015). Several call sequences were auto-identified as Long-legged Myotis. However, these call sequences lacked the definitive characteristics necessary to confirm the species presence.

Table 7. Species definitively detected by month across the acoustic detector network (blue cells) and at the Big Sheep Creek detector (X)

Species	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Big Brown Bat (*Eptesicus fuscus*)	🟦	🟦	🟦	🟦	🟦	🟦 X	🟦 X	🟦 X	🟦 X	🟦 X	🟦	🟦
Silver-haired Bat (*Lasionycteris noctivagans*)	🟦	🟦	🟦 X	🟦 X	🟦 X	🟦 X	🟦 X	🟦 X	🟦 X	🟦 X	🟦 X	🟦
Hoary Bat (*Lasiurus cinereus*)				🟦	🟦	🟦	🟦 X	🟦 X	🟦 X	🟦		
California Myotis (*Myotis californicus*)[1]			🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	
Western Small-footed Myotis (*Myotis ciliolabrum*)	🟦	🟦	🟦 X	🟦 X	🟦 X	🟦 X	🟦 X	🟦 X	🟦 X	🟦	🟦	🟦
Long-eared Myotis (*Myotis evotis*)				🟦	🟦 X	🟦 X	🟦 X	🟦 X	🟦 X	🟦 X	🟦	
Little Brown Myotis (*Myotis lucifugus*)		🟦	🟦	🟦 X	🟦 X	🟦 X	🟦 X	🟦 X	🟦 X	🟦 X	🟦	
Long-legged Myotis (*Myotis volans*)[2]					🟦		🟦	🟦	🟦			

[1] California Myotis calls can overlap with Western Small-footed Myotis, Yuma Myotis, and Little Brown Myotis calls (Maxell 2015). Several call sequences were auto-identified as California Myotis. However, these call sequences lacked the definitive characteristics necessary to confirm the species presence. The species presence in the region is currently based on a single call sequence recorded in 2006. Mist net capture and morphological verification is needed.

[2] Long-legged Myotis calls can overlap with Western Small-footed Myotis, Long-eared Myotis, Little Brown Myotis, and Fringed Myotis calls and rarely have call characteristics recorded that allow them to be definitively identified as Long-legged Myotis (Maxell 2015). Several call sequences were auto-identified as Long-legged Myotis. However, these call sequences lacked the definitive characteristics necessary to confirm the species presence.

Table 8. Bat passes summarized by month across all species

Year	Month	Total no. bat passes	No. sample nights[1]	Avg no. of nightly passes	StDev of nightly passes	Min count of nightly bat passes	Max count of nightly bat passes
2012	1	0	1	0		0	0
2012	2	2	29	0.1	0.3	0	1
2012	3	31	31	1	2	0	6
2012	4	211	30	7.2	12.4	0	62
2012	5	567	31	18.8	28.9	0	117
2012	6	1382	30	46.1	54.9	0	212
2012	7	1745	31	56.3	58	4	320
2012	8	2027	31	65.4	46.6	15	201
2012	9	1845	30	61.5	75.3	2	284
2012	10	832	31	26.8	52	0	204
2012	11	15	30	0.5	1.4	0	6
2012	12	1	31	0	0.2	0	1
2013	1	0	31	0	0	0	0
2013	2	0	28	0	0	0	0
2013	3	23	31	0.7	2.9	0	16
2013	4	102	30	3.4	5.4	0	23
2013	5	97	31	3.1	4.8	0	22
2013	6	76	30	2.5	3.3	0	15
2013	7	335	31	10.8	15.1	0	74
2013	8	449	31	14.5	12.8	1	58
2013	9	723	30	24.1	34.1	0	118
2013	10	896	31	28.9	63.5	0	322
2013	11	3	30	0.1	0.5	0	3
2013	12	0	31	0	0	0	0
2014	1	0	31	0	0	0	0
2014	2	0	28	0	0	0	0
2014	3	0	31	0	0	0	0
2014	4	47	30	1.6	2.7	0	13
2014	5	60	31	1.9	2.5	0	12
2014	6	176	25	7	9.2	0	32
2014	7	453	21	21.6	15.1	2	52
2014	8	147	13	11.3	10.2	4	43
2014	9	-	0	-	-	-	-
2014	10	3	19	0.2	0.5	0	2

[1] Number of nights the detector/recorder was powered and logging temperatures and capable of recording bat passes. See Table 3 for periods of time when microphones had lost sensitivity or the detector recorder had power issues and may not have been functioning properly. There were large time periods between 26 June and 25 October of 2014 when the detector/recorder was not properly powered.

Table 9. Nightly background and bat pass temperatures summarized by month[1]

Year	Month	Background Temp C Avg (SD) N	Bat Pass Temp C Avg (SD) N	Background Min Temp C [2]	Bat Pass Min Temp C	Background Max Temp C	Bat Pass Max Temp C
2012	1	-6.0 (3.2) 98	[3]	-11.2	[3]	-1.5	[3]
2012	2	-4.6 (5.1) 8462	3.3 (3.7) 2	-20.5	0.6	6.7	5.9
2012	3	1.2 (5.2) 10516	9 (2.2) 31	-20.5	3.7	12.2	11.8
2012	4	0 (3.2) 5052	6.4 (2.2) 28	-13.2	-0.1	11.8	11.7
2012	5	6.4 (5.2) 2329	14.8 (4.1) 473	-4.1	2.4	20.3	20.3
2012	6	9.5 (5.5) 3092	16.5 (4.4) 1382	-1.6	2.7	23.7	23.7
2012	7	14.7 (4.2) 3323	17.8 (3.3) 1745	1.6	3.1	25.1	24.9
2012	8	13.5 (4.8) 3752	17.2 (3.7) 2027	0.1	6.7	26.7	26.5
2012	9	9.1 (5.2) 4176	16.5 (2.1) 1845	-2.8	4.2	21.9	21.9
2012	10	1 (5.7) 6491	14.3 (2.9) 832	-13.9	4.4	17.4	17.4
2012	11	-2.1 (6.1) 16440	8.5 (2.1) 15	-20.5	4.7	11.5	11.3
2012	12	-5.5 (5.7) 19968	5.2 (4) 1	-20.5	5.2	7.2	5.2
2013	1	-10 (5.4) 12255	[3]	-20.5	[3]	3.1	[3]
2013	2	-4.7 (3.9) 9300	[3]	-20.5	[3]	3.4	[3]
2013	3	-1.9 (4.8) 4509	6.5 (1.4) 23	-14.2	3.9	9.4	8
2013	4	0.7 (4.7) 3808	8.8 (3.2) 102	-11.4	2.9	14.5	14.5
2013	5	6.6 (4.2) 3421	13.3 (3.9) 97	-8.2	6.7	20.4	20.4
2013	6	10.2 (5.1) 3078	15.8 (4.1) 76	-0.6	7.7	22.9	22.7
2013	7	14.5 (4) 3314	19.4 (3) 335	6.4	8.2	24.7	24.7
2013	8	13.9 (4.3) 3746	16.9 (3.8) 449	5.9	7.2	25.7	25.2
2013	9	10.5 (5) 4166	14.9 (4.4) 723	-0.6	4.4	22.1	21.7
2013	10	1.6 (4.1) 4875	10.7 (2.3) 896	-7.7	1.4	13.5	13.5
2013	11	-2.1 (5.3) 5207	3 (1) 3	-16.2	2.4	9.5	4.1
2013	12	-7.8 (8) 5637	[3]	-20.5	[3]	8.2	[3]
2014	1	-4.8 (4.8) 5490	[3]	-17.3	[3]	4.6	[3]
2014	2	-5.5 (7.4) 4592	[3]	-20.5	[3]	7	[3]
2014	3	-0.5 (5.3) 4527	[3]	-15	[3]	10.2	[3]
2014	4	2.1 (4.4) 3823	7.2 (2.8) 47	-10.7	0.1	14.1	13.5

Table 9. Continued.

Year	Month	Background Temp C Avg (SD) N	Bat Pass Temp C Avg (SD) N	Background Min Temp C	Bat Pass Min Temp C	Background Max Temp C	Bat Pass Max Temp C
2014	5	6.6 (4.8) 3455	14 (3.4) 60	-5.6	7.2	19.1	19.1
2014	6	8.9 (3.9) 2579	14.7 (2.7) 176	1.1	5.5	20.9	20.8
2014	7	14.9 (4.3) 2228	18.8 (3.5) 453	2.7	4.9	25.1	25.1
2014	8	14.1 (3.4) 1521	17.8 (3.5) 147	7	9	23.1	22.6
2014	9	[3]	[3]	[3]	[3]	[3]	[3]
2014	10	6 (4.4) 2934	13.7 (1.2) 3	-4.3	13	15.3	15.1

[1] Temperatures should only be regarded as being indicative of the general temperature at the time of detection. Temperatures were recorded at the detector approximately 1 meter above ground level while microphones were mounted at approximately 3 meters above ground level and bats were in flight at an unknown altitude, but probably typically within 30 meters of ground level. Temperatures of the bat's roost environment at the time flights were initiated are also obviously unknown.

[2] It appears that the SM2 detector/recorder failed to record temperatures below -20.5 °C given that it was the lowest temperature recorded on eight separate months.

[3] No calls recorded. See Table 3 for periods of time when microphones had lost sensitivity or the detector recorder had power issues and may not have been functioning properly. There were large time periods between 26 June and 25 October of 2014 when the detector/recorder was not properly powered.

[4] Cannot calculate standard deviation with a single value.

Table 10. Monthly minimum bat pass temperatures (°C) recorded for individual species hand confirmed as definitively present[1]

Species[2]	Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
EPFU	2012						16.6	19.3	15.8	16.1	17.4		
EPFU	2013								15.6		2.2		
EPFU	2014						14.5						
LACI	2012							16.8	17.1	13.2			
LACI	2013								19.9	4.4			
LACI	2014							15.6	15.8				
LANO	2012			5.7	5.7	15	19.6	16.1	15.1	16.3	4.4	4.7	
LANO	2013				9.2					18.1	3.1		
LANO	2014					19.1		17.1	17				
MYCI	2012					18.9	6.2	17.4	8.7	14.6			
MYCI	2013			7.2	6.5	12.8		21.4	11	13			
MYCI	2014					16.5		15.1	19.9				
MYEV	2012					12	8.9	8	15	11	10.3		
MYEV	2013					6.7	10.2	22.9	8.2				
MYEV	2014					8.7	11.8	13.8	17				
MYLU	2012					8.5	10.7	12.2	18.4	17.9	9.7		
MYLU	2013				14.5	12.7		14	15.6	18.9	11.3		
MYLU	2014							20.3	19.9				

[1] Temperatures should only be regarded as being indicative of the general temperature at the time of detection. Temperatures were recorded at the detector approximately 1 meter above ground level while microphones were mounted at approximately 3 meters above ground level and bats were in flight at an unknown altitude, but probably typically within 30 meters of ground level. Temperatures of the bat's roost environment at the time flights were initiated are also obviously unknown.

[2] Species codes are the first two letters of the genus and species names.

Table 11. Minimum bat pass temperatures recorded for definitive call sequences of species across the detector network and at the Big Sheep Creek detector [1]

Species	Minimum Temperature Recorded (°C) Across Network [2]	Minimum Temperature Recorded (°C) at Big Sheep Detector [3]
Pallid Bat (*Antrozous pallidus*)	5.2	na
Townsend's Big-eared Bat (*Corynorhinus townsendii*)	6.0	na
Big Brown Bat (*Eptesicus fuscus*)	-4.8	2.2
Spotted Bat (*Euderma maculatum*)	1.9	na
Eastern Red Bat (*Lasiurus borealis*)	1.6	na
Silver-haired Bat (*Lasionycteris noctivagans*)	-4.9	3.1
Hoary Bat (*Lasiurus cinereus*)	-0.6	4.4
California Myotis (*Myotis californicus*)	-0.5	na
Western Small-footed Myotis (*Myotis ciliolabrum*)	-4.8	6.2
Long-eared Myotis (*Myotis evotis*)	-2.1	6.7
Little Brown Myotis (*Myotis lucifugus*)	-0.5	8.5
Fringed Myotis (*Myotis thysanodes*)	3.1	na
Long-legged Myotis (*Myotis volans*)	5.5	na
Yuma Myotis (*Myotis yumanensis*)	6.7	na

[1] Temperatures should only be regarded as being indicative of the general temperature at the time of detection. Temperatures were recorded at the detector approximately 1 meter above ground level while microphones were mounted at approximately 3 meters above ground level and bats were in flight at an unknown altitude, but probably typically within 30 meters of ground level. Temperatures of the bat's roost environment at the time flights were initiated are also obviously unknown.

[2] Probable call sequences of Big Brown Bat (-8.4°C), Silver-haired Bat (-7.4°C), Hoary Bat (-2°C), Western Small-footed Myotis (-8.6°C), Long-eared Myotis (-2.9°C) were also recorded.

[3] Probable call sequences of Big Brown Bat (0.6), Big Brown Bat or Silver-haired Bat (-0.1°C), Western Small-footed Myotis (5.5°C), Long-eared Myotis (5.7°C), and Little Brown Myotis (3.9°C) were also recorded. na = outside species' range or not documented in this study.

Figure 1. Network of long term ultrasonic acoustic detectors as of December 2015

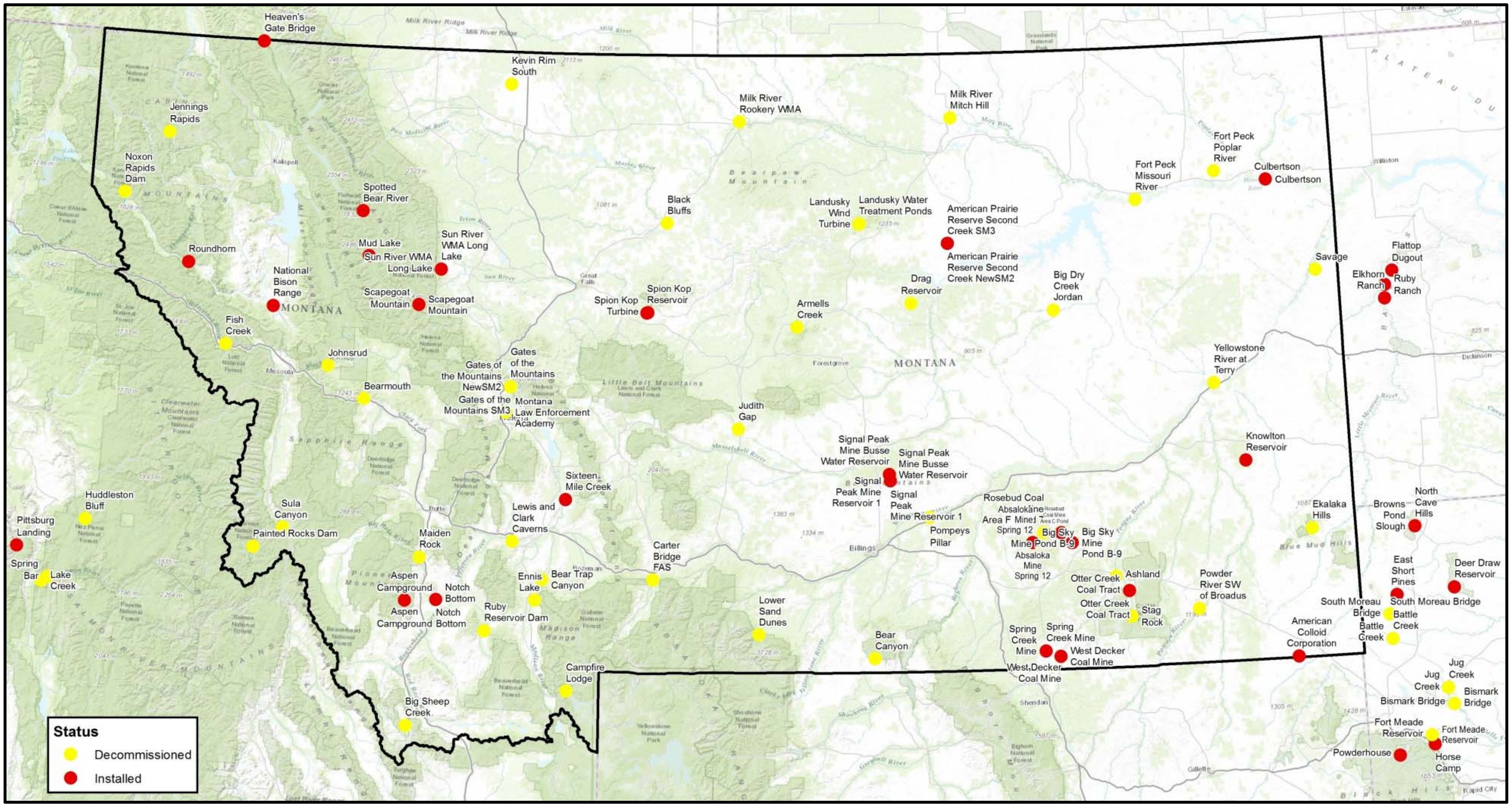


Figure 2. Location of the Big Sheep Creek detector recorder (red x) within the Tendoy Mountains and Harkness weather station (red circle) at landscape (a) and local (b) views.

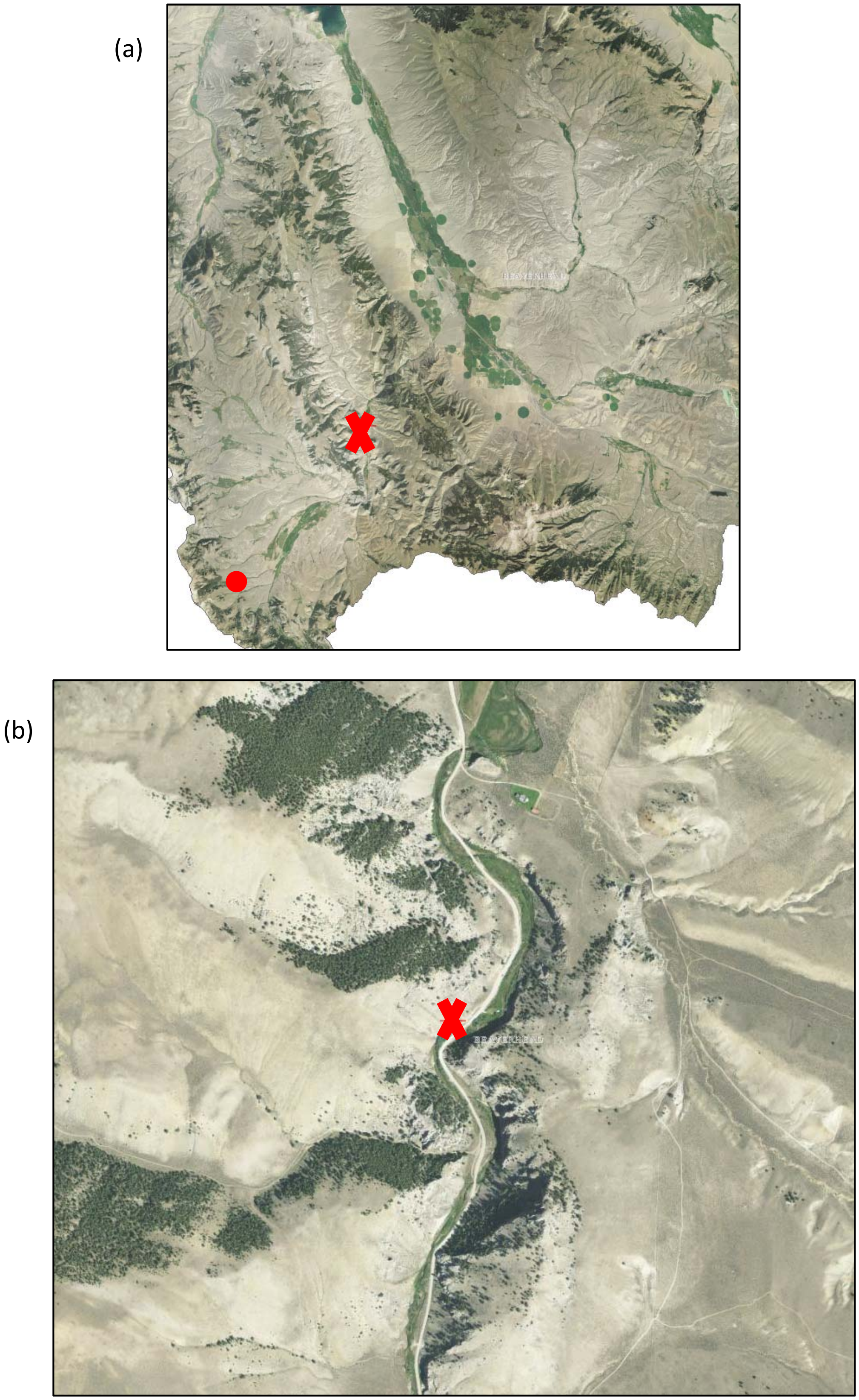


Figure 3. Downslope (a) and upslope (b) views of bat detector on Big Sheep Creek. SM2 Bat+ detector/recorder and solar panel (red squares) and microphone (red star).

