Final
Survey Report
Passive Acoustic Bat Surveys in Support of the Proposed Fallon Range Training Complex Expansion, Nevada

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Cover: Acoustic recorder set up at Bat17-08 within the proposed B-16 expansion area.

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Acronyms and Abbreviations

ac	acre(s)
BLM	Bureau of Land Management
CDFW	California Department of Fish and Wildlife
DoN	U.S. Department of the Navy
DVTA	Dixie Valley Training Area
FRTC	Fallon Range Training Complex
FS	full spectrum
ft	foot/feet
GPS	global positioning system
ha	hectare(s)
kHz	kilohertz
km	kilometer(s)
m	meter(s)
mi	mile(s)
NAS	Naval Air Station
NWAPT	Nevada Wildlife Action Plan Team
U.S.	United States

1.0 INTRODUCTION

Naval Air Station (NAS) Fallon manages the Fallon Range Training Complex (FRTC), which currently encompasses a combination of withdrawn and acquired lands totaling approximately over 223,600 acres (ac) (90,490 hectares [ha]) of military training land located southeast of Fallon, Nevada (Figure 1). The FRTC is the United States (U.S.) Department of the Navy's (DoN or Navy) premier integrated strike warfare training complex, supporting air units and special operations forces in a variety of mission areas. Since World War II, the Navy has extensively used the ranges and airspace of the FRTC to conduct military air warfare and ground training, including live-fire training activities. However, the current training areas are insufficient for implementation of realistic training scenarios and do not provide the associated buffers required for public safety. In order to effectively meet these needs, the Navy proposes to modernize the land and airspace configurations of the FRTC. The Navy is currently proposing to expand the land administered by NAS Fallon by approximately 680,000 ac (275,200 ha). The proposed expansion areas are broken into four discontinuous areas associated with four of the current training ranges (ranges B-16, B-17, B-20, and Dixie Valley Training Area [DVTA]) (Figure 1):

- The area west of B-16 is the proposed B-16 Expansion Area.
- The area surrounding B-20 is the proposed B-20 Expansion Area.
- The areas west and east of B-17 and south of Highway 50, and areas north of Highway 50 surrounding the DVTA are the proposed DVTA Expansion Areas.
- The area south of B-17 and Highway 50 and east of B-17 is the proposed B-17 Expansion Area.

Currently, the Navy is preparing an Environmental Impact Statement (EIS) to assess the potential environmental effects of the proposed FRTC expansion. In support of the EIS, Naval Facilities Engineering Command, Southwest contracted ManTech International Corporation (ManTech) to perform a variety of ecological surveys to inventory the flora and fauna within the proposed FRTC expansion areas. This report details the results of acoustic bat surveys conducted in 2017 under contract N62742-14-D-1863, Task Order FZNG and in 2019 under Task Order FZNG, Modification 4 (Figure 1).

1.1 PROJECT AREA

The project area lies within the geographic feature known as the Great Basin, particularly the Great Basin Desert. The Great Basin Desert is the largest desert in the U.S., roughly bounded by the Sierra Nevada – Cascade mountain ranges to the west and the Rocky Mountains to the east. Between these large mountain ranges are a series of basins interspersed by smaller, north-south running mountain ranges. This desert covers roughly 158,000 square miles (mi) (409,218 square kilometers [km]) of southern Idaho, southeastern Oregon, western Utah, eastern California, and nearly all of Nevada (MacMahon 1985). The Great Basin is a high, cold desert, with most of its elevations over 4,000 feet (ft) 1,200 meters [m]), and most of its precipitation in the form of snow, although rain showers can occur throughout the year (Sowell 2001).