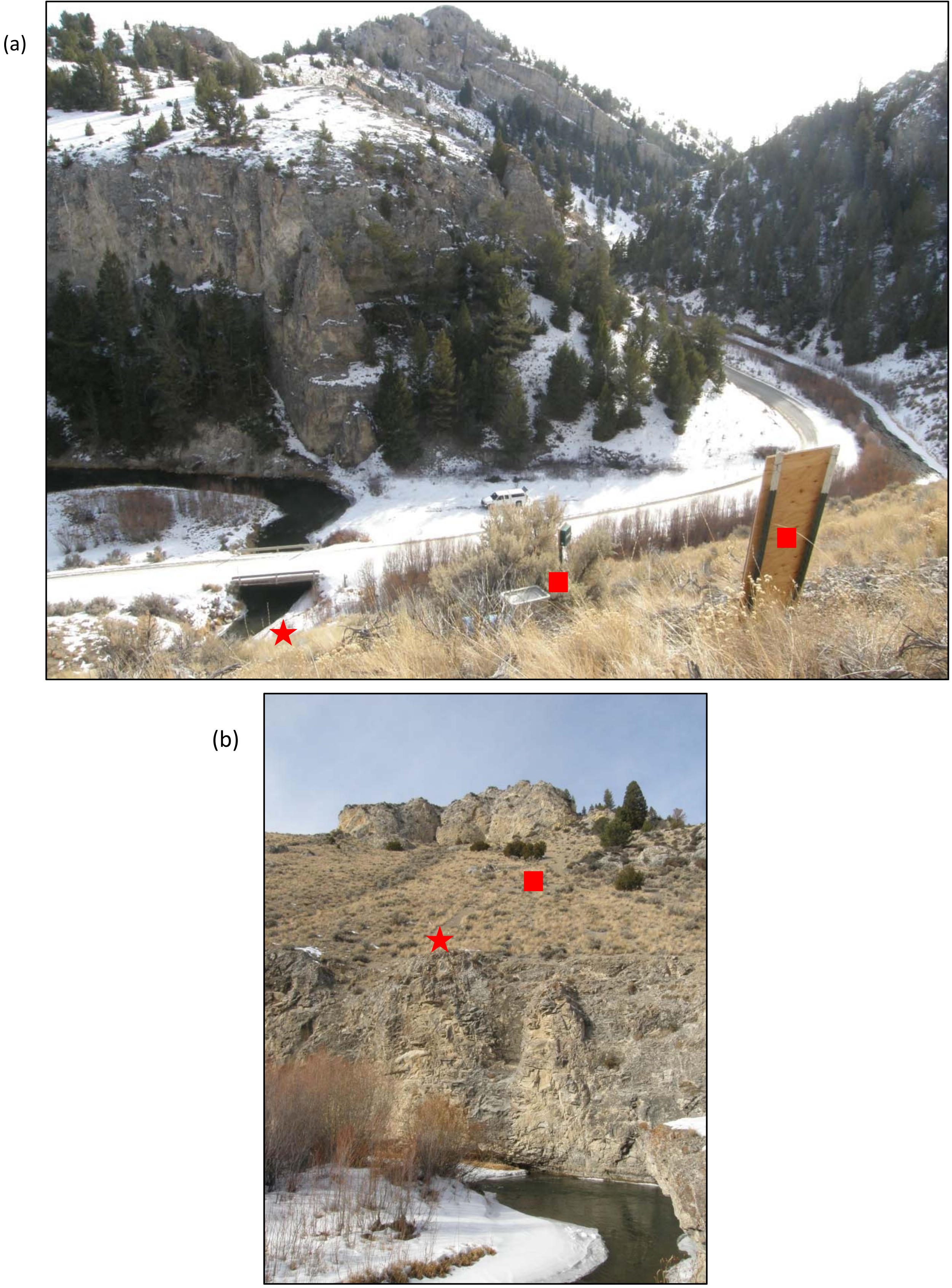


Figure 4. Percent of call sequences auto-identified to species each month.

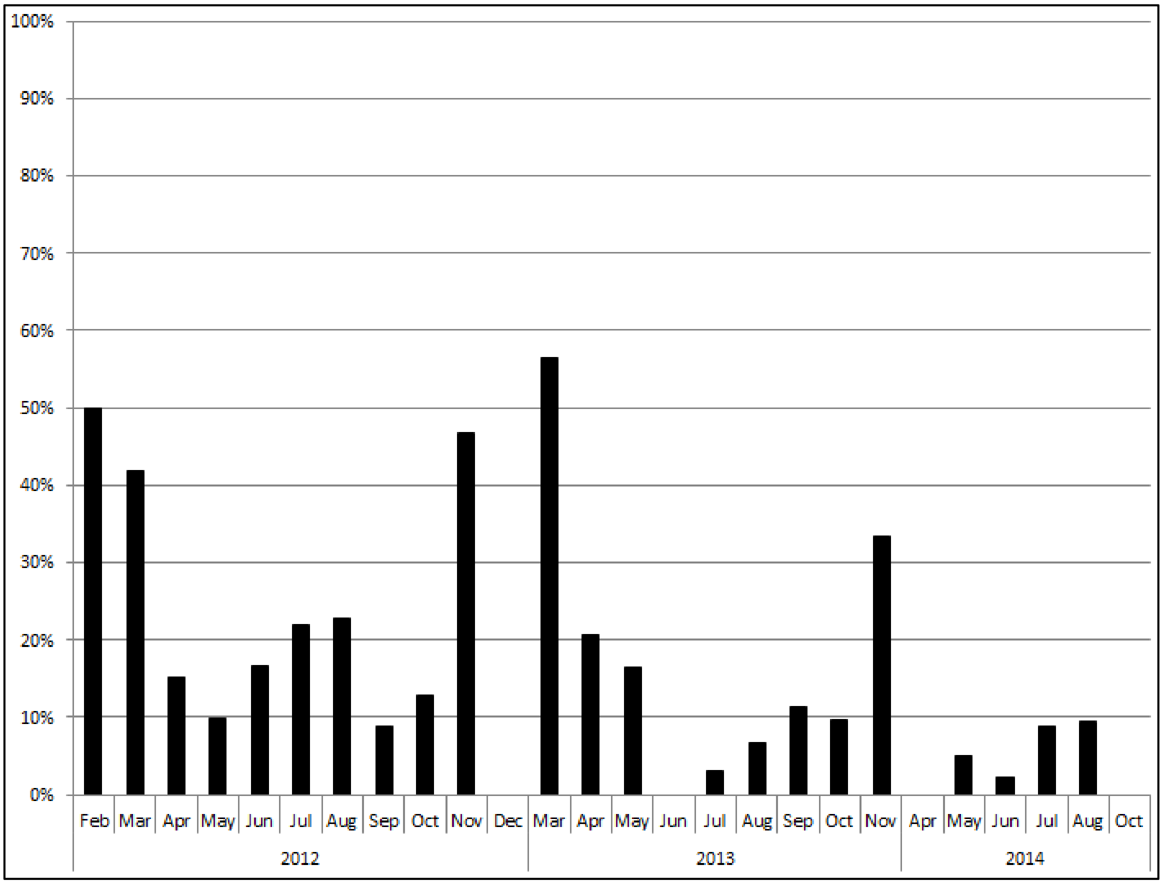


Figure 5. Average (blue) and maximum counts (red) of bat passes per night by month. Numbers on X-axis are years and months.

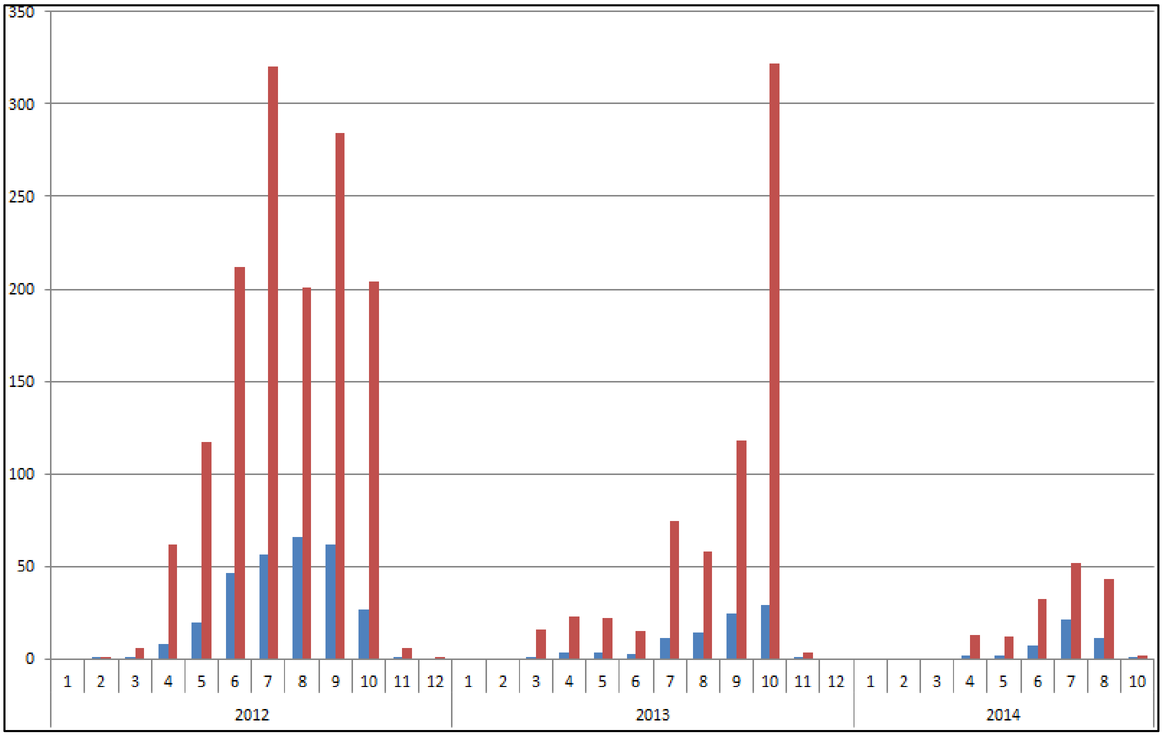


Figure 6. Average number of bat passes per night by week for active season (a) and inactive season (b). Numbers on X axis are years, months, and weeks.

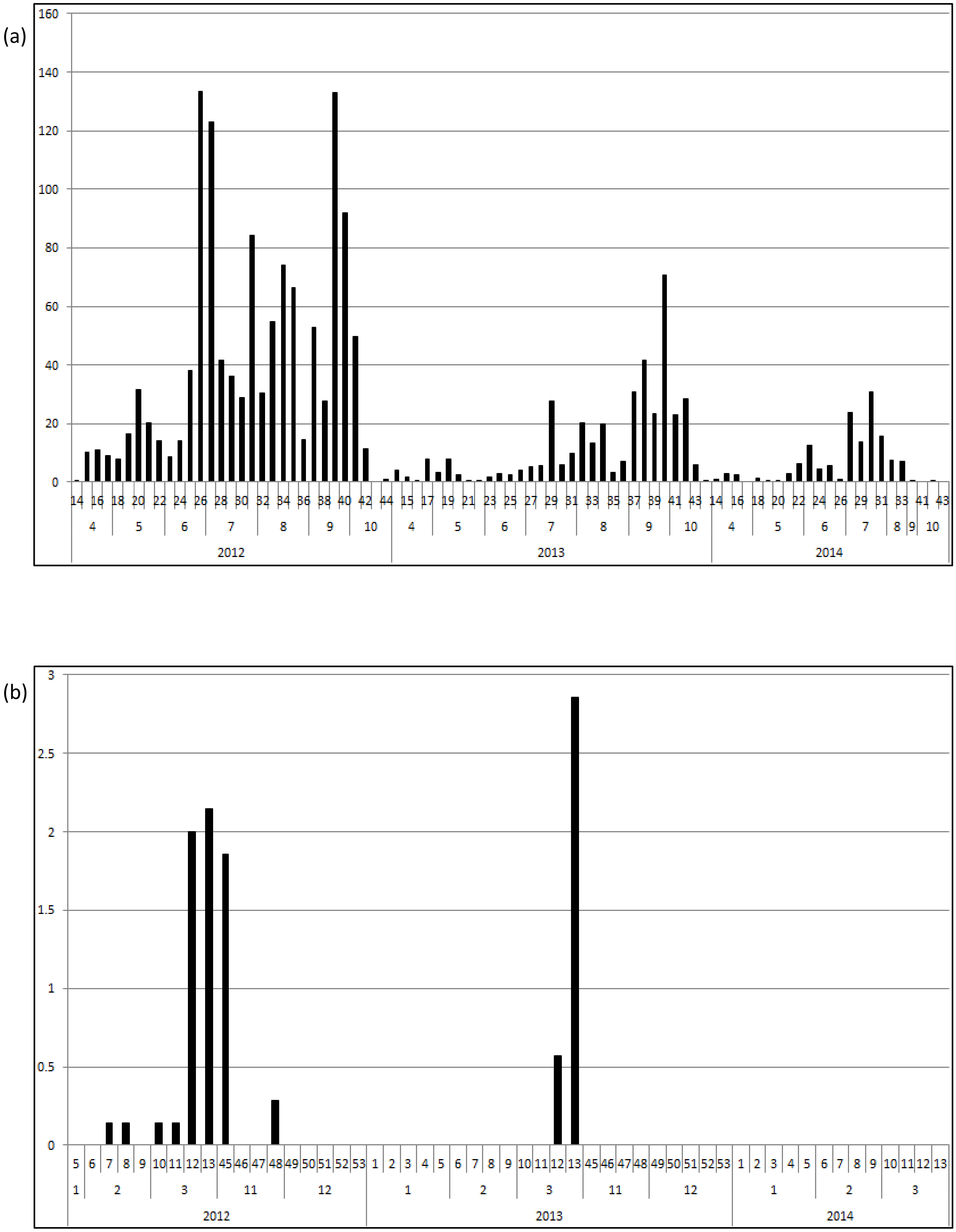


Figure 7. Average number of bat passes per night by week across the detector network for active season (a) and inactive season (b). Numbers on X axis are years, months, and weeks.

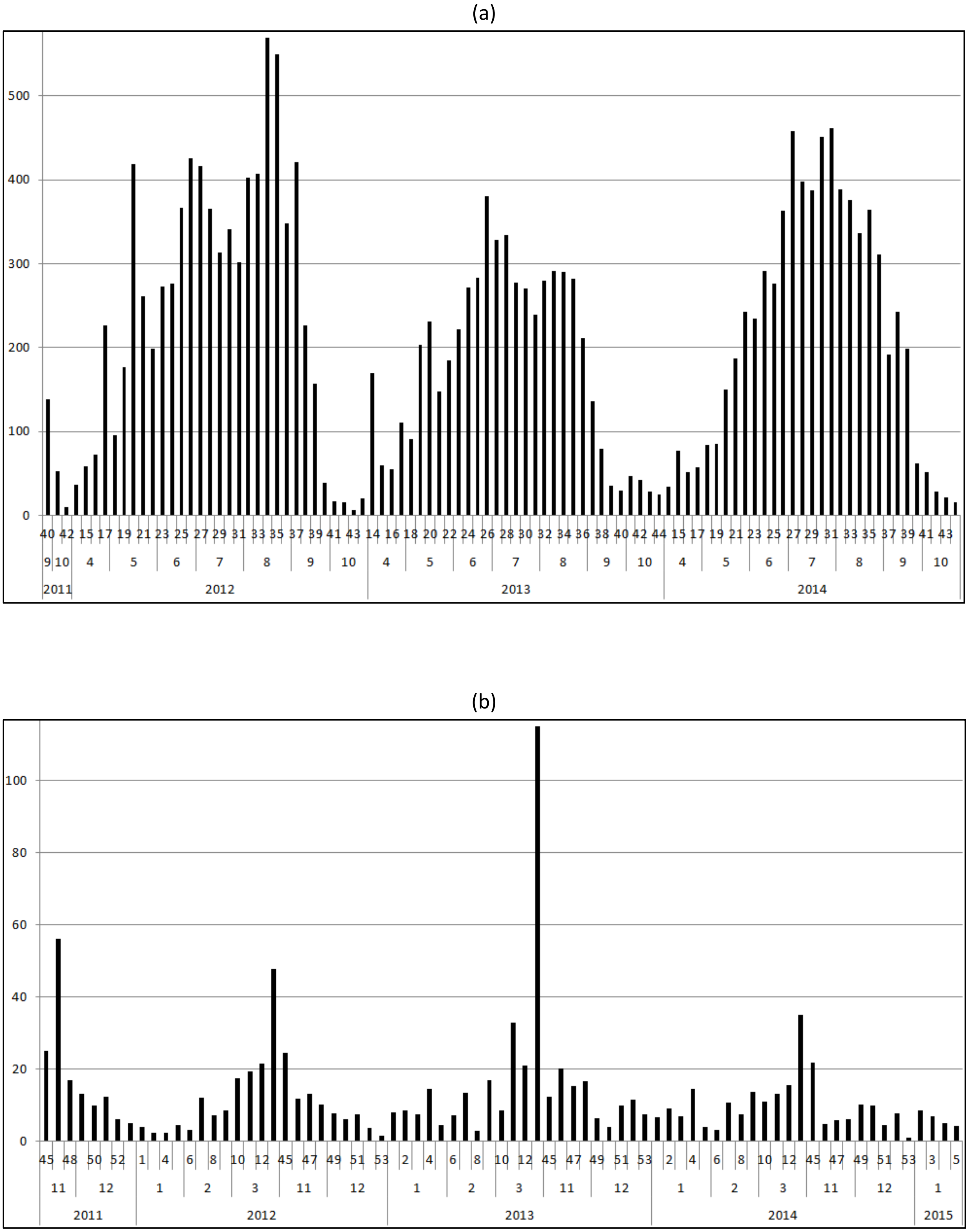


Figure 8. Total number of bat passes per night by week across the detector network and across all years for active season (a) and inactive season (b) as of fall 2015.

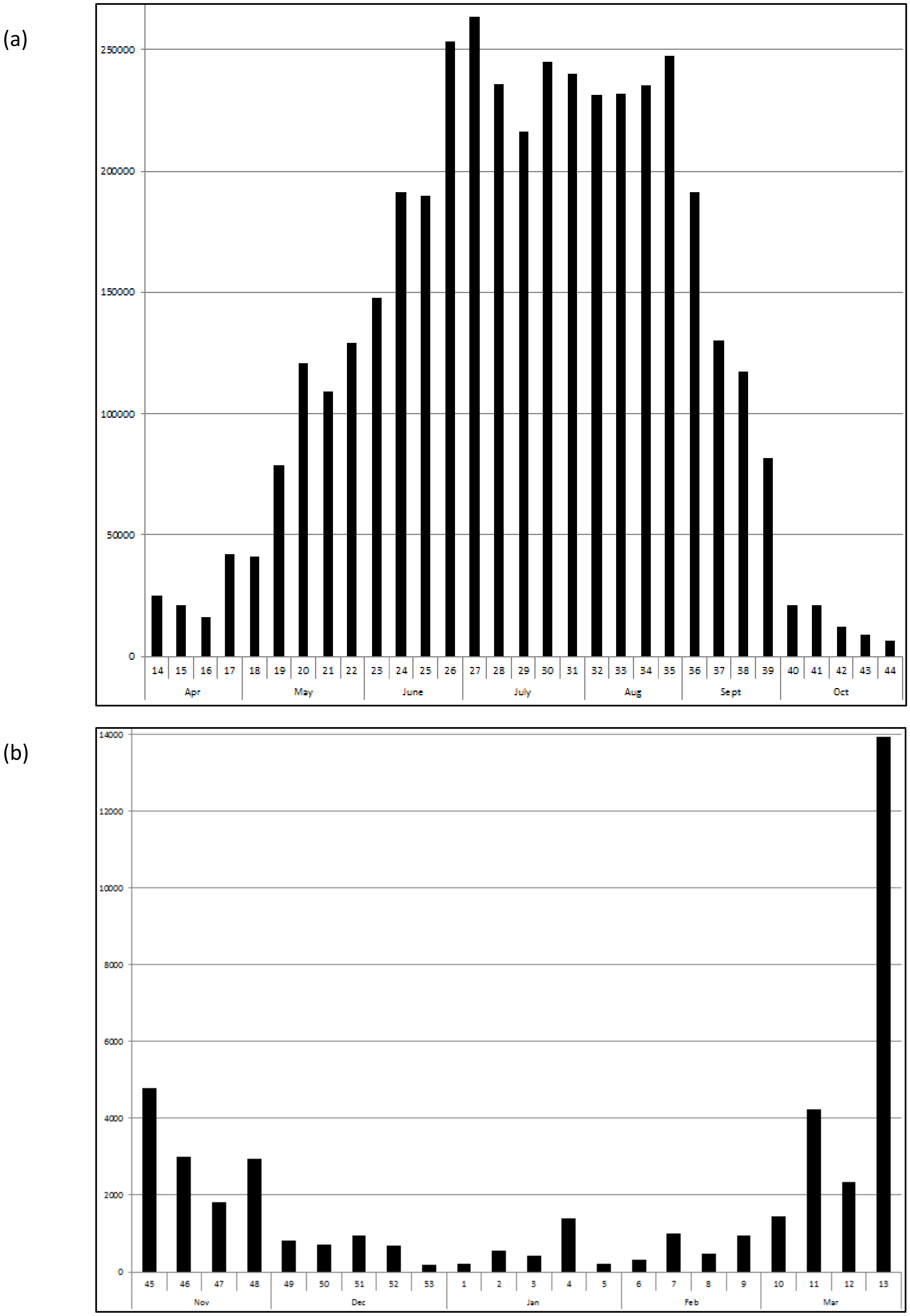
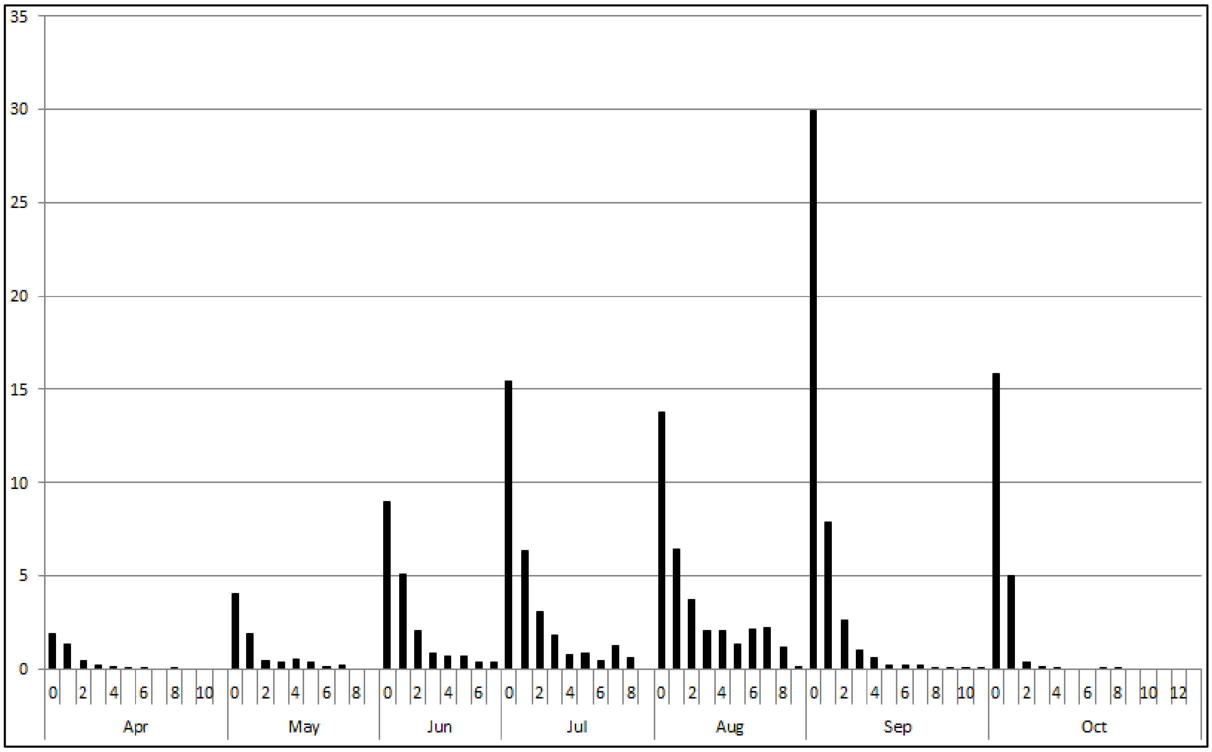


Figure 9. Average number of bat passes each hour after sunset across all years during active (a) and inactive season (b). Numbers on X axis are months and weeks.

(a)



(b)

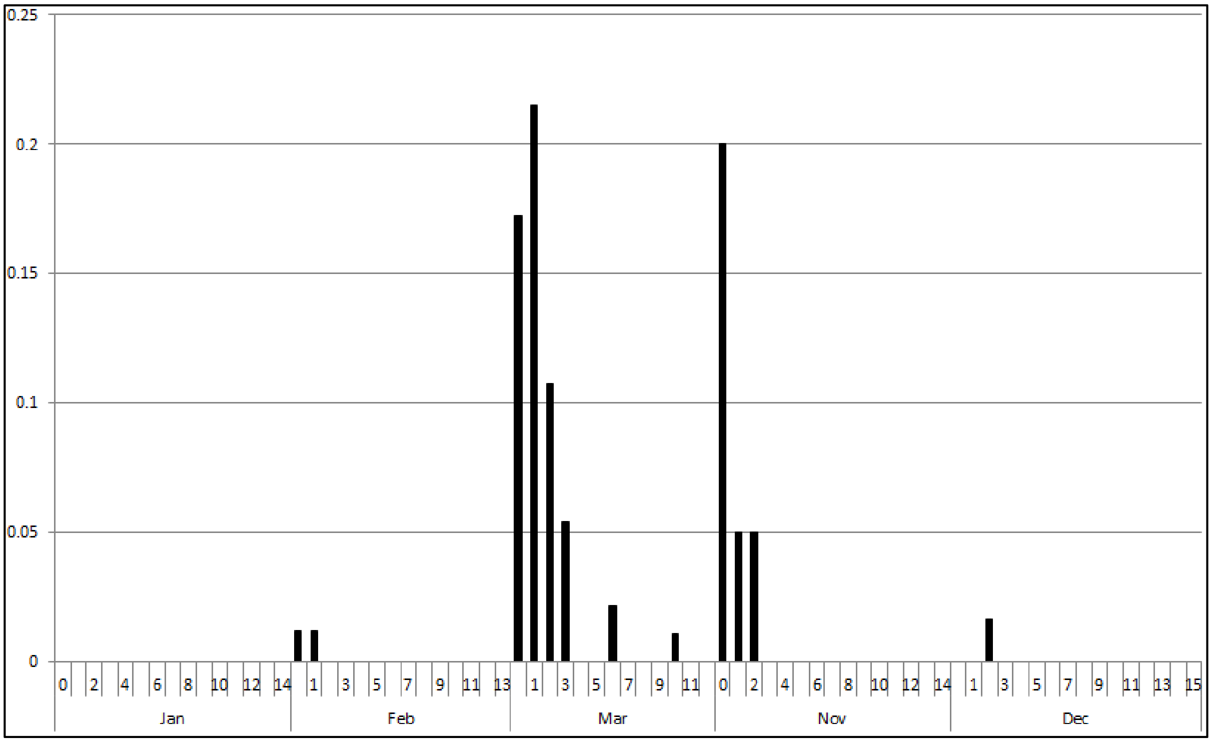


Figure 10. Average nightly background (blue) and bat pass (red) temperatures by month. Numbers on X axis are years and months.

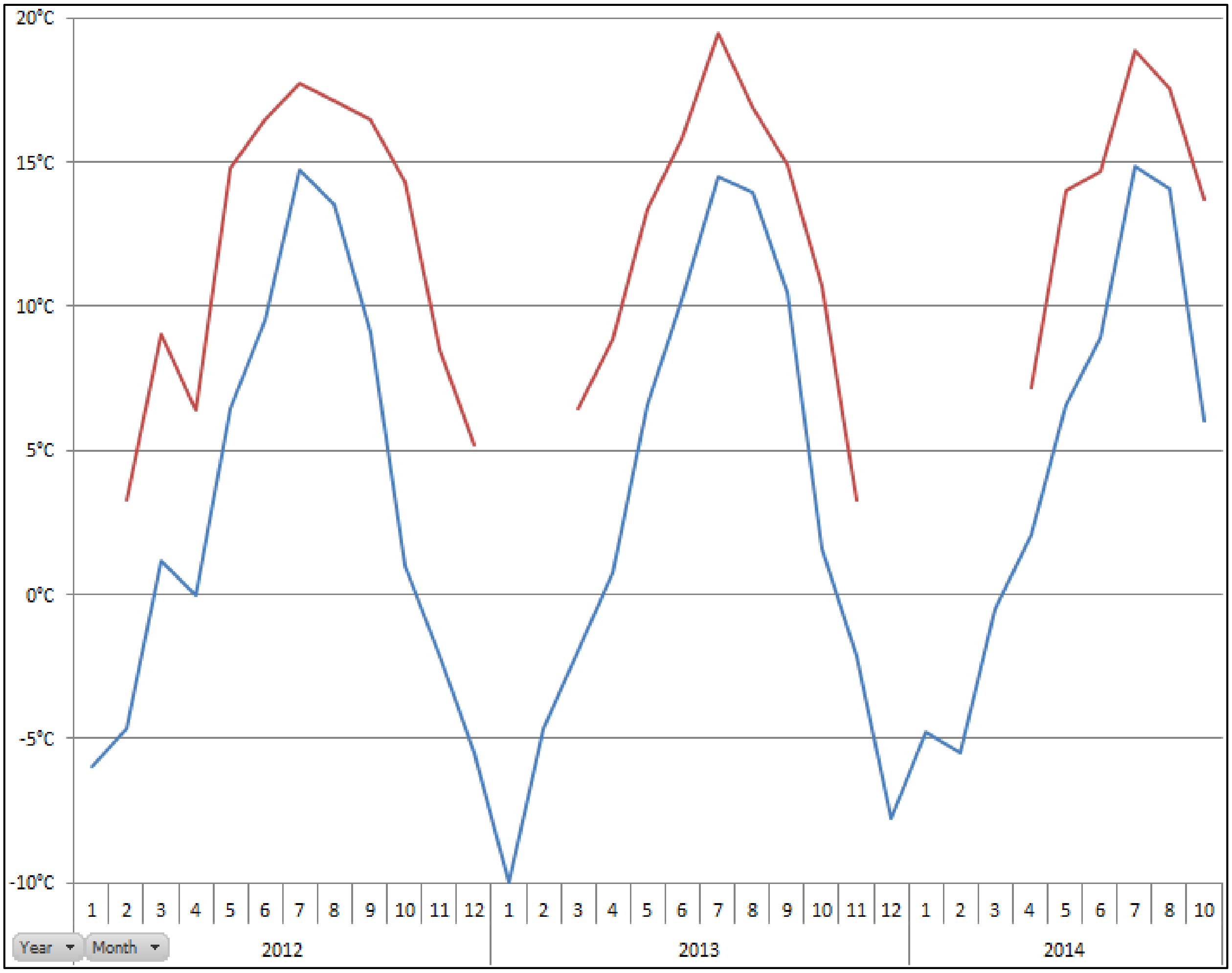


Figure 11. Percent of nightly hours with average background temperatures (blue) and average temperatures associated with bat passes (red) for the Harkness weather station which is 20.1 kilometers to the southwest. Numbers are lower ends of °C temperature bins.

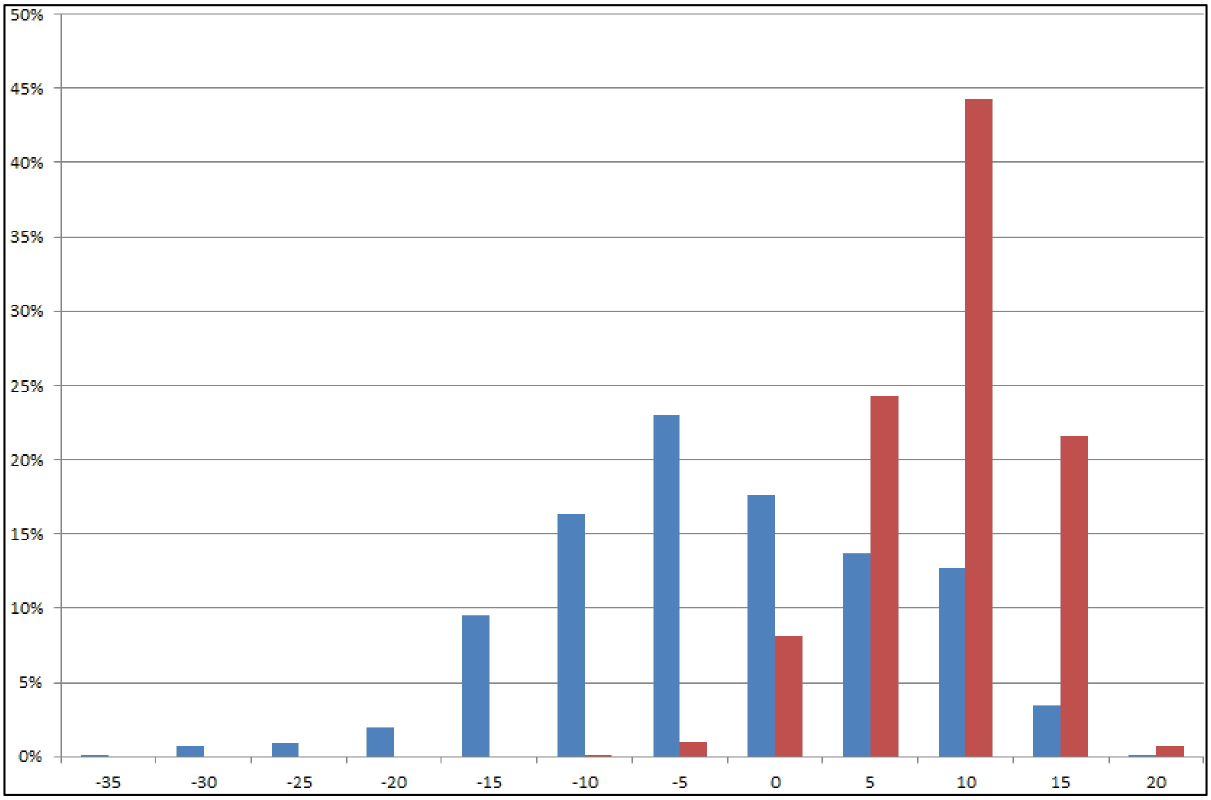


Figure 12. Percent of nightly hours with average background temperatures (blue) and average temperatures associated with bat passes (red) across the regional network of detectors. Numbers are lower ends of °C temperature bins. Of the 467,512 hours that detectors have been deployed, temperature data was available from nearby weather stations for 457,613 hours (98%). Note that some detectors were up to 43 kilometers from the weather station where temperatures were recorded (X = 14.9 km, SD = 10.3 km).

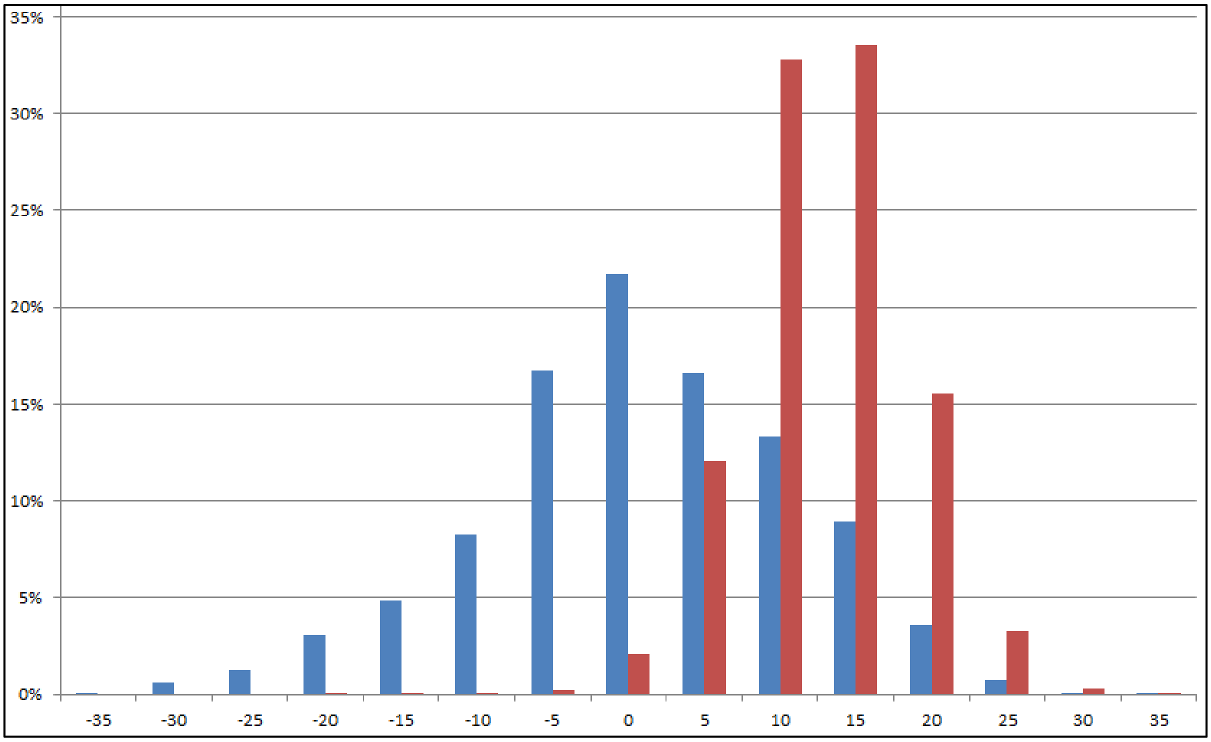


Figure 13. Percent of hours with average background wind speeds (blue) and average wind speeds associated with bat passes (red) at the Harkness weather station which is 20.1 kilometers to the southwest. Wind speed categories are meters per second.

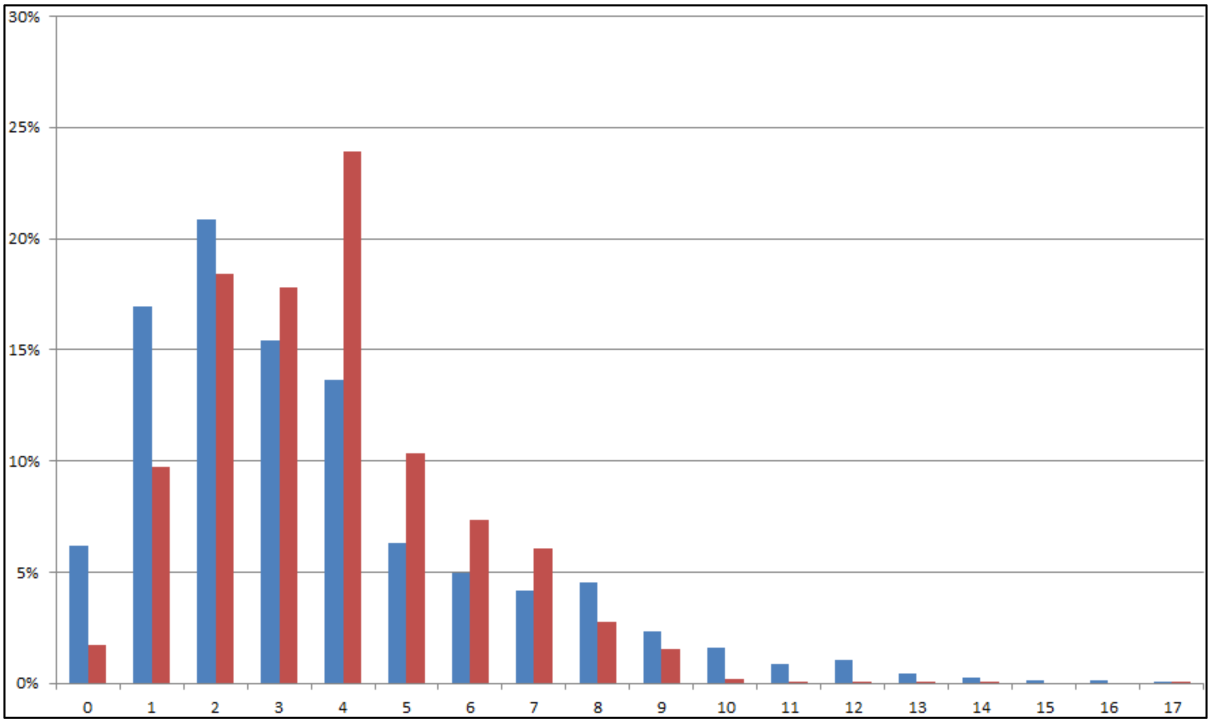


Figure 14. Percent of hours with average background wind speeds (blue) and average wind speeds associated with bat passes (red) across the regional network of detectors. Wind speed categories are meters per second. Of the 467,512 hours that detectors have been deployed, wind speed data was available from nearby weather stations for 455,361 hours (97%). Note that some detectors were up to 43 kilometers from the weather station where wind speeds were recorded (X = 16.9 km, SD = 10.5 km).

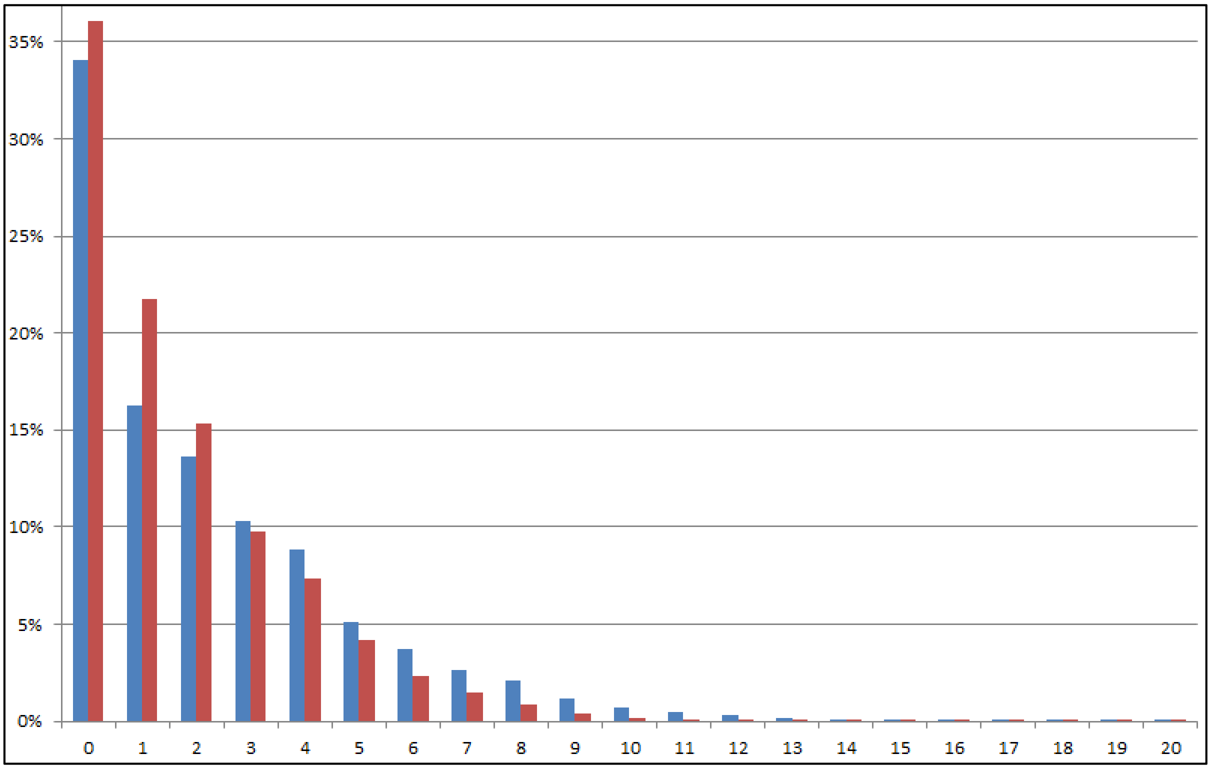


Figure 15. Percent of hours with background barometric pressure changes (blue) and barometric pressure changes associated with bat passes (red) at the Dillon Airport weather station which is 74.4 kilometers to the north-northeast. Numbers shown are the lower ends of categories of millibars of change per hour.