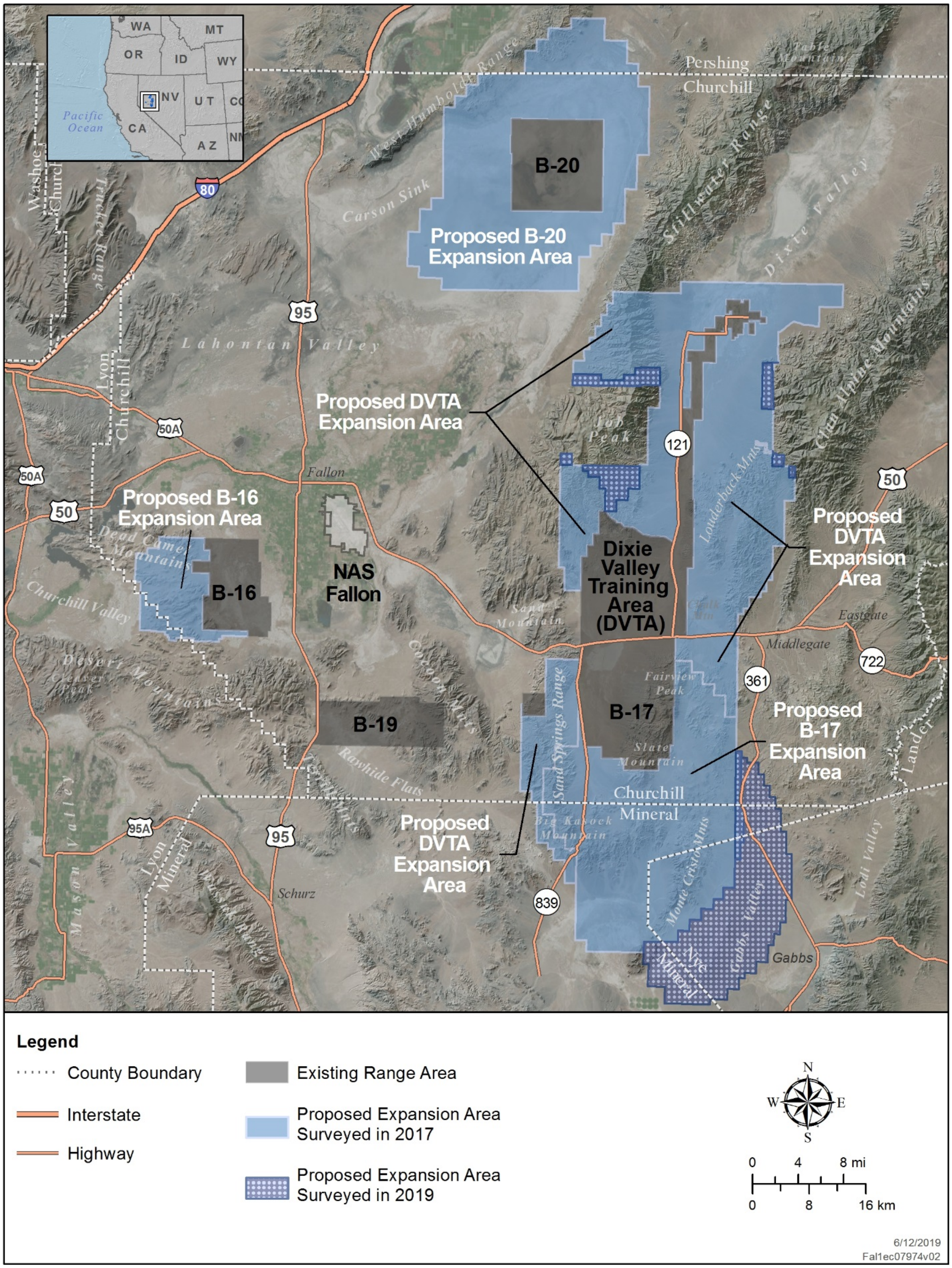

Figure 1. Regional Location of the Proposed FRTC Expansion Areas

1.2 Overview of Bat Populations and Distribution in Nevada

Of the 40 species of bats that occur in North America, 23 bat species are known to occur in Nevada (Bradley et al. 2006). Nevada supports a number of favorable habitats for bats, both on the landscape level (e.g., riparian corridors, subalpine coniferous forests, desert shrub habitats) and localized features that concentrate bats (e.g., caves, abandoned mines, springs) (Kuenzi et al. 1999; Ports and Bradley 1996). Despite the numerous habitat types that support a mix of resident and migratory bat species, the composition of the bat communities on many public lands in Nevada remains poorly understood, primarily because inventory for bat species was considered a lower priority compared to other species (O'Shea et al. 2016).

A number of factors, however, are reversing this trend. First, massive population declines in multiple hibernating bat species has been attributed to the spread of White-nose Syndrome (WNS), with the first instance of WNS west of the Rocky Mountains reported in 2016 in King County, Washington (Lorch et al. 2016). In July 2019, the fungus that causes WNS was detected in a second western state: in Chester, California, approximately 95 northwest of Reno (California Department of Fish and Wildlife [CDFW] 2019). Inventory of bat species and bat habitats is a primary conservation goal for stakeholder agencies and organizations in western states and would establish baseline conditions prior to WNS spread into unaffected areas (Burkholder et al. 2015; Hilty et al. 2016; Bat Conservation International 2018).

In addition, the build-out of utility-grade wind energy development has raised concerns for bat populations. Between 2000 and 2011, an estimated 650,000 to 1.3 million bats have died from collisions with wind turbines in the U.S. and Canada. Bat fatalities, however, in the Great Basin/Southwest Desert region of the U.S. exhibits lower bat mortality from wind facilities (1.0-1.8 bats/megawatt [MW]), compared to other regions in the U.S. (6.1-10.5 bats/MW in the northeastern deciduous forests, 4.9-11.0 bats/MW in Midwestern forests and agricultural areas, and 4.0-8.1 bats/MW in the Great Plains) (Arnett & Baerwald 2013). Another factor enabling bat conservationists to monitor bat populations is recent improvements in acoustic recorder hardware (e.g., ultrasonic microphone sensitivities, digital storage capacity enabling longer recorder deployments) and software (e.g., automatic classification algorithms to facilitate the interpretation of acoustic recordings and identify specific bat species) (Mac Aodha et al. 2017).

1.3 Seasonal Roosting and Behavior of Bats in Nevada

In the 1850s, Nevada experienced a large increase in mine excavations (Bradley et al. 2006), and today has over 300,000 abandoned mines (Furey and Racey 2016), which are the most important bat roost sites for cave dwelling species. Other important roosting habitats besides mines (including adits, the horizontal passages in mine shafts excavated for access or drainages) identified in the Nevada Bat Conservation Plan include natural caves; cliff, crevice, and talus habitats; tree roosts; and man-made structures (e.g., bridges, buildings, culverts) (Bradley et al. 2006).

Bats use a variety of roosts during all seasons, including hibernacula (winter roosts), maternity wards (summer colonies where pups are born and reared), transient roosts (resting spots during summer and migration), bachelor roosts (where male bats of some species group together), and mating sites (where swarming behavior and mating may occur) (Bradley et al. 2006; Neubaum et al. 2017) (Table 1). Some bat species, particularly tree-roosting bats of the genus *Lasiurus*, may occupy roosts individually or in small groups. Seasonal roost use and gathering activity by bats may overlap with each other and change from one year to the next. Consequently, seasonal ranges of use and activity listed in Table 1 are liberal in their approximate timing extents to account for this variation.