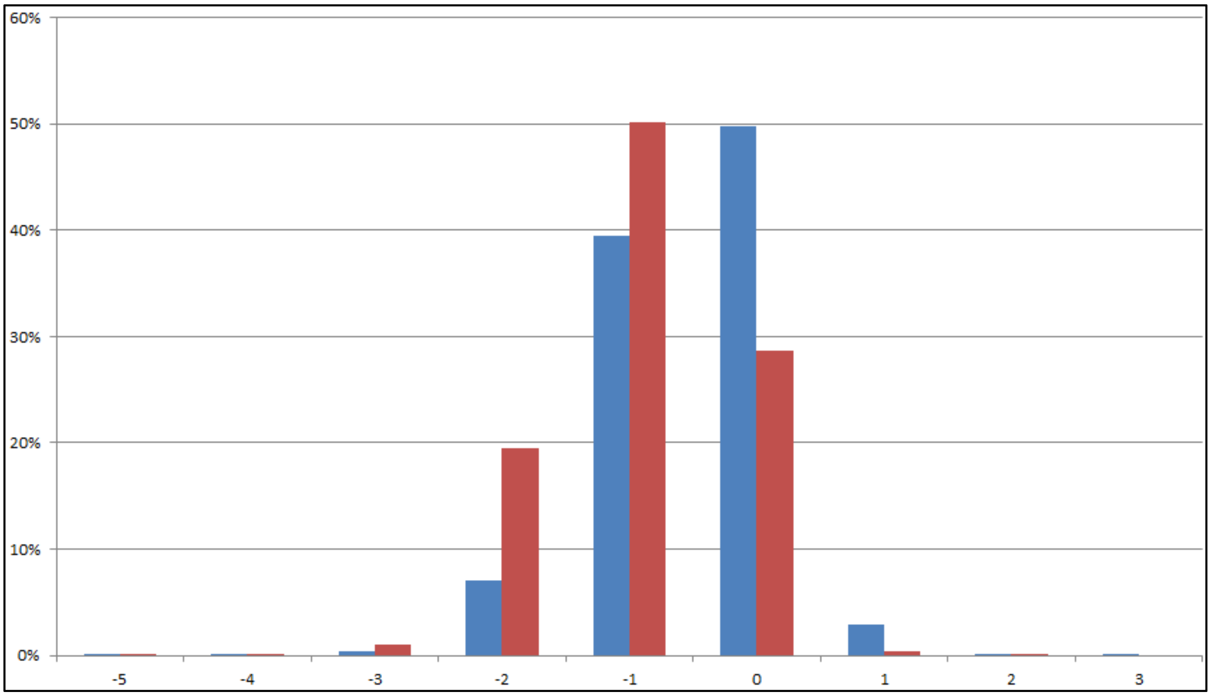


Figure 16. Percent of hours with background barometric pressure changes (blue) and barometric pressure changes associated with bat passes (red) across the regional network of detectors. Numbers shown are the lower ends of categories of millibars of change per hour. Of the 467,512 hours that detectors have been deployed, barometric pressure data was available from nearby weather stations for 420,412 hours (90%). Note that some detectors were up to 94 kilometers from the weather station where barometric pressures were recorded (X = 35.4 km, SD = 21.5 km).

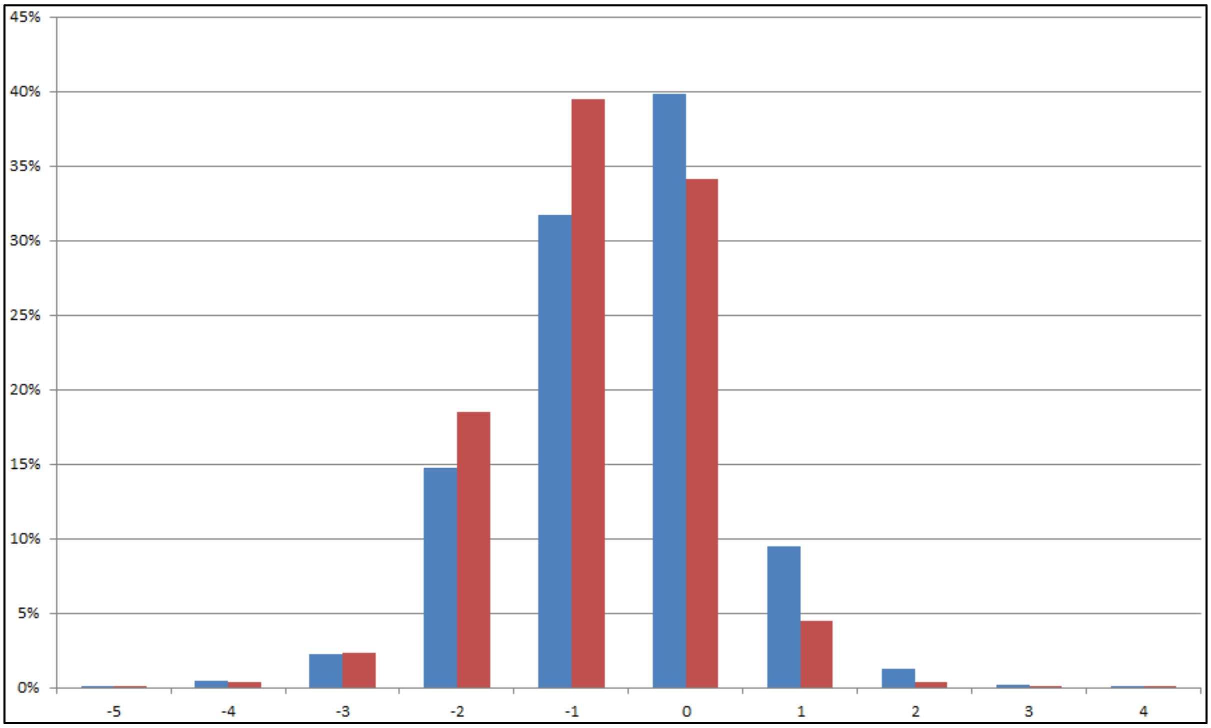


Figure 17. Percent of background hours (blue) and hours with bat passes (red) with (0) and without (1) precipitation at the Harkness weather station which is 20.1 kilometers to the southwest.

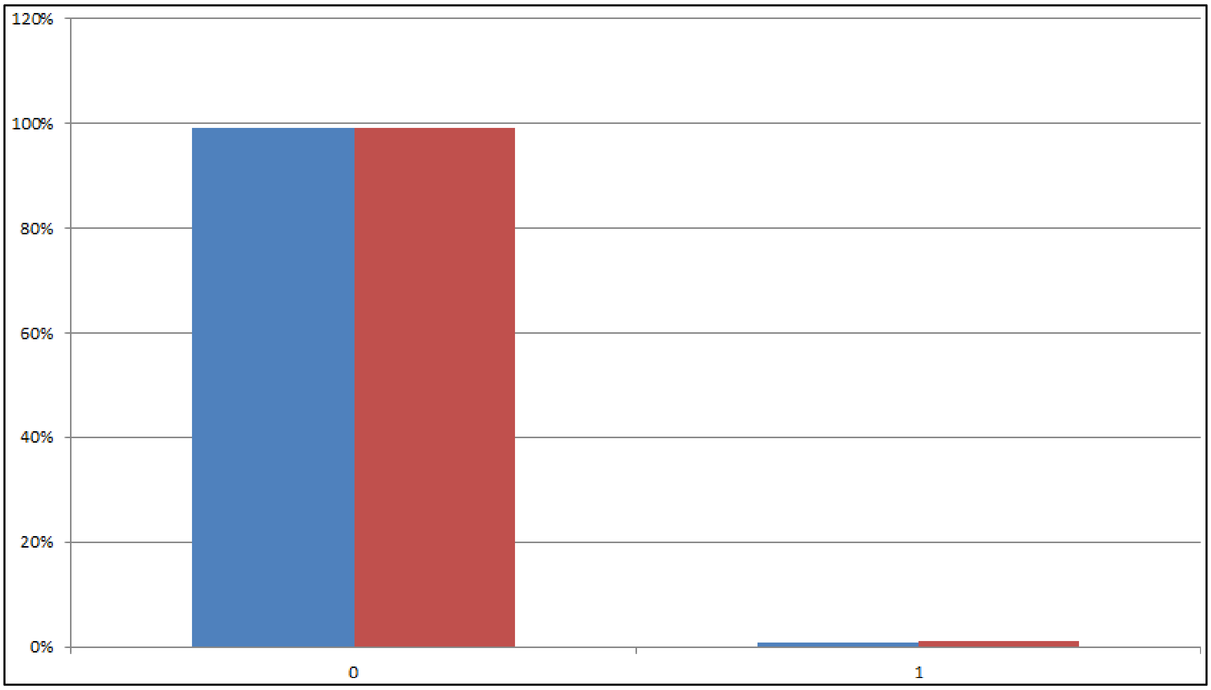


Figure 18. Percent of background hours (blue) and hours with bat passes (red) with (0) and without (1) precipitation across the regional network of detectors. Of the 467,512 hours that detectors have been deployed, precipitation data was available from nearby weather stations for 454,006 hours (97%). Note that some detectors were up to 75 kilometers from the weather station where precipitation events were recorded (X = 30.0 km, SD = 14.2 km) and bats are capable of flight within minutes of the passing of a rain shower.

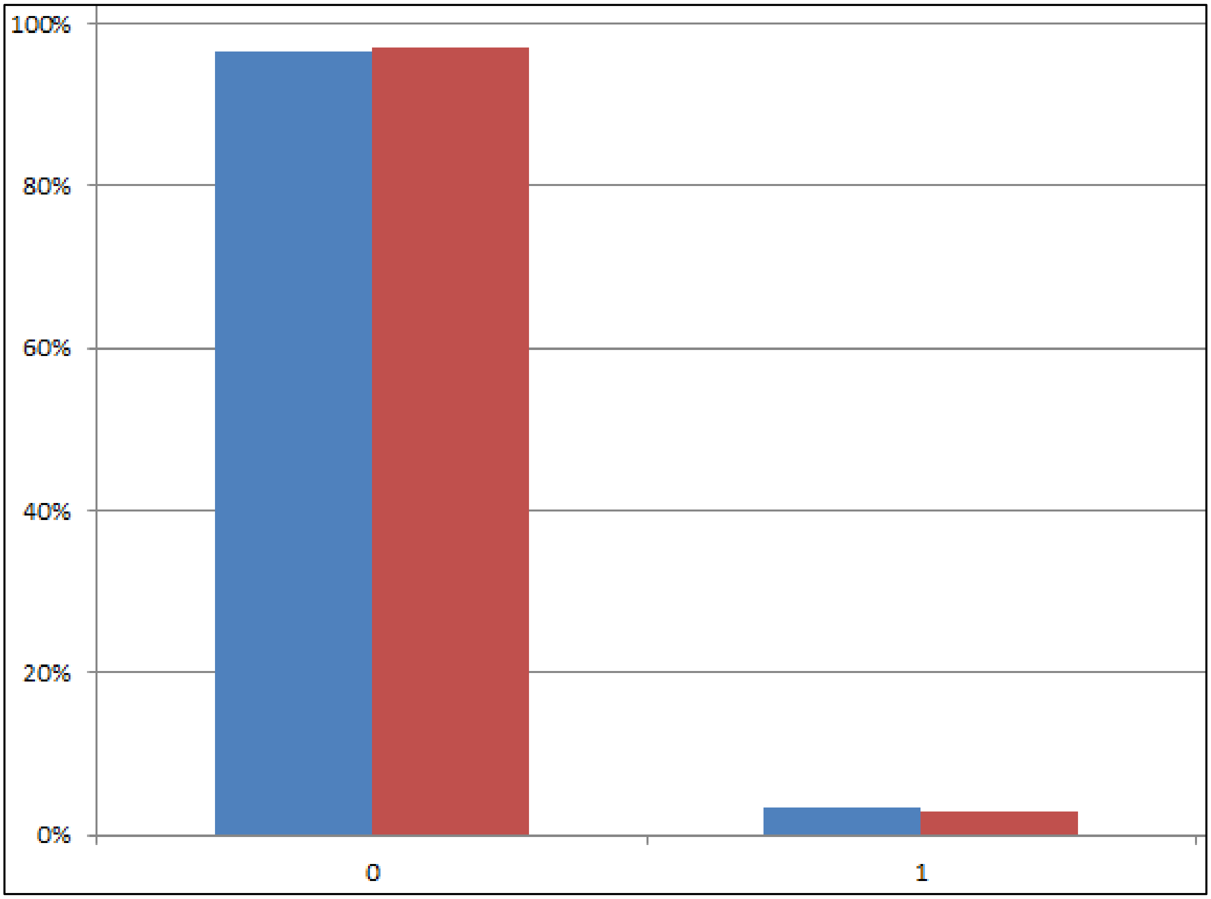


Figure 19. Percent of background hours (blue) and hours with bat passes (red) at various moon illumination categories (0 = no illumination and 1 = full moon) and with the moon above and below the horizon.

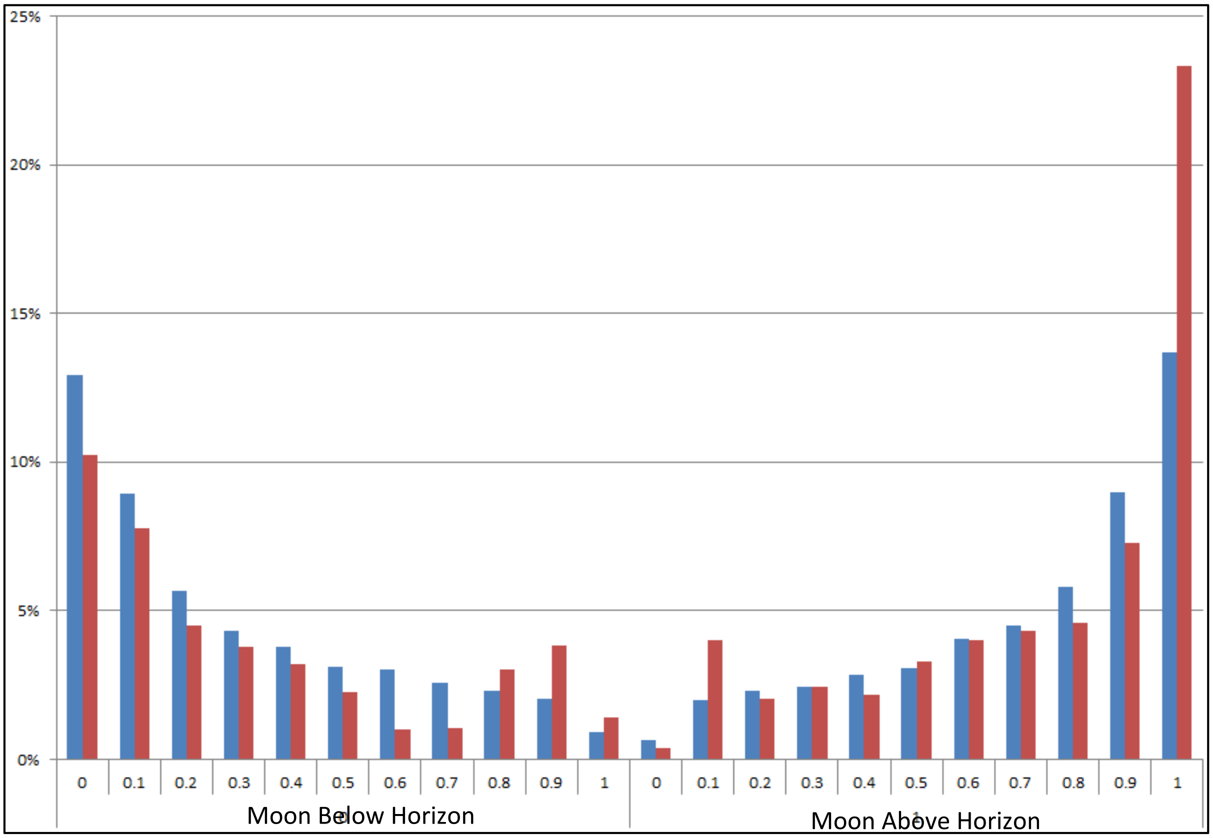


Figure 20. Percent of background hours (blue) and hours with bat passes (red) associated with various moon illumination categories (0 = no illumination and 1 = full moon) and with the moon below or above the horizon across the regional network of detectors. Moon illumination values were able to be calculated for 100% of the 467,512 hours that detectors have been deployed.

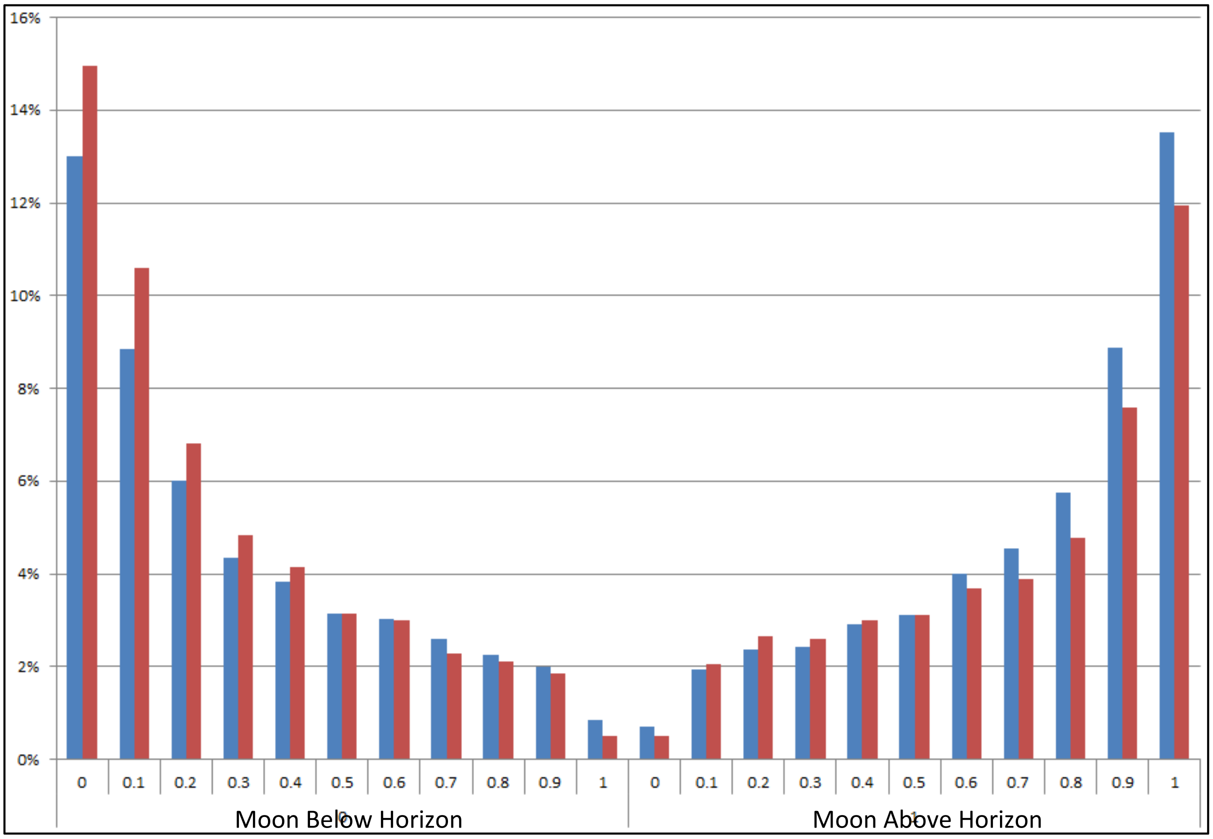


Figure 21. Average number of nightly bat passes each week auto-identified as Big Brown Bat. Numbers on X axis are years, months, and weeks.