Table 1. General Seasonal Bat Behavior and Occurrence at Roosts

Type/Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hibernaculum												
Maternity Roost												
Transient Roost												
Bachelor Roost												
Swarming Sites												

Sources: Kuenzi et al. 1999; Sherwin et al. 2000; Morrison and Fox 2009; Neubaum et al. 2017.

Hibernacula. Hibernacula have stable microclimates that limit freezing temperatures but stay cold enough for a bat to utilize prolonged bouts of torpor during the time of year when food resources are not available (Bradley et al. 2006). Most winter roosts, including roosts in Nevada, are associated with mines, caves, and rock crevices (Morrison and Fox 2009; Furey and Racey 2016). However, Weller et al. (2016) showed that trees and foliage may support hibernacula for free ranging hoary bats (*Lasiurus cinereus*). Mine adits provide good hibernacula for wintering bats in Nevada because of their abundance, providing more opportunities for mines to support stable temperatures and relative humidity levels throughout the winter. During a mine survey for hibernating bats in western central Nevada (Mineral, Esmeralda, and Nye counties), Kuenzi et al. (1999) found Townsend’s big-eared bat (*Corynorhinus townsendii*), Western small-footed myotis (*Myotis ciliolabrum*), and Western pipistrelle (*Pipistrellus hesperus*) in 27% of surveyed mines. Surveys showed no distinction in average temperature and relative humidity in occupied and non-occupied mine adits; however, the surveyors only visited each mine site once during winter surveys, and therefore were unable to determine variability in temperature and humidity throughout the winter. Recent work by Lemen et al. (2016) suggests that crevices have been underestimated as hibernacula for North American bats.

Maternity Roosts. Maternity roosts provide warm microclimates for raising young during early summer and can have large numbers of adult females depending on the species (Neubaum et al. 2017). In Nevada, the longer adits and those with a greater number of vertical and horizontal connections to the surface are generally the more complex habitats and seem to be preferred by bats, especially for maternity roosts (Bradley et al. 2006).

Transient Roosts. Transient roosts are used by bats in spring and fall when moving between hibernacula and maternity colonies. They are used for shorter periods of time and tend to have microclimates that are warmer than hibernacula but cooler than maternity roosts, thus allowing daily bouts of torpor. The number of bats at transient roosts ranges widely and such roosts may be used sporadically, making use more difficult to confirm (Ingersoll et al. 2010).

Studying migration behaviors in bats is extremely challenging because of their nocturnal activity patterns and secretive roosting**.** For North American bats, migratory behaviors are most closely associated with tree roosting bats, but many species’ migratory patterns are largely unknown and the subject of speculation (Ports and Bradley 1996; Bradley et al. 2006). For example, hoary bats roost individually in the foliage of trees at low density and, despite a wider distributional range than most mammals, are rarely encountered through vast areas of their range (Ports and Bradley 1996; Bradley et al. 2006; O'Shea et al. 2016). Weller et al. (2016) radiotracked three male hoary bats during autumn and observed a variety of movement behaviors. One bat showed no evidence that it vacated the area of where it was captured, whereas another bat flew 42-mi (68-km) straight line distance in a single night, and a third bat completed a greater than 621-mi (1,000-km) circumnavigation of northern California, Oregon, and Nevada over the course of a month.

Bachelor Roosts. Colonial bachelor roost sites are used in summer by aggregations of primarily male bats, and is a common strategy used by cave and adit roosting bat species in Nevada (Ports and Bradley 1996; Bradley et al. 2006). Male bats of most species in North America tend to roost alone or in small groups, but some species, such as the Brazilian free-tailed bat (*Tadarida brasiliensis*), may form large bachelor colonies (Ingersoll et al. 2010).

Swarming Sites. Swarming activity in bats is largely limited to species that make use of underground sites seasonally, hibernating there in winter but roosting elsewhere in summer. Swarming in bats is thought to occur in autumn when large numbers of individuals aggregate at caves, mines, or other locations, and interact through repeated circling, diving, chasing, and landing events (Veith et al. 2004). However, smaller numbers of bats than associated with swarming may use the behavior in preparation for hibernation (Ingersoll et al. 2010; Neubaum et al. 2017). Neubaum et al. (2017) suggest that swarming behavior could serve multiple social purposes, including mating and orientation of young bats for either migration or with potential hibernacula.

2.0 METHODS

2.1 DETECTION OF BAT SOUNDS

Bats produce a wide variety of sounds that have various functions, such as communication and social interaction (low frequency sounds that generally overlap with human hearing) and navigation and feeding. Echolocating bats use high frequency ultrasound (generally above 20 kilohertz [kHz]). The complex ultrasonic pulses are species specific, and may incorporate a combination of frequencies, duration, and intensities to suit particular activities (e.g., navigating, pursuing prey) (Ammerman et al. 2012).

Detection of ultrasonic sounds from bats in the field began in the 1950s, and required a station wagon to carry all of the equipment (Brigham et al. 2002). Today's recorders are easily carried by hand and can be deployed remotely for extended periods of time. Once collected, the sound files are processed using advanced software that compares individual sound files to known attributes of specific species and provides classification to species of the calls.

2.2 RECORDING METHODS

Full spectrum (FS) ultrasonic recordings are digital recordings made at high sample rates, typically 200-500 kHz, to record bat calls up to 100-150 kHz. Recordings are analyzed by specialized computer software to generate spectrograms representing the frequency sweep of species-specific echolocation calls including harmonic details and the power distribution of the signal. *Zero crossing*, another recording format, is sometimes used as an alternative to FS recordings when a small number of known species are inventoried in the field and when digital storage media is limited.

FS recordings enjoy advantages over zero crossing recordings in that zero crossing information can be extracted from FS recordings that would not be possible directly from a zero crossing recorder. A zero-crossing detector may not be capable of detecting a weak signal against broadband background noise, such as ambient environmental noise or insect sounds. In addition, a FS recording can be manipulated in the frequency domain by applying noise reduction, echo cancellation and band-pass filters to detect, extract and enhance the narrowband signal representing the echolocation calls of bats.

Another reason for choosing FS recorders is that a high number of bat species are likely present within the area of a recorder. Given that 10 recorders were deployed within the study area, FS file analysis was thought to afford more accurate bat species identification with a large and diverse dataset collected in the field.

2.3 FIELD METHODS

2.3.1 Driving Transects (Mobile Acoustic Sampling)

Mobile acoustic sampling can be used to examine landscape-level bat use and is a qualitative method that can characterize bat movements and provide an inventory of species presence. Bradley et al. (2006) describe standard protocols for conducting mobile surveys (see Appendix A). These include maintaining vehicle speeds of 5-10 mi per hour (8-16 km per hour) while the area in front and to the side is scanned with a hand-held FS recorder and ultrasonic microphone.

In 2017, six driving transects were conducted over the course of three nights: September 16, 17, and 19. Two transects were conducted each night, each transect lasting approximately 2 hours. In 2019, 12 driving transects were conducted on the nights of May 7 – 12 with a duration of approximately 30 minutes to 2 hours (Figures 2 and 3; Table 2).

Table 2. Summary of Bat Acoustic Surveys along Driving Transects

Year	Transect	Date	Survey Times	Distance (miles)	Proposed Expansion Area
2017	1	Sep 17	2019-2223	7	DVTA North
	2	Sep 17-18	2300-0115	8	DVTA North
	3	Sep 18	0200-0315	5	DVTA North
	4	Sep 17	1850-1950	6	DVTA North
	5	Sep 16	1930-2045	6	DVTA South
	6	Sep 16	2100-2225	8	B-17
2019	7	May 8	2001-2200	9	DVTA North
	8	May 8	2204-2341	6	DVTA North
	9	May 9	2000-2115	7	DVTA North
	10	May 10	0145-0317	9	DVTA North
	11	May 10	2000-2157	8	DVTA North
	12	May 8	0031-0127	5	DVTA North
	14	May 10-11	2210-0019	12	DVTA North
	15	May 7	2228-2338	8	B-17
	16	May 7	2000-2201	17	B-17
	17	May 11	2216-2310	7	B-17
	18	May 11-12	2346-0020	4	B-17
	19	May 11	2000-2206	9	B-17

An FS recorder and ultrasonic microphone (EchoMeter Touch Pro, Wildlife Acoustics, Inc.) were used during driving transects to conduct mobile acoustic sampling. Routes were selected for surveyor safety (avoiding roads with fast moving vehicular traffic) and to avoid noise from traffic or other sources (e.g., electrical lines that may emit sounds in the ultrasonic range). Road selection for driving transects prioritized safe driving conditions at night and relatively quiet roads, with habitat selection as a secondary selection factor. This is in contrast to the selection of fixed acoustic recorder locations that were placed in a variety of habitats. Roads within B-16 and B-20 did not meet criteria for safe night-time driving conditions.

The FS recorder was mounted on the car's dashboard (to allow for two hands on the steering wheel) and connected to an ultrasonic microphone mounted outside the passenger-side window. For each transect the following items were noted: (1) date and start and end times, including start time of acoustic recorder; (2) odometer readings at start and end locations; and (3) weather and temperature information at the start and end of the transect, (4) general descriptions of artificial light and noise conditions (none, low, moderate, high), and (5) global positioning system (GPS) coordinates of the start and end locations.

When a bat was acoustically detected, the vehicle was immediately stopped to acoustically monitor the surroundings for 60 seconds. During this time, the surveyor noted mileage and GPS coordinates on a field data form. If no further vocalizations were detected, the surveyor continued driving. If more bat acoustic activity was detected after the 60 seconds, the surveyor continued monitoring for 5 minutes, and then resumed driving. A single recording would indicate a commuting bat. More prolonged activity may indicate a foraging site or other habitat feature resulting in concentrated use. Each location that had a bat encounter through the acoustic detector and resulted in a vehicle stop during the prior evening, was examined the next day and characterized by habitat and any features that might provide insight into bat use.