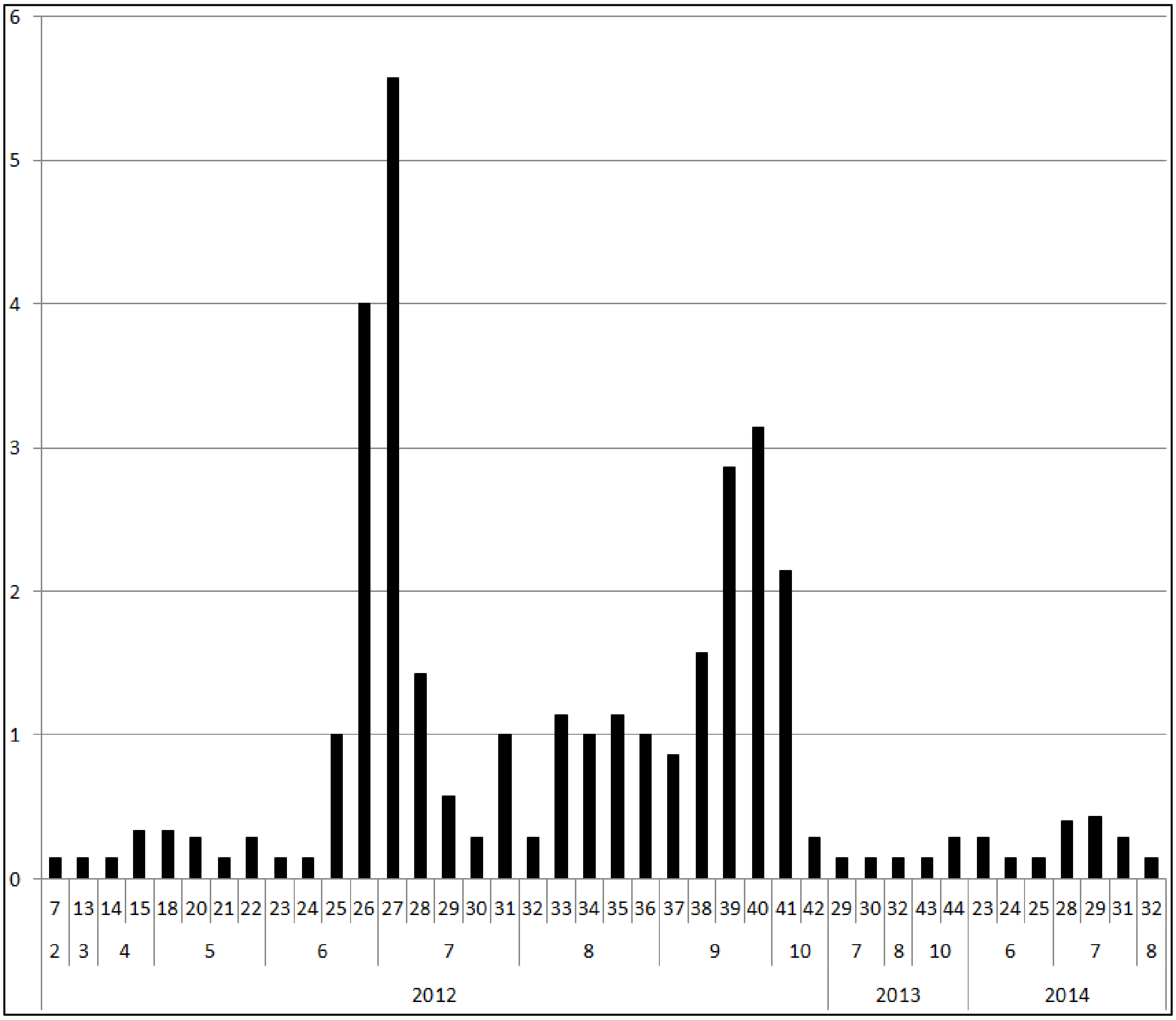


Figure 22. Average number of nightly bat passes each week auto-identified as Silver-haired Bat. Numbers on X axis are years, months, and weeks.

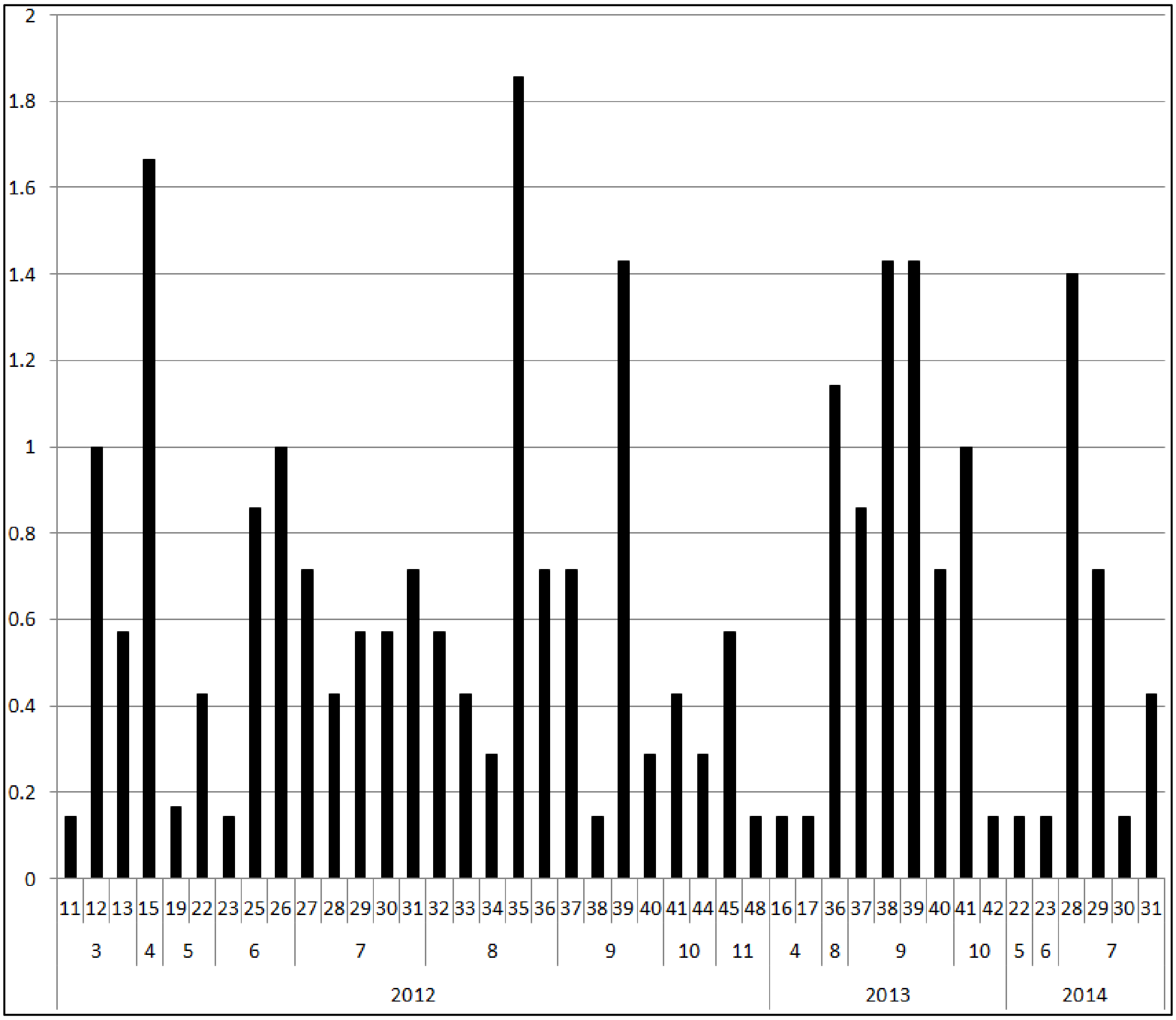


Figure 23. Average number of nightly bat passes each week auto-identified as Western Small-footed Myotis. Numbers on X axis are years, months, and weeks.

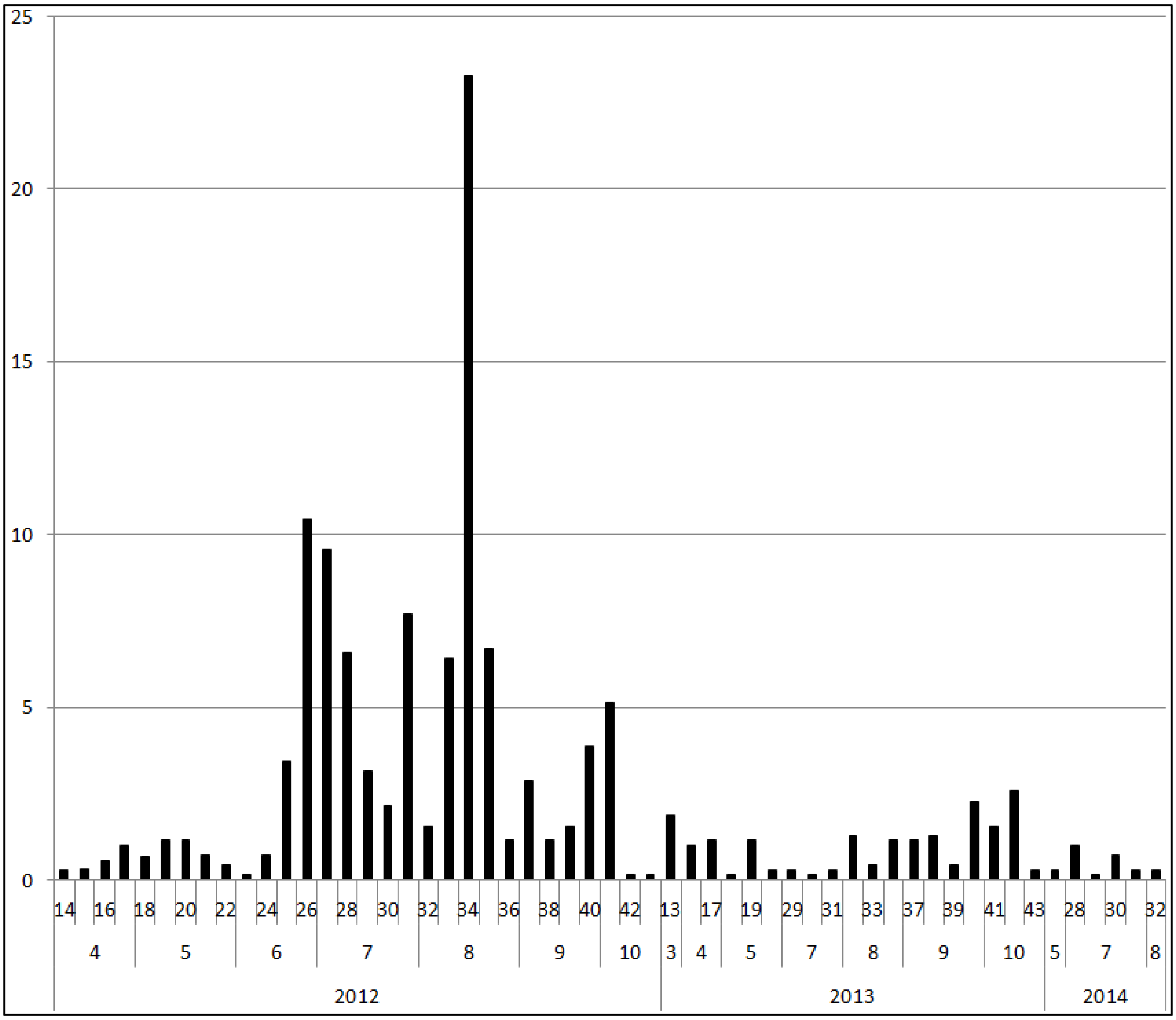
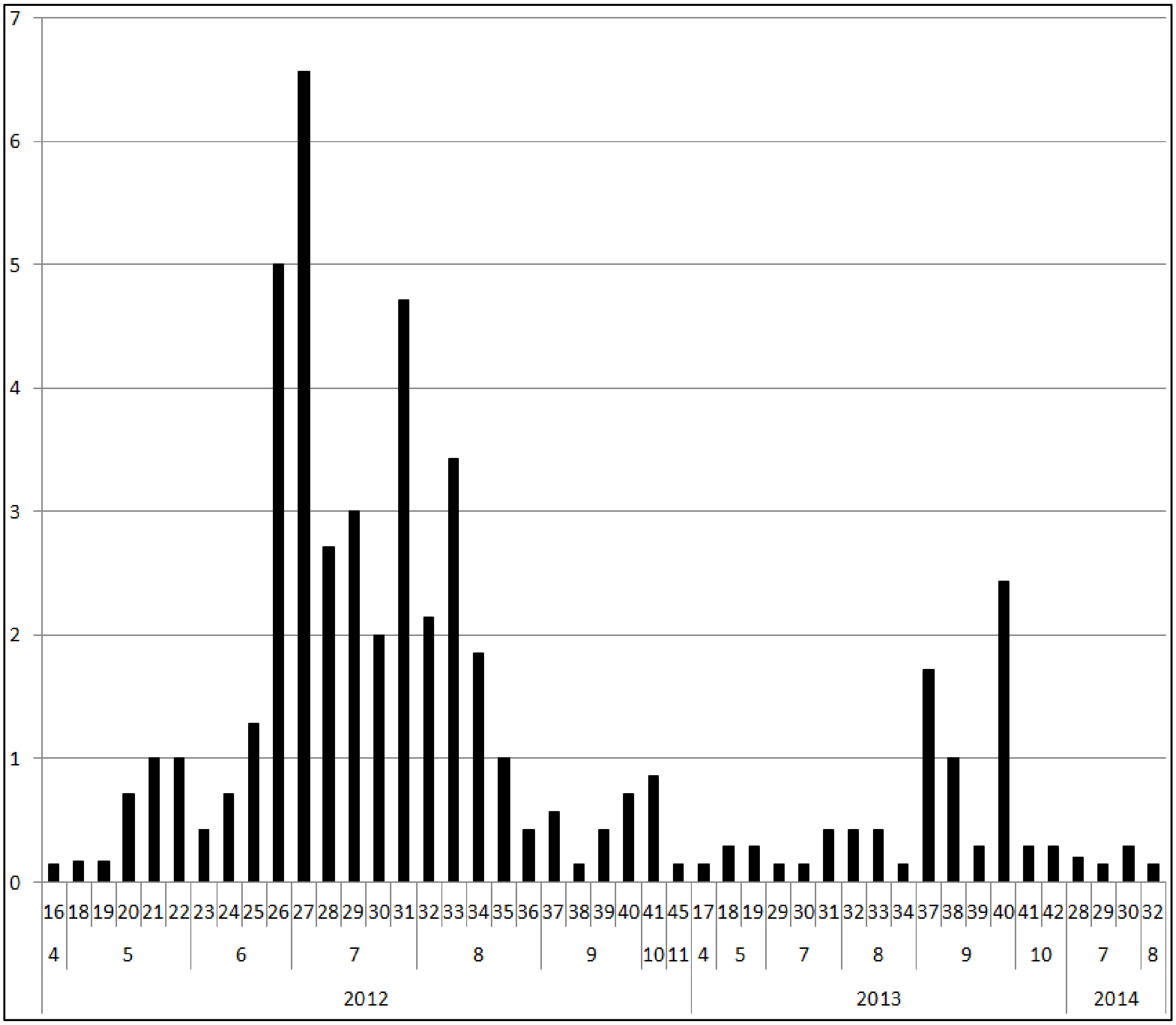


Figure 24. Average number of nightly bat passes each week auto-identified as Little Brown Myotis. Numbers on X axis are years, months, and weeks.



Appendix A

References on Wind Turbine and other Human Structure Collision Impacts on Bats

Compiled by Bryce A. Maxell, Senior Zoologist, Montana Natural Heritage Program

September 2015

An * in front of a citation, indicates the article has particular value for wind turbine impacts to bats and turbine management in Montana. Additional information on wind turbine impacts to bats and other wildlife can be found at the Wind-Wildlife Impacts Literature Database (WILD) at http://wild.nrel.gov

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Appendix B

Bat Pass Temperatures Summarized by Species and Month for Big Sheep Creek[1]

Species[2]	Year	Month	Bat Pass Temp C Avg (SD) N	Bat Pass Min Temp C	Bat Pass Max Temp C
Epfu	2012	2	0.6 ([3]) 1	0.6	0.6
Epfu	2012	3	11.7 ([3]) 1	11.7	11.7
Epfu	2012	4	6.3 (3) 3	3.6	9.5
Epfu	2012	5	16.6 (2.7) 4	14.3	20.1
Epfu	2012	6	15.2 (3.5) 38	8.7	21.7
Epfu	2012	7	18.3 (2.5) 56	9.7	23.6
Epfu	2012	8	17.7 (2.5) 31	11.7	21.4
Epfu	2012	9	17.4 (1.6) 50	15.5	21.9
Epfu	2012	10	16.1 (1.2) 33	13.3	17.4
Epfu	2013	7	20.9 (0.8) 2	20.3	21.4
Epfu	2013	8	15.6 ([3]) 1	15.6	15.6
Epfu	2013	10	3.1 (1.3) 2	2.2	4.1
Epfu	2013	11	2.4 ([3]) 1	2.4	2.4
Epfu	2014	6	16.2 (3) 4	14.3	20.6
Epfu	2014	7	17.2 (4.7) 6	9.4	22.1
Epfu	2014	8	14.9 (5.6) 2	11	18.9
Laci	2012	7	17.8 (0.9) 3	16.8	18.4
Laci	2012	8	21.3 (5.9) 2	17.1	25.4
Laci	2012	9	13.2 ([3]) 1	13.2	13.2
Laci	2013	8	19.9 ([3]) 1	19.9	19.9
Laci	2013	9	13.3 (8.1) 5	4.4	20.1
Laci	2013	10	5.2 ([3]) 1	5.2	5.2
Laci	2014	7	15.6 ([3]) 1	15.6	15.6
Laci	2014	8	16.7 (1.3) 2	15.8	17.6
Lano	2012	3	8.2 (1.4) 12	5.7	9.8
Lano	2012	4	6.3 (2) 9	5.4	11.7
Lano	2012	5	12.5 (3.5) 2	10	15
Lano	2012	6	15.1 (4.8) 15	8.4	23.4
Lano	2012	7	17 (3.4) 17	8	21.4
Lano	2012	8	17.2 (4.3) 26	9.8	23.6
Lano	2012	9	17 (2.8) 23	10.3	21.9
Lano	2012	10	10.1 (3.9) 5	4.4	15.1
Lano	2012	11	7.6 (2.7) 5	4.7	11
Lano	2013	4	7.8 (2) 2	6.4	9.2

Species[2]	Year	Month	Bat Pass Temp C Avg (SD) N	Bat Pass Min Temp C	Bat Pass Max Temp C
Lano	2013	9	13.4 (5.2) 34	4.7	20.8
Lano	2013	10	8.3 (2.2) 13	3.1	11.7
Lano	2014	5	19.1 ([3]) 1	19.1	19.1
Lano	2014	6	15 ([3]) 1	15	15
Lano	2014	7	17.8 (4.1) 14	8.5	22.2
Lano	2014	8	19.6 (3.7) 2	17	22.2
Myci	2012	4	7.2 (1.1) 2	6.4	8
Myci	2012	5	14.7 (4.4) 20	6.5	20.1
Myci	2012	6	17.1 (3.7) 103	6.2	23.2
Myci	2012	7	18.4 (3.3) 173	7.5	24.4
Myci	2012	8	14.2 (3.6) 297	7.4	25.9
Myci	2012	9	16.6 (2.2) 58	12.3	20.4
Myci	2012	10	12.1 (3.2) 53	4.7	17.4
Myci	2012	11	6.4 ([3]) 1	6.4	6.4
Myci	2013	3	7.3 (0.2) 13	7	8
Myci	2013	4	8.9 (2.6) 15	5.5	14.5
Myci	2013	5	13.2 (2.2) 11	9	16
Myci	2013	7	21 (1.5) 4	19.8	22.9
Myci	2013	8	19.3 (3.7) 21	11	24.1
Myci	2013	9	14.5 (4.2) 20	7	21.6
Myci	2013	10	10.7 (2.2) 47	6.7	13.5
Myci	2014	5	17.1 (0.9) 2	16.5	17.8
Myci	2014	7	19.2 (3.2) 11	14.8	22.7
Myci	2014	8	20.5 (0.8) 4	19.9	21.7
Myev	2012	5	14.5 (3.3) 3	12	18.3
Myev	2012	6	15.7 (5.2) 9	8.9	22.7
Myev	2012	7	14.7 (4.3) 8	8	19.8
Myev	2012	8	16.8 (1.9) 4	15	19.1
Myev	2012	9	11 ([3]) 1	11	11
Myev	2012	10	10.3 ([3]) 1	10.3	10.3
Myev	2013	5	12 (7.5) 2	6.7	17.3
Myev	2013	6	10.2 ([3]) 1	10.2	10.2
Myev	2013	7	19.8 (4) 3	15.3	22.9
Myev	2013	8	15 (6) 3	8.2	19.4
Myev	2014	5	12.3 (5) 2	8.7	15.8
Myev	2014	6	10.8 (4.7) 3	5.7	15
Myev	2014	7	17.9 (2.7) 5	13.8	21.1
Myev	2014	8	18.4 (2.1) 2	17	19.9

Species[2]	Year	Month	Bat Pass Temp C Avg (SD) N	Bat Pass Min Temp C	Bat Pass Max Temp C
Mylu	2012	5	13.4 (3.7) 17	3.9	17.6
Mylu	2012	6	16.4 (4.8) 54	6.7	23.4
Mylu	2012	7	17.6 (3.4) 110	8	23.9
Mylu	2012	8	17.7 (3.7) 82	7.7	26
Mylu	2012	9	14.2 (4.3) 14	4.2	19.8
Mylu	2012	10	12.2 (2.7) 8	9.7	16.1
Mylu	2012	11	9.8 ([3]) 1	9.8	9.8
Mylu	2013	4	14.5 ([3]) 1	14.5	14.5
Mylu	2013	5	11.8 (2.8) 4	8.5	15.1
Mylu	2013	7	16.9 (6.4) 4	9.2	22.9
Mylu	2013	8	21 (2.7) 8	15.6	25.2
Mylu	2013	9	18.5 (3.5) 21	11	21.7
Mylu	2013	10	11.6 (2.3) 21	7.5	13.5
Mylu	2014	7	19.6 (3) 4	15.5	22.7
Mylu	2014	8	19.9 ([3]) 1	19.9	19.9

[1] Only records auto-identified to species and able to be associated with temperatures are included and only species with auto identification accuracies from Sonobat 3.0 evaluated through manual review as greater than 50% are included.

[2] Species codes are the first two letters of the genus and species names.

[3] Cannot calculate standard deviation with a single value.

Appendix C

Overview of Roosting Habitat and Home Range / Foraging Distance Documented for Montana Bats

Bryce A. Maxell, Montana Natural Heritage Program - 24 February 2015

The table, figures, and images below summarize and provide examples of what is known about winter, maternity, and day/night roost habitat use for Montana bat species in the state and/or elsewhere across their ranges. Protection of these cave, mine, cliff, rock outcrop, ground crevice, large tree, bridge, and building habitats with cracks and crevices ranging from $^1/_3$ to 1 inch in width and associated temperature and humidity regimes, is essential for protection and conservation of Montana's bats. Artificial bat roosts that provide summer maternity, night, and day roosts, can be deployed to serve as a surrogate for large diameter tree and other roosts that have been lost and/or to encourage roosting away from buildings where bats would be in close proximity to sleeping humans. Artificial winter roost habitat is not a viable management option at the present time.