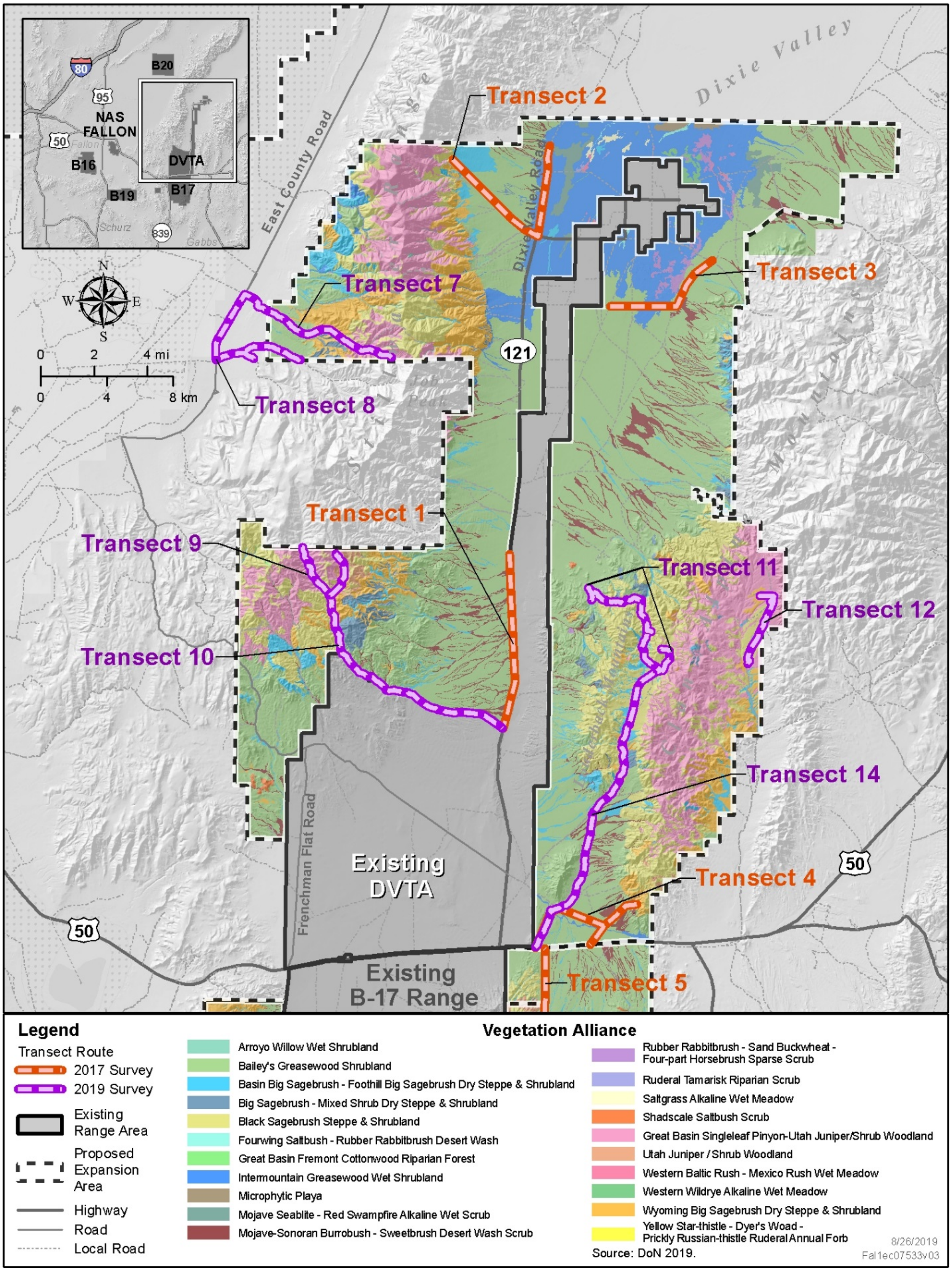

Figure 2. 2017 and 2019 Driving Transects within the Proposed Northern DVTA Expansion Area