Species / Comments	Winter Roost	Summer Maternity Roost	Summer Day/Night Roost	Home Range/Foraging Distance
Pallid Bat **(*Antrozous pallidus*)** Low roost site fidelity with 90% of inter-night movements of 50-600 meters. [3] Highly social, often using day and night roosts in groups of 20 or more guided by social vocalizations and odors.[2, 4] Yearling females typically give birth to a single pup, but older females typically give birth to 2 pups.[4, 43]	Not documented in Montana, but likely occurs in deep rock crevices if the species is present.[1, 4]	Not documented in Montana. Elsewhere in vertical and horizontal rock crevices, under rock slabs, in buildings, and on taller and larger diameter live trees and tree snags with loose bark in mature stands with southerly aspects and lower percentages of overstory.[4, 37, 38, 41, 42, 44]	Under rock slabs, in horizontal and vertical rock crevices, and on farm equipment in Montana.[1] Elsewhere occasionally on buildings, bridges, caves, mines, vertical and horizontal rock crevices that are typically on east or southeast aspects, and taller and larger diameter live trees and tree snags with loose bark in mature stands with southerly aspects and lower percentages of overstory.[2, 4, 21, 22, 23, 30, 37, 38, 39, 40, 41, 44]	Lactating females moved an average of 2,450 meters +/- 845 from roost to foraging areas and had an average foraging area size of 1.56 square km +/- 0.88 SE. Post-lactating females moved an average of 210 meters from roost to foraging areas and had an average foraging area size of 5.97 square km +/- 2.69 SE in northern California.[37] Individuals commuted 1 to 4 km between day roosting and foraging areas, 0.5 to 1.5 km between day roosts and night roosts, and switched day roosts often, usually moving <200 meters between roosts (range 25 to 3,660 meters) in eastern Oregon. [38, 39] Individuals typically commuted 1-2 km from day roosts to foraging areas, but one male often used different day roosts separated by 10 km in California. [42]
Townsend's Big-eared Bat **(*Corynorhinus townsendii*)** High fidelity to maternity and hibernacula roosts, lower interseasonal roost site fidelity, and travel up to 24 km from hibernacula to summer foraging areas.[73] Forage and commute adjacent to vegetation.[72]	Twilight areas of caves, mines, and unused tunnels in Montana.[1, 31, 32, 75, 84] Limestone or lava tube caves and mines are known to be used elsewhere with arousal and movement within or between sites, possibly responding to changing temperature.[5, 73, 74, 82]	Caves and mines, often in twilight areas in Montana.[1, 75] Reported in caves, mines, buildings, and basal tree hollows elsewhere.[2, 5, 72, 73, 81, 82, 83] Females prefer cooler maternity roosts than other vespertilionid bat species.[2]	In Montana, usually in caves and mines, often in twilight areas, but more rarely building attics, root cellars, and pocket/daylight caves.[1, 21, 31, 32, 75] Reported in caves, mines, buildings and large diameter basal tree hollows elsewhere.[2, 5, 72, 81, 82, 83]	Average one-way travel distances between day roosts and foraging areas was 3.2 km +/- 0.5 SD for males and 1.3 km +/- 0.2 SD for females in coastal California; maximum distance traveled from the day roost was 10.5 km.[72]

Species / Comments	Winter Roost	Summer Maternity Roost	Summer Day/Night Roost	Home Range/Foraging Distance
Big Brown Bat (***Eptesicus fuscus***) Males often roost solitarily during summer. Rarely move more than 80 km between summer and winter roosts. [2, 6] Roost switching is common at natural roosts, but show high fidelity to man-made roosts.[64, 65, 71]	Caves, mines, and some evidence for rock crevices which are probably the most widespread winter roost in Montana.[1, 31, 84] Known to use narrow deep rock crevices or erosion holes in steep valley walls on the Canadian prairie and buildings in Ohio.[6, 62]	Buildings, bridges, large diameter trees snags with hollows or loose bark in Montana.[1, 75] Primarily large diameter tree snag hollows and crevices, but also live aspen hollows, in more sparsely spaced stands, deep rock crevices, and older human structures are known to be used elsewhere. [6, 29, 59, 64, 65, 66, 67, 68, 71]	Rock crevices, buildings, bridges, and caves in Montana.[1, 22, 31] Larger diameter tree snags with hollows and crevices and preferential selection for older more sparsely spaced stands, older buildings, and rock crevices with good solar exposure are known to be used elsewhere. [27, 29, 30, 64, 65, 66, 67, 68, 69, 71] Caves and mines known to be used as night roosts elsewhere.[70,]	Average of 1.5 km +/- 0.9 SD (range 0.4 to 1.8 km) from roosts to capture locations with average movement between successive roosts of 1.1 km +/- 0.7 SD (range 0.4 to 2.0 km) in the Black Hills of South Dakota.[29] Average one-way travel distances between day roosts and foraging areas of 1.8 km +/- 0.1 SE) range (0.3 to 4.4 km) in southern British Columbia.[64]
Spotted Bat (***Euderma maculatum***) High roost site fidelity with multiple individuals following the same nightly commuting routes up side canyons to foraging areas at speeds of up to 53 km/hr. [8, 49] Forage over clearings and along cliff rims. [49, 50, 51]	Not documented in Montana. Deep rock cracks and crevices are commonly used elsewhere and caves and human structures are rarely used elswhere.[1, 2, 7, 51]	Not documented in Montana. Rock cracks and crevices in upper portions of tall remote south facing cliffs near perennial waters are used elsewhere. [1, 2, 7, 8, 50]	Buildings and other human structures in Montana. [1, 47] Rock cracks and crevices in upper portions of tall remote cliffs near perennial waters, and, apparently more rarely, cave entrances and buildings elsewhere. [2, 7, 8, 45, 46, 47, 48, 49, 50, 51]	50-60 km round trip flight distances nightly with average home range size of 297 +/- 25 SE (range = 242.5 to 363.8) square km in northern Arizona. [8] Nightly round trip commutes of >77 km between day roosts, foraging areas, and night roosts that differed in elevation by ca. 2,000 meters in northern Arizona.[49] Nightly round trip foraging flights of 12 to 20 km in British Columbia. [50]
Silver-haired Bat (***Lasionycteris noctivagans***)	Not documented in Montana. Known to use loose bark, basal tree cavities, cavities under tree roots, and rock crevices on more southerly aspects and in older stands of trees, elsewhere with retreat to more underground sites at lower temperatures. [93] Use of mines is also known. [94]	Large diameter tree snags with loose bark or cavities in Montana. [1, 9, 26] Hollows and crevices in live aspen and large diameter and taller trees or tree snags in older lower canopy closure stands known to be used elsewhere. [9, 59, 86, 90, 91, 92, 95, 96]	Large diameter tree snags with loose bark or cavities and a building in Montana. [1, 26, 78] Large diameter trees or tree snags in older stands with hollows and crevices are predominant summer roost elsewhere, but rock crevices, buildings, bridges, and other human structures also used.[9, 22, 86, 90, 91, 96]	Distance between capture locations and roost snags ranged from 0.1 to 3.4 km (averages for juvenile males, juvenile females, adult males, and adult females were 1.3, 1.5, 1.8, and 0.5 km, respectively) in northeastern Washington. [96]

Species / Comments	Winter Roost	Summer Maternity Roost	Summer Day/Night Roost	Home Range/Foraging Distance
Eastern Red Bat **(*Lasiurus borealis*)** Species is a solitary rooster at heights of 1 to 6 meters from the ground, but forage and migrate in groups. [10]	Not documented in Montana and thought to migrate far to the south where they use tree roosts on warmer days and nights and retreat below leaf litter when temperatures dip below freezing. [10, 54]	Maternity roosts or lactating individuals have not been detected in Montana. Elsewhere, known to roost mostly in dense foliage that provides shade and protection from the wind, but also on trunks, of larger diameter mature deciduous and conifer trees, often in riparian areas. [10, 52, 53, 55, 56, 57]	Not documented in Montana. Elsewhere, known to roost mostly in denser foliage, but also on trunks, of larger diameter mature deciduous and conifer trees, often in riparian areas. Also more rarely in shrubs, under leaf litter, and on human structures. [10, 52, 53, 55, 56, 57]	Maximum distances traveled to foraging areas averaged 1.24 km (range 0.19 to 3.28) and foraging areas averaged 94.4 Ha +/- 20.2 SE with no significant differences between sex and age classes in Mississippi. [52] Maximum distances traveled from diurnal roosts to foraging areas ranged from 1.2 to 5.5 km for females and 1.4 to 7.4 km for males with average foraging area size of 334 Ha in Kentucky [53]
Hoary Bat **(*Lasiurus cinereus*)** Species is a solitary rooster at heights of 3 to 5 meters from the ground, but forage and migrate in groups. [11]	Not documented and thought to migrate far to the south of Montana in the winter. [11]	Only a bridge roost documented in Montana.[1] Known to be a solitary rooster in deciduous and conifer tree foliage that offers shelter from the wind and more southern exposure to the sun elsewhere. [11, 85, 86, 87, 88, 89]	A bridge and cottonwood foliage in Montana.[1] Known to roost in deciduous and conifer tree foliage elsewhere. [1, 11, 85, 86, 87]	Females traveled one-way distances up to 20 km from day roosts while on first of up to five nightly foraging bouts in Manitoba Canada.[85]
California Myotis **(*Myotis californicus*)** Roosts alone or in groups. [12]	Recent acoustic and telemetry data indicates species likely overwinters in rock crevices in Montana.[1, Nate Schwab, personal communication] Rock crevices, caves, mines, tunnels, and buildings are used elsewhere. [2, 12, 25, 61]	Not documented in Montana. Elsewhere known to roost under loose bark or in holes or cracks in more isolated larger diameter tree snags in areas with lower canopy closure.[58, 59] More rarely, known to use buildings elsewhere. [60]	A house and a cellar in Montana. [32] Elsewhere known to roost under loose bark or in holes or cracks in more isolated larger diameter tree snags in areas with lower canopy closure.[58, 59] Also known to use rock crevices, bridges, buildings, and other human structures elsewhere. [12, 21, 22, 30, 60]	*No documentation found.
Western Small-footed Myotis **(*Myotis ciliolabrum*)** Mostly a solitary rooster, but sometimes aggregates in small groups. Fidelity to roost areas is shown, but roost switching within those areas is frequent [13, 63] Also show a high fidelity to commuting corridors.[63]	Caves and mines documented in Montana.[1, 76, 84] Known to use lava tube caves, deep cracks in ground, deep rock crevices, tunnels, and drill holes in rock elsewhere. [2, 13, 77]	Rock outcrop crevices with good solar exposure in Montana. [1] Known to rely mostly on vertical and horizontal crevices in cliffs and rock outcrops, but also documented using buildings elsewhere. [13, 63]	Rock outcrop crevices, bridges, caves, mines, and buildings in Montana. [1, 31, 32] Known to use rock outcrops, cracks in ground, tree hollows, and trees with loose bark elsewhere. [13, 63] No bats were detected using night roosts in a north central Oregon study.[63]	6 to 24 km round trip travel distances from roosts to foraging areas in north central Oregon. [63]

Species / Comments	Winter Roost	Summer Maternity Roost	Summer Day/Night Roost	Home Range/Foraging Distance
Long-eared Myotis (***Myotis evotis***) Suspected of only traveling short distances between summer and winter roosts. [14] Have low fidelity to individual roosts, but high fidelity to roost areas.[97, 98, 99]	Caves and mines.[1, 75, 84] May also use deeper rock crevices. [14]	Caves, cliff and rock outcrop crevices, and large diameter trees in Montana.[1, 26, 76] Known to use sheltered erosion cavities on stream banks, crevices in basalt, conifer stumps, conifer snags, buildings, and mine tunnels elsewhere. [14, 97, 98, 99]	Large diameter trees, rock outcrops, buildings, and caves in Montana. [1, 26, 31, 79] Known to use buildings, trees/snags with loose bark, trestle bridges, mines, rock crevices, stream bank cavities, and sink holes elsewhere. [14, 21, 27, 97, 98, 99]	Traveled an average of 970 meters (range 35-5,154 meters) between roosts in western Montana.[26] Moved 1 to 812 meters between day roosts and had roosting home ranges that ranged from 0.08 to 1.93 ha in Alberta.[97] Traveled 620 meters from capture sites to day roosts in western Oregon .[98] Traveled an average distance between day roosts of 148.9 m in northeastern Washington.[99]
Little Brown Myotis (***Myotis lucifugus***) Show high fidelity to summer colonies and hibernacula across years, but some individuals relocated between years a median distance of 315 km between hibernacula (range 6 to 563 km) and 431 km between summer roosts (range 25 to 464 km).[100] Males and nonreproductive females occupy cooler roosts than pregnant or lactating females.[15]	Caves and mines with high humidities and temperatures above freezing in Montana and elswhere. [1, 31, 36, 75, 84] May also use deeper rock crevices. [15] Predominantly documented using caves elsewhere. [100]	Attics and roofs of buildings, bridges, and bat houses in Montana. [1] Known to use cracks or hollows in larger diameter tree snags in older stands, rock crevices, and buildings elsewhere. [2, 15, 35, 90, 101, 102, 103]	Large diameter tree, rock crevices, buildings, bridges, caves, and bat houses in Montana. [1, 26, 31, 80] Known to use cracks or hollows in larger diameter tree snags in older stands, wood piles, and rock crevices elsewhere.[15, 35, 90] Caves and mines known to be used as night roosts elsewhere.[70]	Average 970 meters (range 35-5,154 meters) between roosts in western Montana.[26] Traveled 10 to 647 km from hibernacula to summer colonies in Manitoba and northwestern Ontario, Canada.[100] Female home range averaged 30.1 ha +/- 15.0 SD during pregnancy and 17.6 ha +/-9.1 SD during lactation in Quebec, Canada.[101] Males moved and average of 275 m +/- 406 SD between successive roosts, had mean minimum roosting areas of 3.9 ha +/- 7.9 SD, mean minimum foraging areas of 52.0 ha +/- 57.4 SD, mean distance between roosting and foraging areas of 254 m +/- 254.2 SD, and mean distances between capture sites and first roosts of 761 m +/- 623 SD in New Brunswick.[102] Mean home range area was 143 ha +/- 71.0 SE in New York.[103]

Species / Comments	Winter Roost	Summer Maternity Roost	Summer Day/Night Roost	Home Range/Foraging Distance
Northern Myotis (***Myotis septentrionalis***) Low roost site fidelity, but often stay in same general area within a season. May travel up to 56 km between summer and winter roosts. [16]	Only known from a single abandoned coal mine in Montana.[1, 75] Known from caves, with a preference to cluster in deep crevices and possibly move between caves within a winter elsewhere. [16]	Not documented in Montana. Known to use bark and hollows of larger diameter trees, usually in decay, and building crevices and bat houses elsewhere. [16, 29, 35, 69, 102]	Not documented in Montana. Known to use bark and hollows of larger diameter trees, usually in decay, and building crevices and bat houses elsewhere.[16, 29, 35, 69] Caves and mines known to be used as night roosts elsewhere.[70,]	Average of 2.2 km +/- 1.4 SD (range 0.1 to 5.9 km) from roosts to capture locations with average movement between successive roosts of 0.6 km +/- 0.5 SD (range 0.1 to 1.5 km) in the Black Hills of South Dakota.[29] Females/males moved and average of 457/158 m +/- 329/127 SD between successive roosts, had mean minimum roosting areas of 8.6/1.4 ha +/- 9.2/1.4 SD, mean minimum foraging areas of 46.2/13.5 ha +/- 44.4/8.3 SD, mean distance between roosting and foraging areas of 584.6/293.0 m +/- 405.8/282.8 SD, and mean distances between capture sites and first roosts of 1001/402 m +/- 693/452 SD in New Brunswick.[102]
Fringed Myotis (***Myotis thysanodes***) Very sensitive to roost site disturbance. [17] Maintain at least some level of group integrity when switching roosts. [29]	Not documented in Montana and presumed to migrate south of Montana. [1]	Caves. [1] Known to use cracks and hollows of larger diameter trees, usually in decay, rock crevices on south-facing slopes, and buildings elsewhere. [17, 29]	Caves in Montana. [1, 32] Known to use cracks and hollows of larger diameter trees, usually in decay, rock crevices on south-facing slopes, mines, buildings, and bridges elsewhere. [17, 21, 22, 29]	Average of 1.0 km +/- 0.6 SD (range 0.1 to 2.0 km) from roosts to capture locations with average movement between successive roosts of 0.5 km +/- 0.6 SD (range 0.1 to 2.0 km) in the Black Hills of South Dakota.[29]
Long-legged Myotis (***Myotis volans***)	Caves and mines in Montana and elsewhere. [1, 19, 31, 36, 75, 84]	Large diameter trees in Montana. [1, 26] Elsewhere in taller, but random to normal diameter tree snags with loose bark or cracks, especially in areas with less habitat fragmentation, greater snag density but with greater tree spacing. [28, 33, 34, 35] Also in rock crevices, cracks in the ground, and buildings are known to be used elsewhere with south-facing roosts preferred. [2, 29]	Buildings, mines, caves and large diameter trees in Montana. [1, 26, 31, 32, 78, 79] Elsewhere in taller but random to larger diameter tree snags with loose bark or cracks, especially in areas with less habitat fragmentation, greater snag density but with greater tree spacing, are known to be used elsewhere with south-facing roosts preferred. [27, 28, 29, 30, 33, 34, 35] Also in buildings, cracks in the ground, rock crevices, and caves. [19, 36]	Average of 2.0 km +/- 0.1 SE from roosts to capture locations with average movement between successive roosts of 1.4 km +/- 0.1 SE across four study areas in Washington and Oregon.[28] Average of 1.9 km +/- 1.6 SD (range 0.4 to 3.7 km) from roosts to capture locations with average movement between successive roosts of 0.7 km +/- 0.5 SD (range 0.2 to 1.6 km) in the Black Hills of South Dakota.[29] Average home range size of 647 ha +/- 354 SE (range 16.5 to 3,029 ha) for males, 448 ha +/- 78.7 SE for pregnant females, and 304 ha +/- 53.8 SE for lactating females in Idaho.[33]

Species / Comments	Winter Roost	Summer Maternity Roost	Summer Day/Night Roost	Home Range/Foraging Distance
Yuma Myotis (*Myotis yumanensis*) Sensitive to roost site disturbance. [2]	Not documented in Montana, but acoustic evidence indicates overwintering in rock crevices in cliffs. [1]	Building, bridges, and bat houses in Montana.[1] Buildings, bridges, caves, mines, and abandoned cliff swallow nests are known elsewhere. [2, 20, 21, 22, 25]	Buildings, bridges, and bat houses in Montana.[1, 79] Large diameter trees, buildings, rock/cliff crevices and abandoned cliff swallow nests elsewhere. [2, 21, 22, 23, 24, 25, 30]	Average of 2 km (range 0.59-3.5 km) from roosts to capture locations in California.[24] 4 km from maternity roost to foraging areas in British Columbia.[25]

[1] supported by observations in Montana's statewide point observation database.