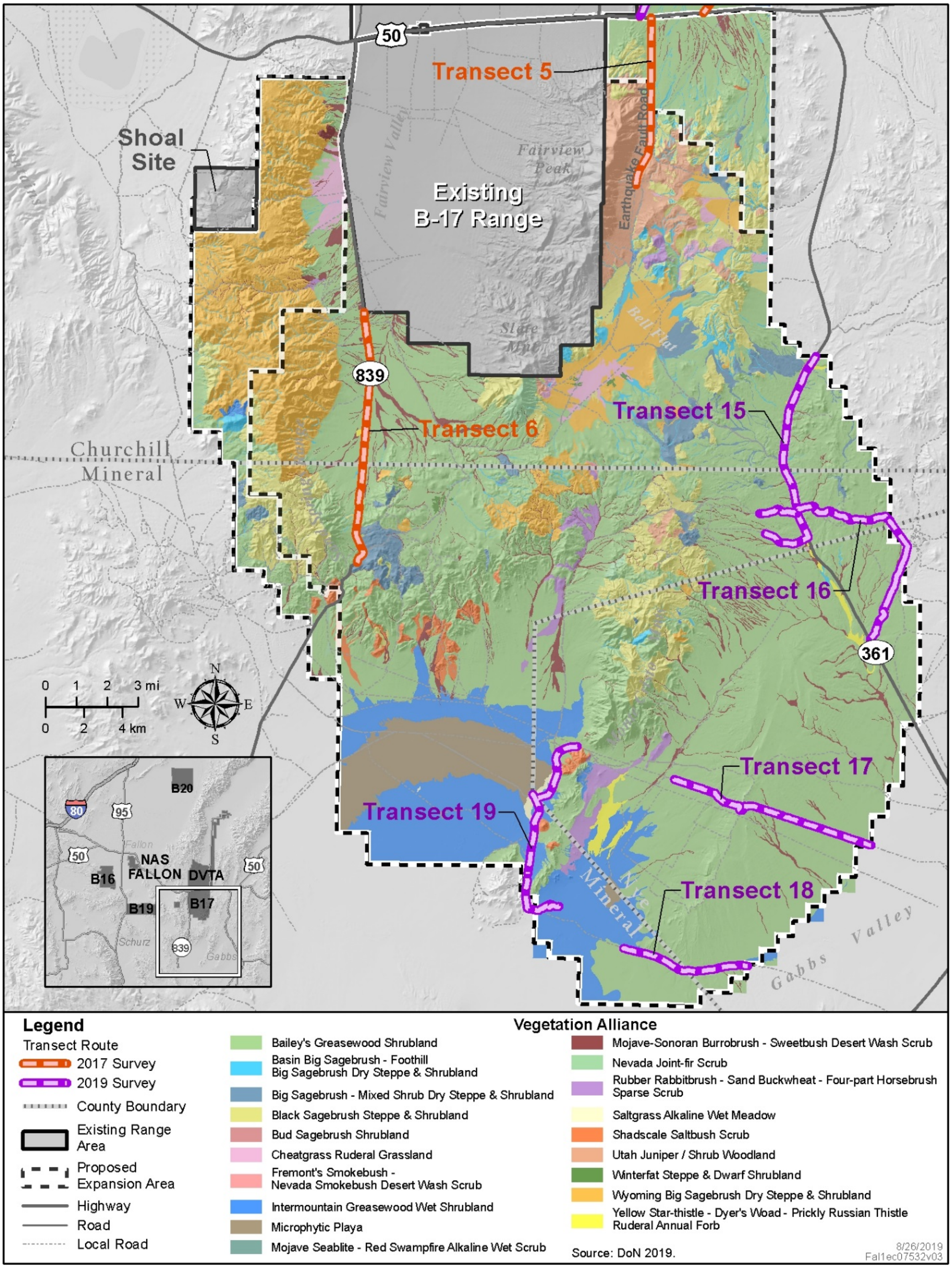

Figure 3. 2017 and 2019 Driving Transects within the Proposed B-17 Expansion Area

2.3.2 Acoustic Recorder Sites (Passive Fixed-Point Sampling)

2.3.2.1 Site Selection

In the summer of 2017 and spring of 2019, biologists conducted a suite of natural resource surveys within the study area (i.e., avian surveys, rare plant surveys, vegetation mapping, raptor surveys, and camera trap surveys). Most of these surveys were helicopter-based or used helicopters to access survey sites. During these activities, biologists provided recommendations to the bat survey team for placement of SM4BAT FS recorders for the 2017 and 2019 bat surveys. The recommended locations included brief descriptions of vegetation types and water sources, along with observations of potential roost site features (e.g., crevices, mine shafts, trees). Final deployment sites for SMB4Bat FS recorders were selected to: (1) represent a diverse set of vegetation types, (2) be in proximity to a diverse set of potential roost sites, and (3) be distributed within all of the proposed expansion areas. A total of 16 sites were selected by helicopter: 10 in September 2017 and 6 in April 2019 (Figures 4 through 7). Brief descriptions of each bat acoustic recorder location are provided in Table 3.

Using the SM4 Configurator (Wildlife Acoustics, Inc.), a configurator file was created and loaded onto 64-gigabyte SD flash cards and uploaded to each of the 10 recorder units prior to deployment. Settings included:

(1) each unit's GPS coordinates and unit name,
(2) 12-decibel (dB) gain setting,
(3) 256 kHz sample rate,
(4) 1.5-millisecond sample duration,
(5) minimum trigger frequency of 16 kHz,
(6) 12-dB trigger level, and
(7) a trigger window of 3 seconds.

2.3.2.2 Schedule and Duty Cycle of Acoustic Recorders

A schedule and duty cycle for each acoustic recorder was selected to maximize recording days from September into December and conserve battery power and storage space on the SD cards. Recordings were scheduled to begin 1 hour prior to sunset and end 1 hour after sunrise (sunset and sunrise times were calculated based on each unit's GPS coordinates). The unit's duty cycle was set to record 15 minutes and cycle off for 45 minutes between 2 hours after sunset and 2 hours before sunrise. In other words, the unit's duty cycle was continuous and uninterrupted for 3 hours around dusk (1 hour before sunset through 2 hours after sunset), then recorded for 15 minutes and powering off for 45 minutes throughout the night and resumed continuous recording for another 3 hours (2 hours before sunrise through 1 hour after sunrise). These settings were selected to capture the most active times for bats (dusk emergence from roosts and pre-dawn returns), while sampling throughout the night.