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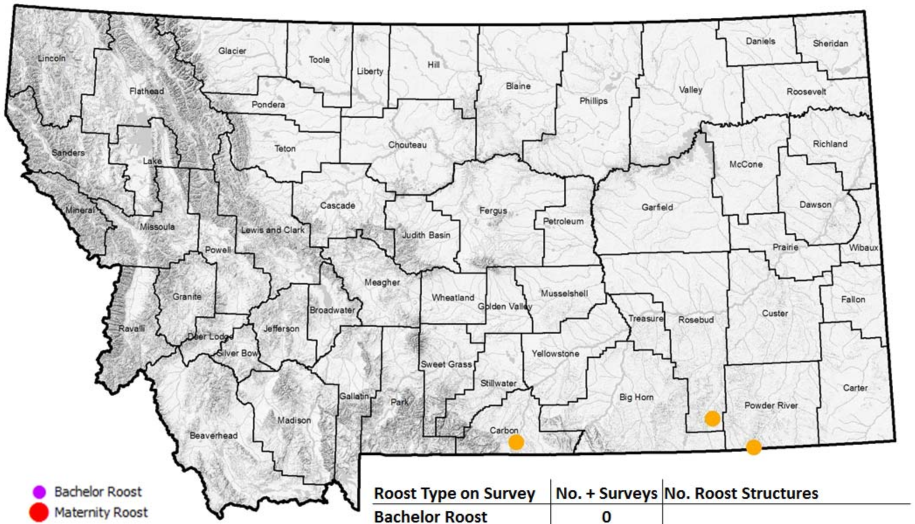
Overview of Known Bat Roosts in Montana

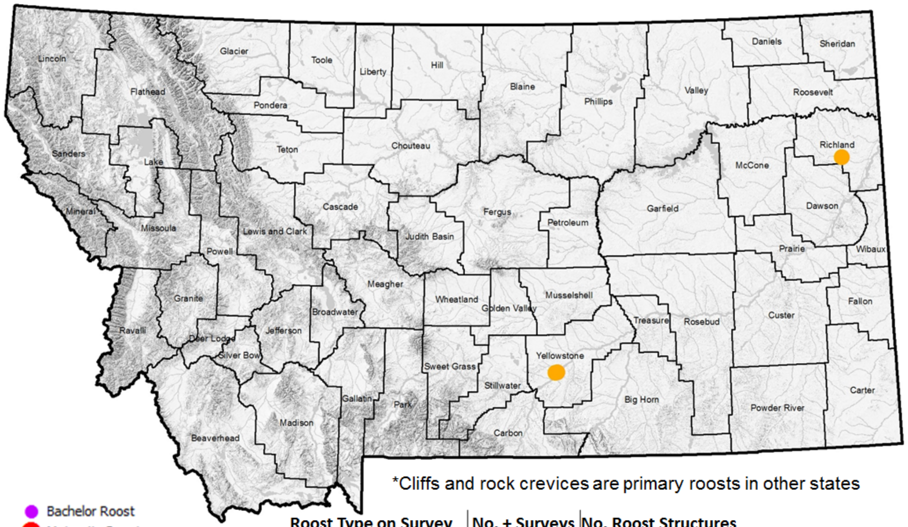
Pallid Bat Roost Use Type Overview



● Bachelor Roost
● Maternity Roost
● Hibernacula
● Day and Night Roost
● Night Roost

Roost Type on Survey	No. + Surveys	No. Roost Structures
Bachelor Roost	0	
Maternity Roost	0	
Hibernacula	0	
Day and Night Roost	3	2 Rock Outcrops, 1 Tractor
Night Roost	0	

Spotted Bat Roost Use Type Overview

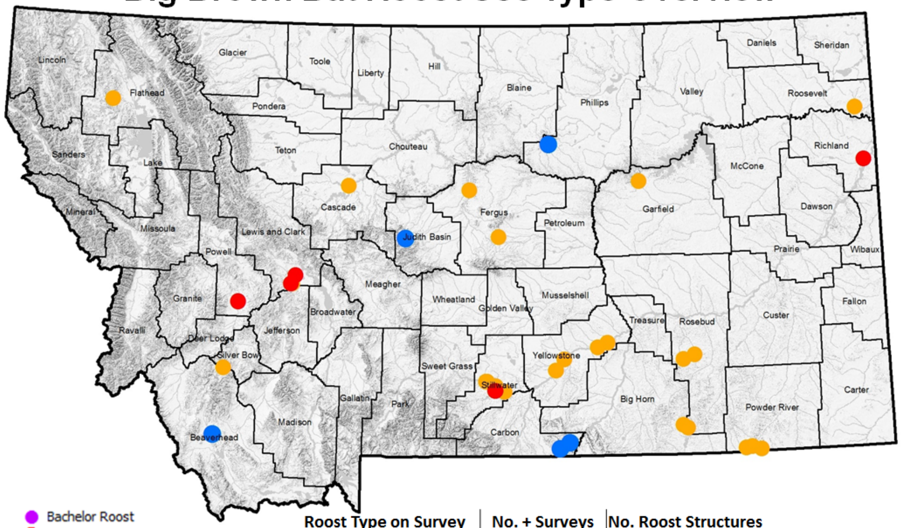


*Cliffs and rock crevices are primary roosts in other states

● Bachelor Roost
● Maternity Roost
● Hibernacula
● Day and Night Roost
● Night Roost

Roost Type on Survey	No. + Surveys	No. Roost Structures
Bachelor Roost	0	
Maternity Roost	0	
Hibernacula	0	
Day and Night Roost	3	1 House, 1 Parking Garage, 1 Electric Meter
Night Roost	0	

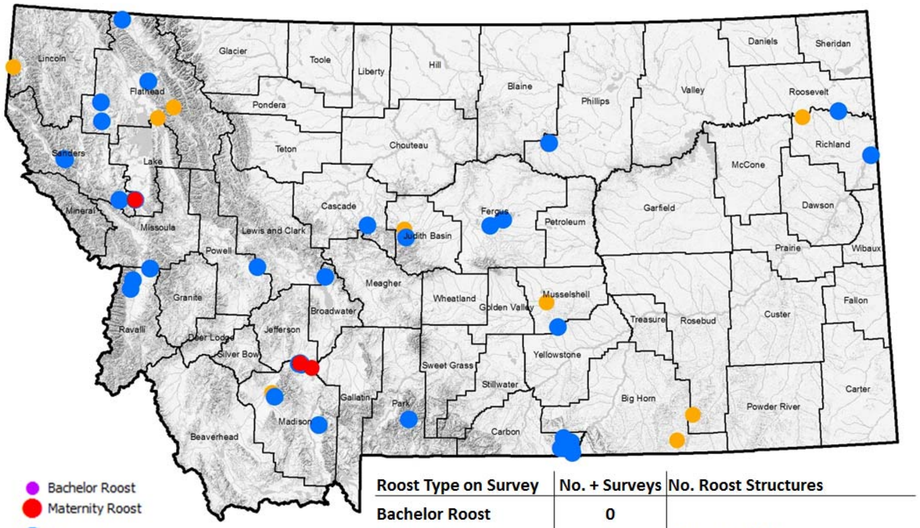
Big Brown Bat Roost Use Type Overview



● Bachelor Roost
● Maternity Roost
● Hibernacula
● Day and Night Roost
● Night Roost

Roost Type on Survey	No. + Surveys	No. Roost Structures
Bachelor Roost	0	
Maternity Roost	12	1 Bridge, 5 Buildings
Hibernacula	6	3 Caves, 2 Mines
Day and Night Roost	44	9 Bridges, 9 Buildings, 5 Rock Outcrops
Night Roost	0	

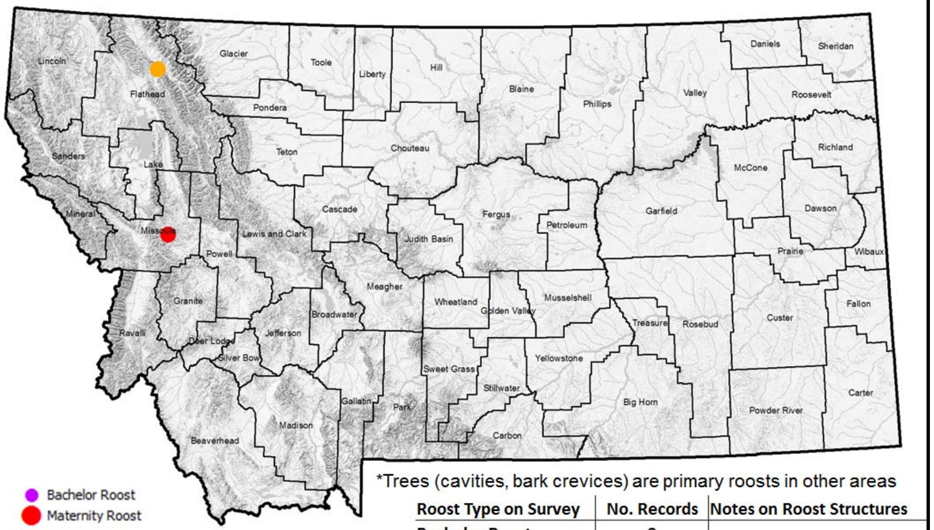
Townsend's Big-eared Bat Roost Use Type Overview



● Bachelor Roost
● Maternity Roost
● Hibernacula
● Day and Night Roost
● Night Roost

Roost Type on Survey	No. + Surveys	No. Roost Structures
Bachelor Roost	0	
Maternity Roost	13	2 Caves, 1 Mine
Hibernacula	69	18 Caves, 20 Mines, 1 Tunnel
Day and Night Roost	33	6 Buildings, 7 Caves, 7 Mines
Night Roost	0	

Silver-haired Bat Roost Use Type Overview



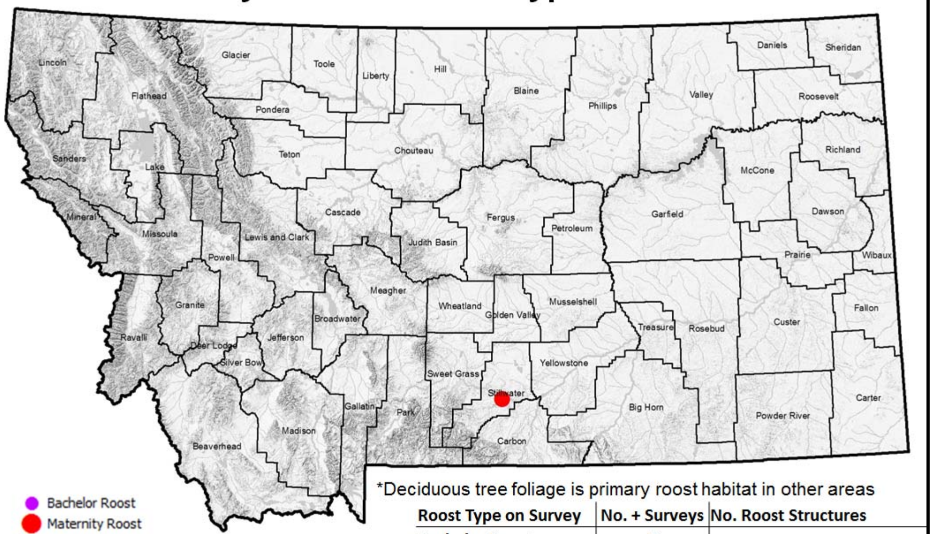
● Bachelor Roost
● Maternity Roost
● Hibernacula
● Day and Night Roost
● Night Roost

*Trees (cavities, bark crevices) are primary roosts in other areas

Roost Type on Survey	No. Records	Notes on Roost Structures
Bachelor Roost	0	
Maternity Roost	1	1 Ponderosa Pine snag
Hibernacula	0	
Day and Night Roost	1	Inside animal hide
Night Roost	0	

*No roost information is available for Eastern Red Bat in Montana, but the species is known to roost in deciduous tree foliage in other states and most acoustic or mist netting records in Montana are from areas adjacent to floodplains with cottonwood gallery forests.

Hoary Bat Roost Use Type Overview



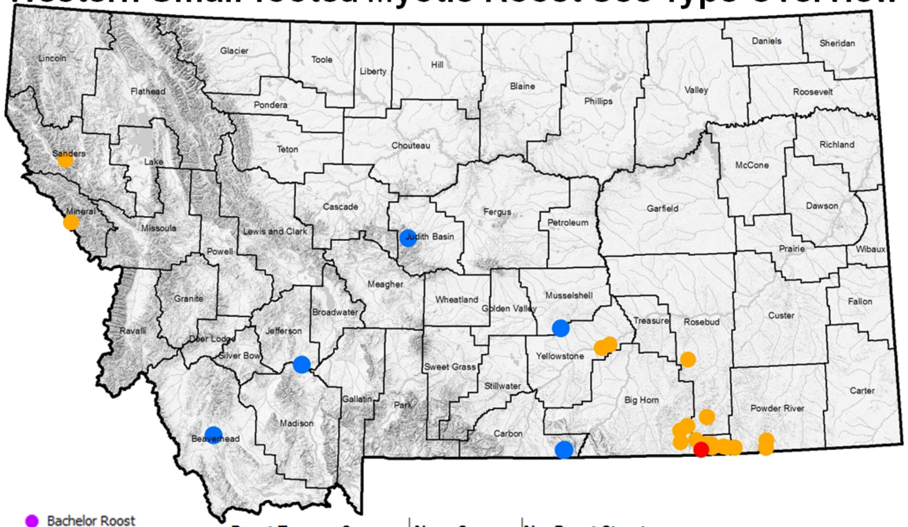
● Bachelor Roost
● Maternity Roost
● Hibernacula
● Day and Night Roost
● Night Roost

*Deciduous tree foliage is primary roost habitat in other areas

Roost Type on Survey	No. + Surveys	No. Roost Structures
Bachelor Roost	0	
Maternity Roost	1	1 Bridge (Hendricks 2005)
Hibernacula	0	
Day and Night Roost	1	1 recent cottonwood tree roost
Night Roost	0	

*Recent radio telemetry data indicates California Myotis likely use tree and rock crevice roosts in the summer and rock crevice roosts in the winter in Montana (Nate Schwab, personal communication). The species is known to roost in rock crevices, trees, caves, and mines in other states.

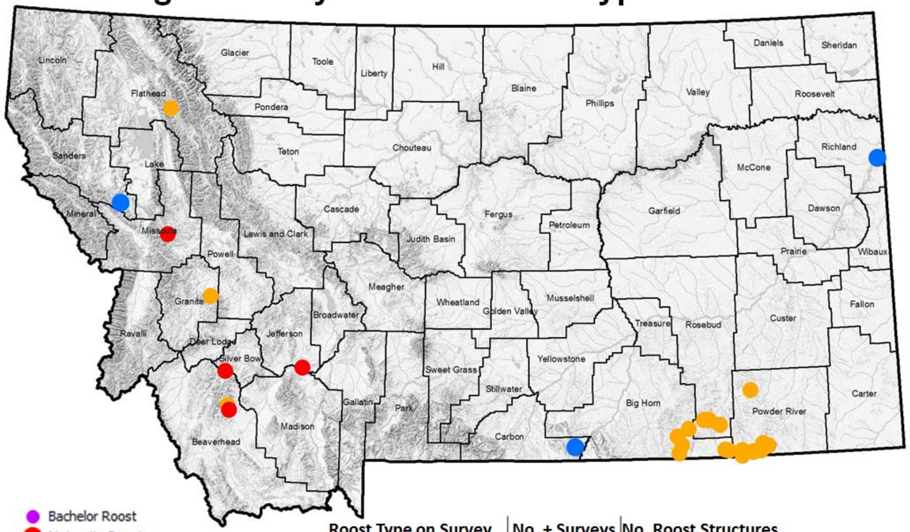
Western Small-footed Myotis Roost Use Type Overview



● Bachelor Roost
● Maternity Roost
● Hibernacula
● Day and Night Roost
● Night Roost

Roost Type on Survey	No. + Surveys	No. Roost Structures
Bachelor Roost	0	
Maternity Roost	1	1 Rock Outcrops
Hibernacula	11	2 Caves, 6 Mines
Day and Night Roost	24	16 Rock Outcrops, 2 Bridges, 2 Buildings, 3 Mines
Night Roost	0	

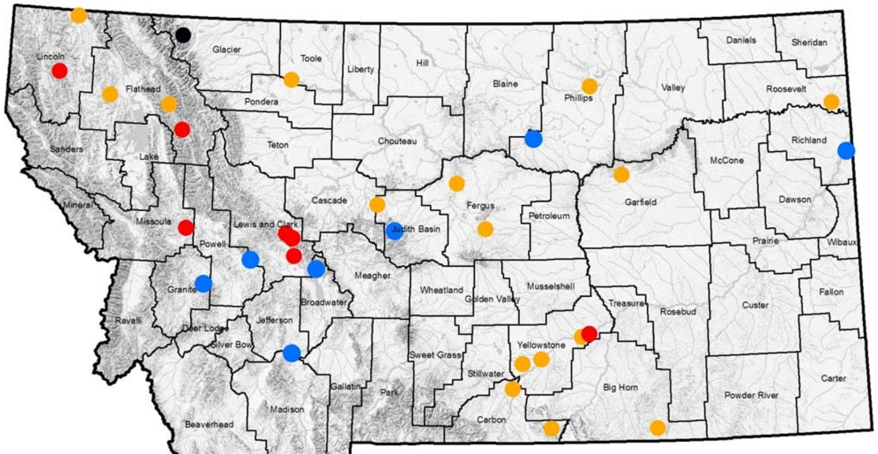
Long-eared Myotis Roost Use Type Overview



● Bachelor Roost
● Maternity Roost
● Hibernacula
● Day and Night Roost
● Night Roost

Roost Type on Survey	No. + Surveys	No. Roost Structures
Bachelor Roost	0	
Maternity Roost	5	1 Cave, 1 Tree, 2 Rock Outcrops
Hibernacula	3	1 Cave, 2 Mines
Day and Night Roost	28	25 Rock Outcrops, 2 Buildings, 1 Cave
Night Roost	0	

Little Brown Bat Roost Use Type Overview

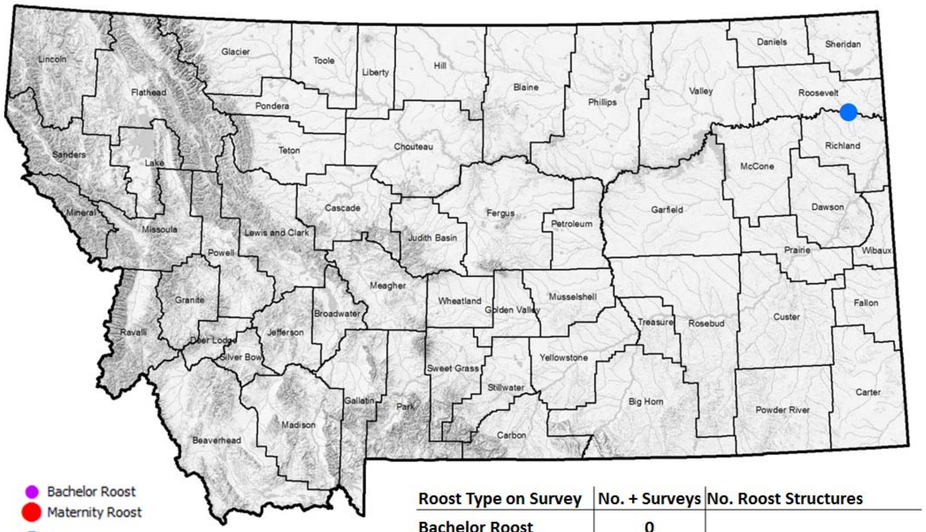


*Trees are also a likely primary roost, but are not well documented.

● Bachelor Roost
● Maternity Roost
● Hibernacula
● Day and Night Roost
● Night Roost

Roost Type on Survey	No. + Surveys	No. Roost Structures
Bachelor Roost	0	
Maternity Roost	16	1 Bridge, 7 Buildings
Hibernacula	12	6 Caves, 1 Mine
Day and Night Roost	36	1 Bat House, 5 Bridges, 10 Buildings, 1 Cave
Night Roost	1	1 Building

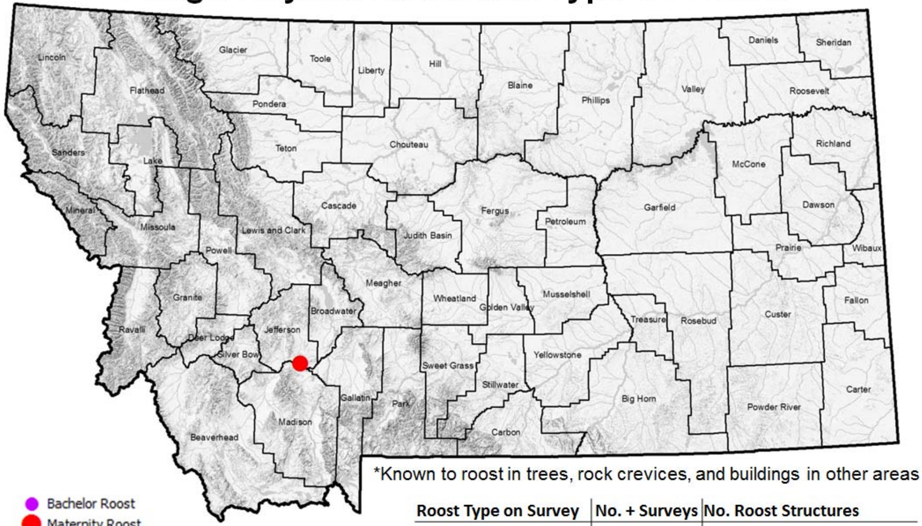
Northern Myotis Roost Use Type Overview



● Bachelor Roost
● Maternity Roost
● Hibernacula
● Day and Night Roost
● Night Roost

Roost Type on Survey	No. + Surveys	No. Roost Structures
Bachelor Roost	0	
Maternity Roost	0	
Hibernacula	1	1 Mine
Day and Night Roost	0	
Night Roost	0	

Fringed Myotis Roost Use Type Overview

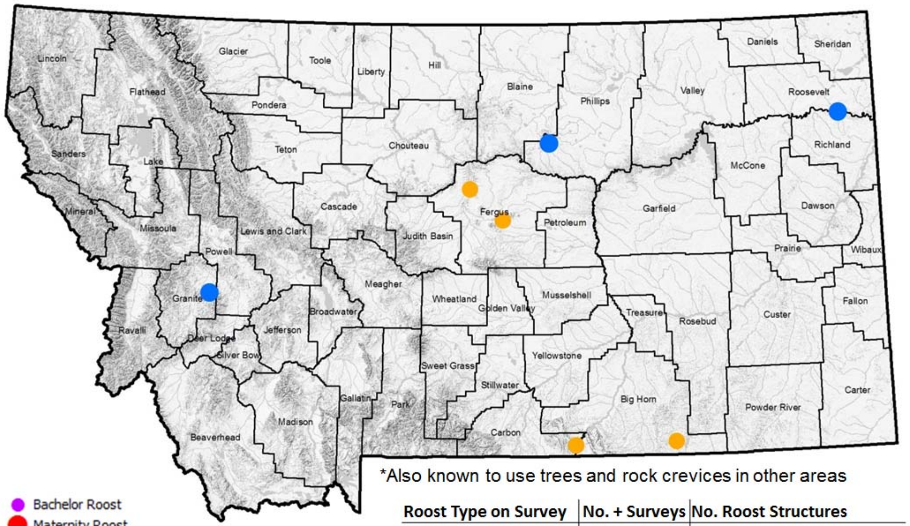


*Known to roost in trees, rock crevices, and buildings in other areas

- ● Bachelor Roost
- ● Maternity Roost
- ● Hibernacula
- ● Day and Night Roost
- ● Night Roost

Roost Type on Survey	No. + Surveys	No. Roost Structures
Bachelor Roost	**0**	
Maternity Roost	**1**	**1 Cave**
Hibernacula	**0**	
Day and Night Roost	**0**	
Night Roost	**0**	

Long-legged Myotis Roost Use Type Overview



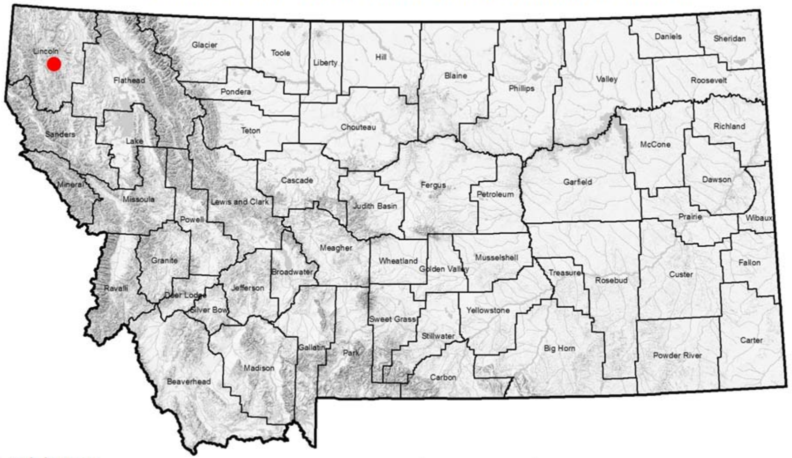
*Also known to use trees and rock crevices in other areas

- ● Bachelor Roost
- ● Maternity Roost
- ● Hibernacula
- ● Day and Night Roost
- ● Night Roost

Roost Type on Survey	No. + Surveys	No. Roost Structures
Bachelor Roost	**0**	
Maternity Roost	**0**	
Hibernacula	**6**	**2 Caves, 1 Mine**
Day and Night Roost	**2**	**1 Building, 1 Mine**
Night Roost	**0**	

Yuma Myotis Roost Use Type Overview

*Call data strongly supports this, but genetic confirmation is needed.



- ● Bachelor Roost
- ● Maternity Roost
- ● Hibernacula
- ● Day and Night Roost
- ● Night Roost

Roost Type on Survey	No. + Surveys	No. Roost Structures
Bachelor Roost	**0**	
Maternity Roost	**1***	**1 Building**
Hibernacula	**0**	
Day and Night Roost	**0**	
Night Roost	**0**	

Examples of Winter Roosts for Montana Bats

Townsend’s Big-eared Bats in cave – James Cummins

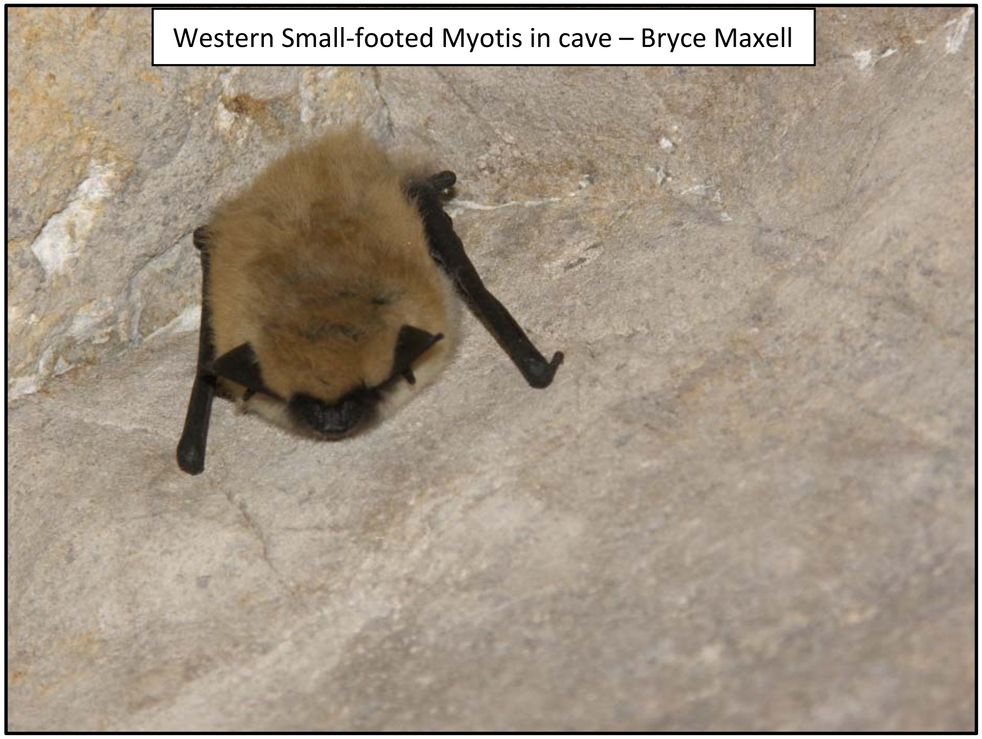
Cluster of Little Brown Myotis in cave – Ronan Donovan

Bats roosting on wall of large cave room – Ronan Donovan, James Cummins

Little Brown Myotis among cave speleotherms – Ronan Donovan

Mine adit supporting Townsend’s Big-eared Bat overwintering – Bryce Maxell

Big Brown Bat in dynamite drill hole – Bryce Maxell



Western Small-footed Myotis in cave – Bryce Maxell

Townsend’s Big-eared Bat in cave – Ronan Donovan

Big Brown Bat in crevice in cave hibernaculum – Bryce Maxell

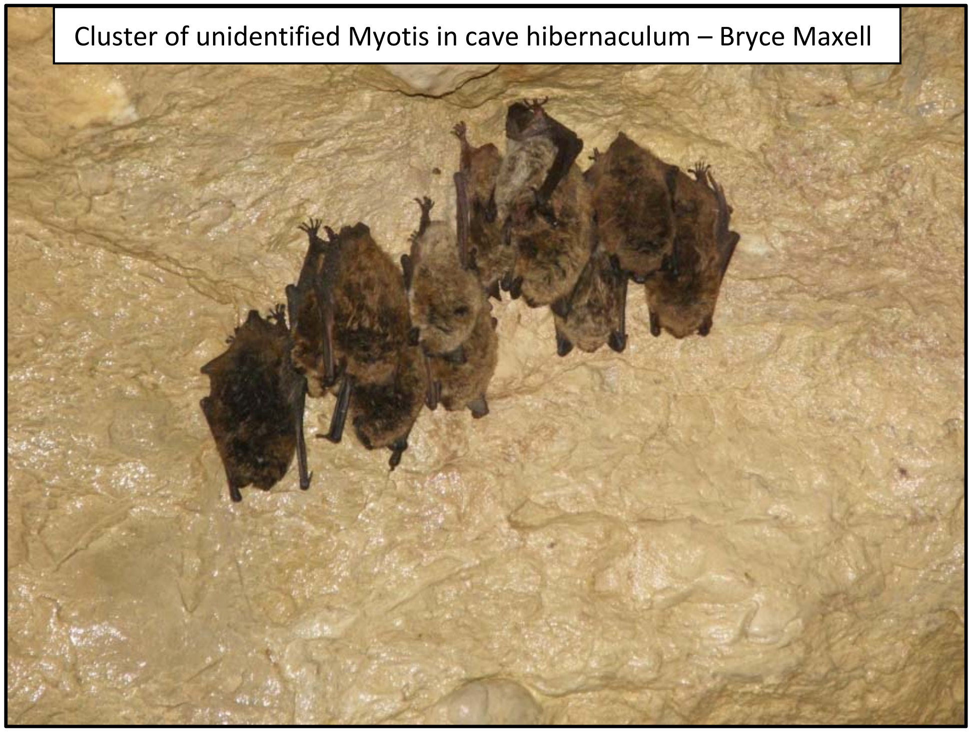
Western Small-footed Myotis in crevice in cave hibernaculum – Bryce Maxell

Western Small-footed Myotis in cave – Bryce Maxell

Long-eared Myotis in crevice in cave hibernaculum – Bryce Maxell


Unidentified Myotis (notice frost on fur) – Alex Jensen


Townsend’s Big-eared Bat in cave – Bryce Maxell


Cluster of unidentified Myotis in cave hibernaculum – Bryce Maxell


Unidentified Myotis (notice damp fur) – Bryce Maxell

Examples of Summer Maternity Roosts for Montana Bats

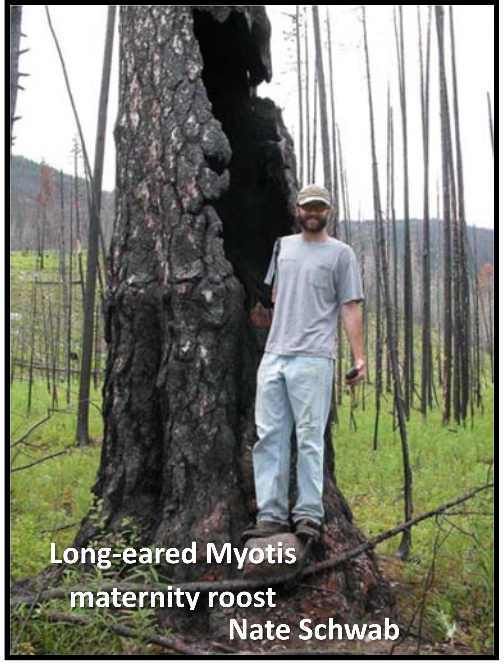
Interior/exterior views of unidentified Myotis maternity colony (notice staining at wall/ceiling junction - Kristi DuBois

Unidentified Myotis maternity roost behind south facing sign on brick wall – Bryce Maxell

Townsend's Big-eared Bat maternity colony in twilight zone of cave - Kristi DuBois

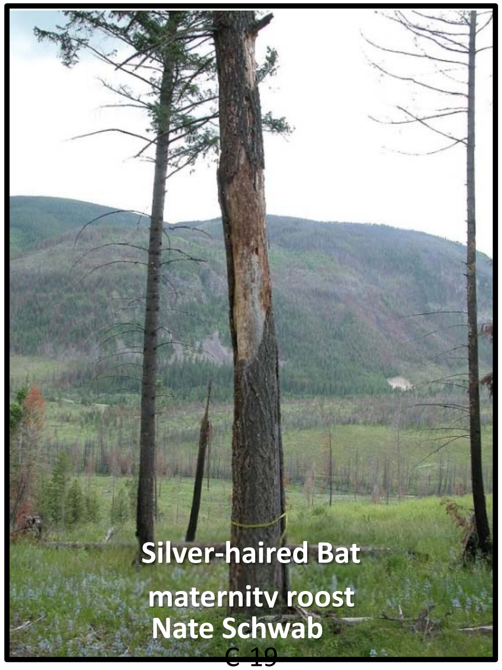
Little Brown Myotis maternity colony in barn - Kristi DuBois

Stump and rounds of large diameter Ponderosa Pine that was a maternity roost for Big Brown Bat and Little Brown Myotis, and a day roost for Silver-haired Bat – Bryce Maxell



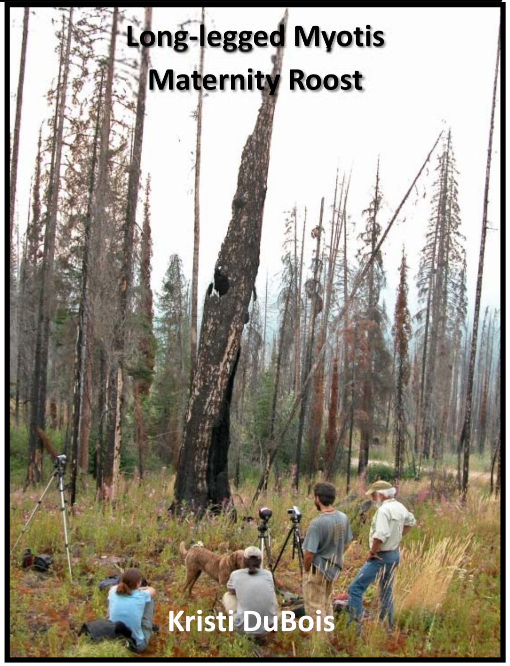
Long-eared Myotis maternity roost

Nate Schwab



Silver-haired Bat maternity roost

Nate Schwab



Long-legged Myotis Maternity Roost

Kristi DuBois

Little Brown Myotis maternity colony in cook house attic. Bat house is not used. – Kristi DuBois

Yuma Myotis maternity colony - Kristi DuBois

Little Brown Myotis maternity colony - Kristi DuBois

Big Brown Bat maternity colony in house attic – Bryce Maxell

Unidentified Myotis maternity colony in interstate highway bridge expansion joint – Bryce Maxell

Entry point for unidentified Myotis maternity colony in garage eves – Bryce Maxell

Droppings from Little Brown Myotis maternity colony – Kristi DuBois

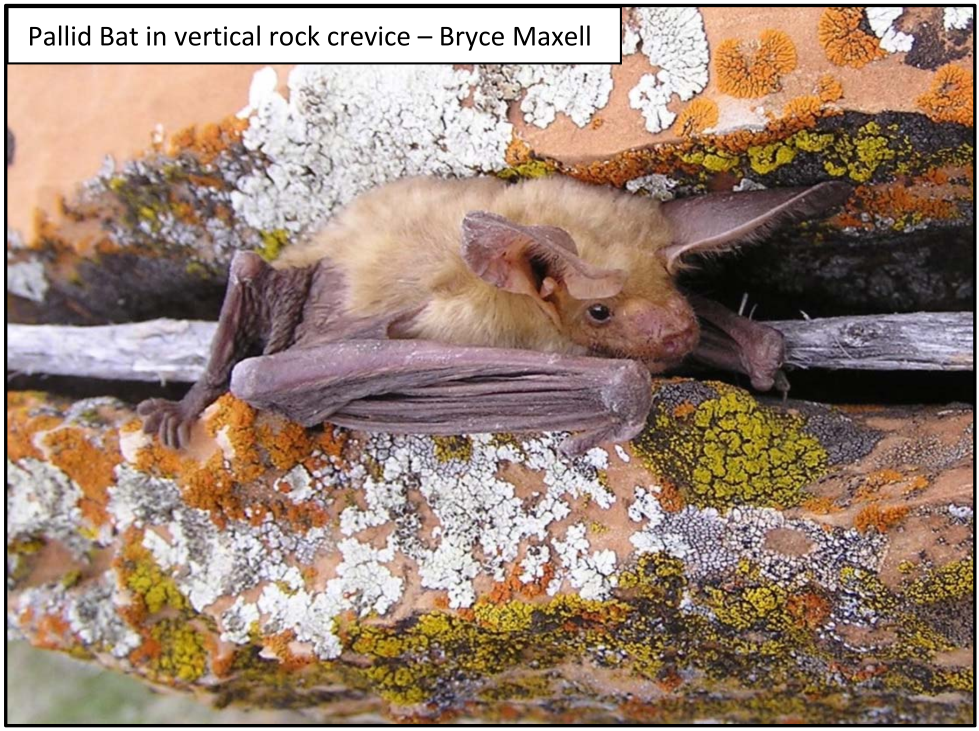
Eve entry points for Little Brown Myotis maternity colony – Kristi DuBois

Big Brown Bat maternity colony on metal barn rafters – Adam Messer

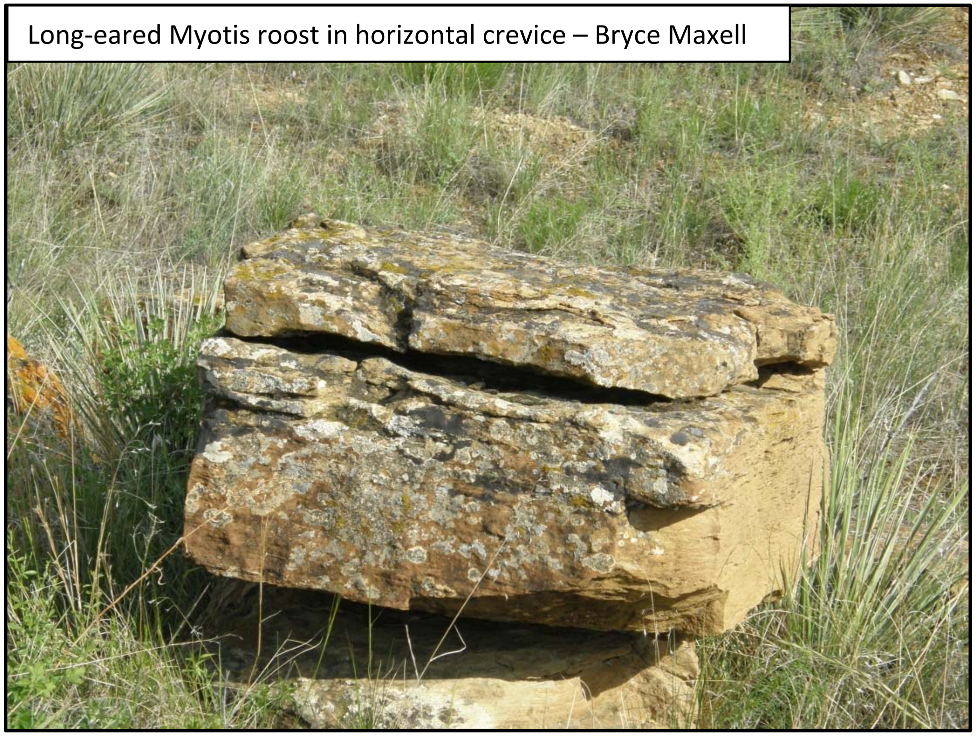
Examples of Summer Night and Day Roosts for Montana Bats


Fringed Myotis in vertical rock crevice – Bryce Maxell

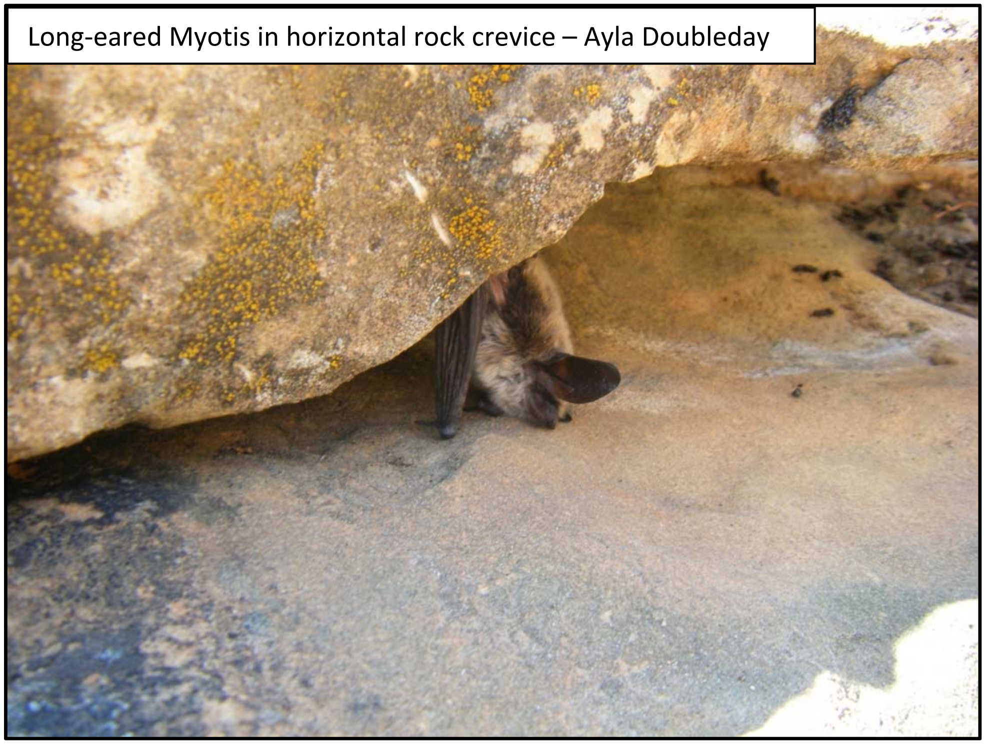

Pallid Bat under slab rock – Keaton Wilson


Pallid Bat in vertical rock crevice – Bryce Maxell


Townsend’s Big-eared Bat in small cavern in sandstone – Alexis McEwan



Long-eared Myotis roost in horizontal crevice – Bryce Maxell



Long-eared Myotis in horizontal rock crevice – Ayla Doubleday

Western Small-footed Myotis under slab rock – Bryce Maxell

Big Brown Bat in horizontal rock crevice – Alexis McEwan

Hoary Bat on tree trunk – Kristi DuBois

Hoary Bat on tree trunk - Kristi DuBois

Big Brown Bat emerging from tree bark – Kristi DuBois

Little Brown Myotis on tree night roost
Bryce Maxell

Fringed Myotis on tree trunk
Kristi DuBois

Hoary Bat roosting in cottonwood foliage – Nathan Cooper

Spotted Bat on brick wall of Billings parking garage – Dick Dede

Townsend's Big-eared Bat on underside of cellar roof – Kristi DuBois

Hoary Bat at atypical (typically in tree foliage) concrete roost – Matt Bell

Bat droppings from night roost under highway bridge – Amie Shovlain

Western Small-footed Myotis on brick wall with good solar exposure – Bryce Maxell

Big Brown Bat in highway expansion joint crevice – Bryce Maxell

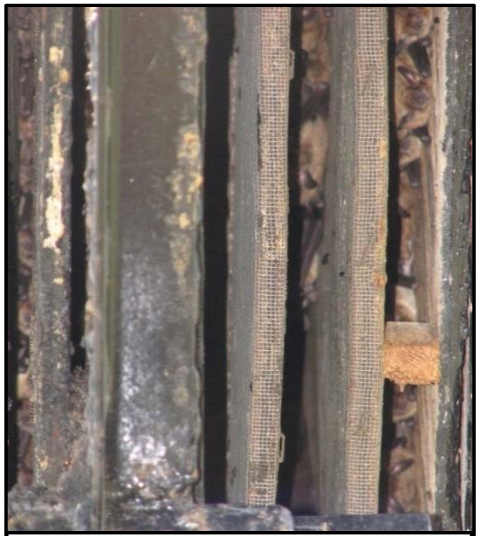
Little Brown Myotis pup in crack of log cabin – Kristi DuBois

Droppings under bridge. Sometimes large volumes of droppings result only from night roosting near foraging areas – Ellen Whittle

Examples of Artificial Summer Roosts (Bat Houses)

Bat houses on 4 x 4 inch posts with good solar exposure – Lewis Young

Bat houses mounted back to back – Lewis Young



Crevices in bat house that supports a Little Brown Myotis maternity colony – Lewis Young

Bat house on old power pole with good solar exposure – Bryce Maxell

Bat house on brick chimney with good solar exposure – Bryce Maxell

Rocket box bat house on eve with good solar exposure – Bryce Maxell

Bat houses on brick wall with good solar exposure – Bryce Maxell