Table 3. Description of Bat Acoustic Recorder Sites

Recorder	Deployed Date	Retrieval Date	Elevation (m)	Site Description/ Vegetation Alliance*	Expansion Area†
2017					
Bat17-01	17 Sep	4 Dec	1,360	Adjacent to vertical mine shaft, on a slight rise on SE foot of Big Kasock Mtns/Bailey’s Greasewood Shrubland	B-17
Bat17-02	17 Sep	4 Dec	1,833	Near an outcrop of unconsolidated rock in the Bell’s Flat/Black Sagebrush Steppe & Shrubland	DVTA South
Bat17-03	17 Sep	4 Dec	1,863	On N side of a ridge within 100 m proximity to at least 3 mine shafts/Basin Big Sagebrush – Foothill Big Sagebrush Dry Steppe & Shrubland	DVTA South
Bat17-04	17 Sep	4 Dec	1,690	On N side of ridge in S end of Clan Alpine Mtns; adjacent to 2 mine shafts on the S side of the ridge, 3 additional shafts on the N side of the ridge/Bailey’s Greasewood Shrubland	DVTA North
Bat17-05	17 Sep	4 Dec	1,490	Adjacent to a vertical mine shaft above a valley floor that feeds into greater Dixie Valley/Bailey’s Greasewood Shrubland	DVTA North
Bat17-06	17 Sep	4 Dec	1,852	Near a mine shaft with standing old triangular beams/Wyoming Big Sagebrush Dry Steppe & Shrubland	DVTA North
Bat17-07	17 Sep	4 Dec	1,585	In a narrow valley with two collapsed shafts within 50 m/Black Sagebrush Steppe & Shrubland	DVTA North
Bat17-08	17 Sep	4 Dec	1,405	Large crevice visible on an outcrop 100 m N of the recorder, near Dead Camel Mtns/Bailey’s Greasewood Shrubland	B-16
Bat17-09	17 Sep	4 Dec	1,180	In dunes near a small playa/Intermountain Greasewood Wet Shrubland	B-20
Bat17-10	17 Sep	4 Dec	1,385	Located in a drainage in the southern foothills of West Humboldt Range/Bailey’s Greasewood Shrubland	B-20
2019					
Bat19-01	21 Apr	22 Jun	1,651	Along ephemeral stream drainage at the base of a small rock outcropping with potential roosting sites. This drainage is on the southern end of the Stillwater Mountains and likely serves as a flight path between the higher elevations and the valley bottom/Basin Big Sagebrush - Foothill Big Sagebrush Dry Steppe & Shrubland	DVTA North
Bat19-03	21 Apr	21 Jun	1,432	Near a mine along the western slopes of the Louderback Mountains/Bailey's Greasewood Shrubland	DVTA North
Bat19-04	21 Apr	21 Jun	1,669	Rocky gap above a seasonal stream north of the town of Gabbs/Big Sagebrush - Mixed Shrub Dry Steppe & Shrubland	B-17
Bat19-06	21 Apr	21 Jun	1,380	East facing drainage of Fissure Ridge, between two playas in Gabbs Valley/Bailey's Greasewood Shrubland	B-17
Bat19-07	21 Apr	21 Jun	1,490	Mouth of a tributary to the large stream drainage that follows Hwy 361 along the E edge of the Gabbs expansion area; a stock pond was approx. 1 km to the N/Mojave-Sonoran Burrobush - Sweetbush Desert Wash Scrub	B-17
Bat19-09	21 Apr	21 Jun	1,413	Near the intersection of two rocky stream drainages on the eastern edge of Dixie Valley/Bailey's Greasewood Shrubland	DVTA North

Note: *Vegetation alliances are based on DoN (2019). †See Figures 4 through 7.

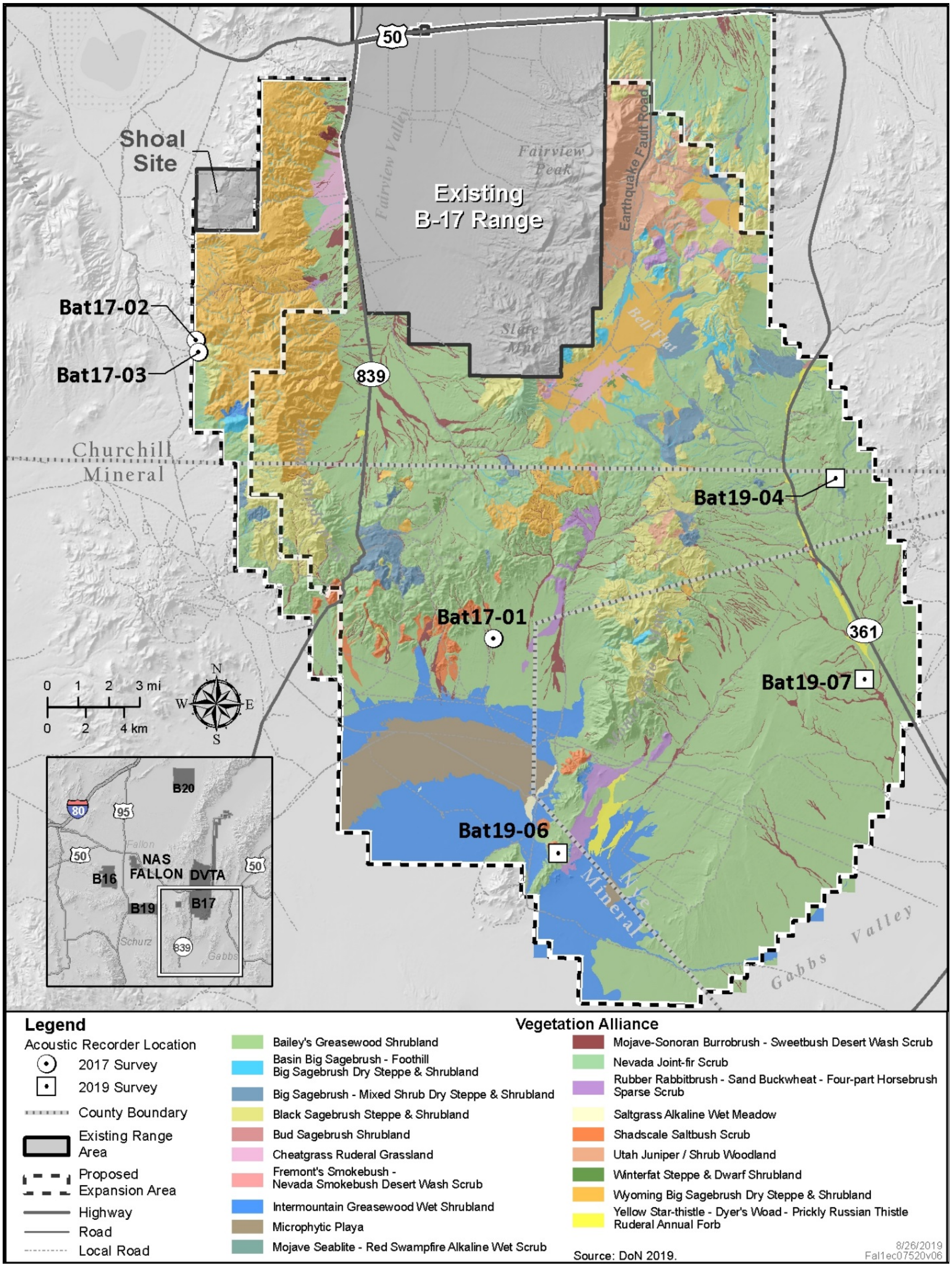

Figure 4. Location of Acoustic Recorder Sites within the Proposed B-17 and Southern DVTA Expansion Areas

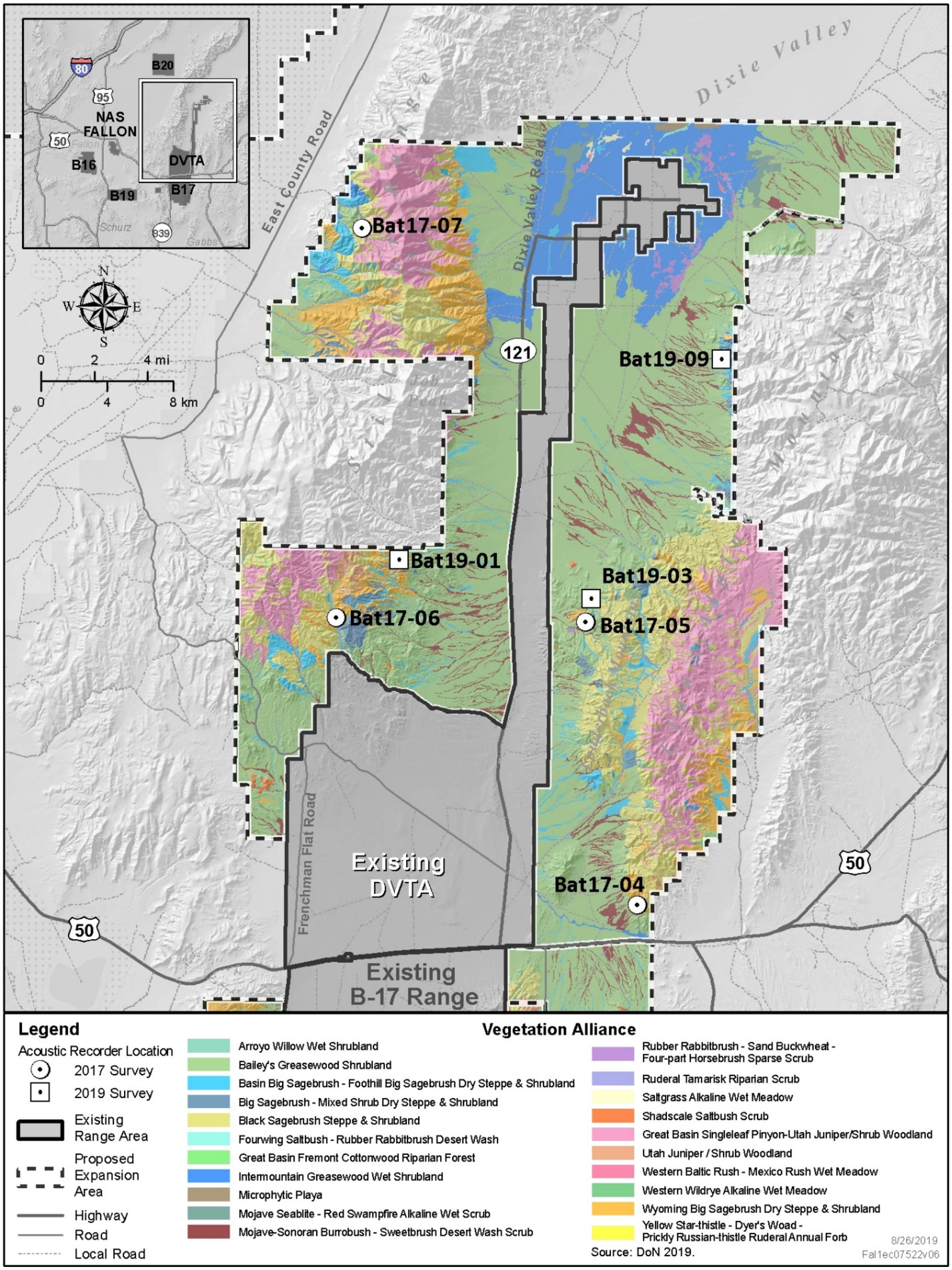

Figure 5. Location of Acoustic Recorder Sites within the Proposed Northern DVTA Expansion Area

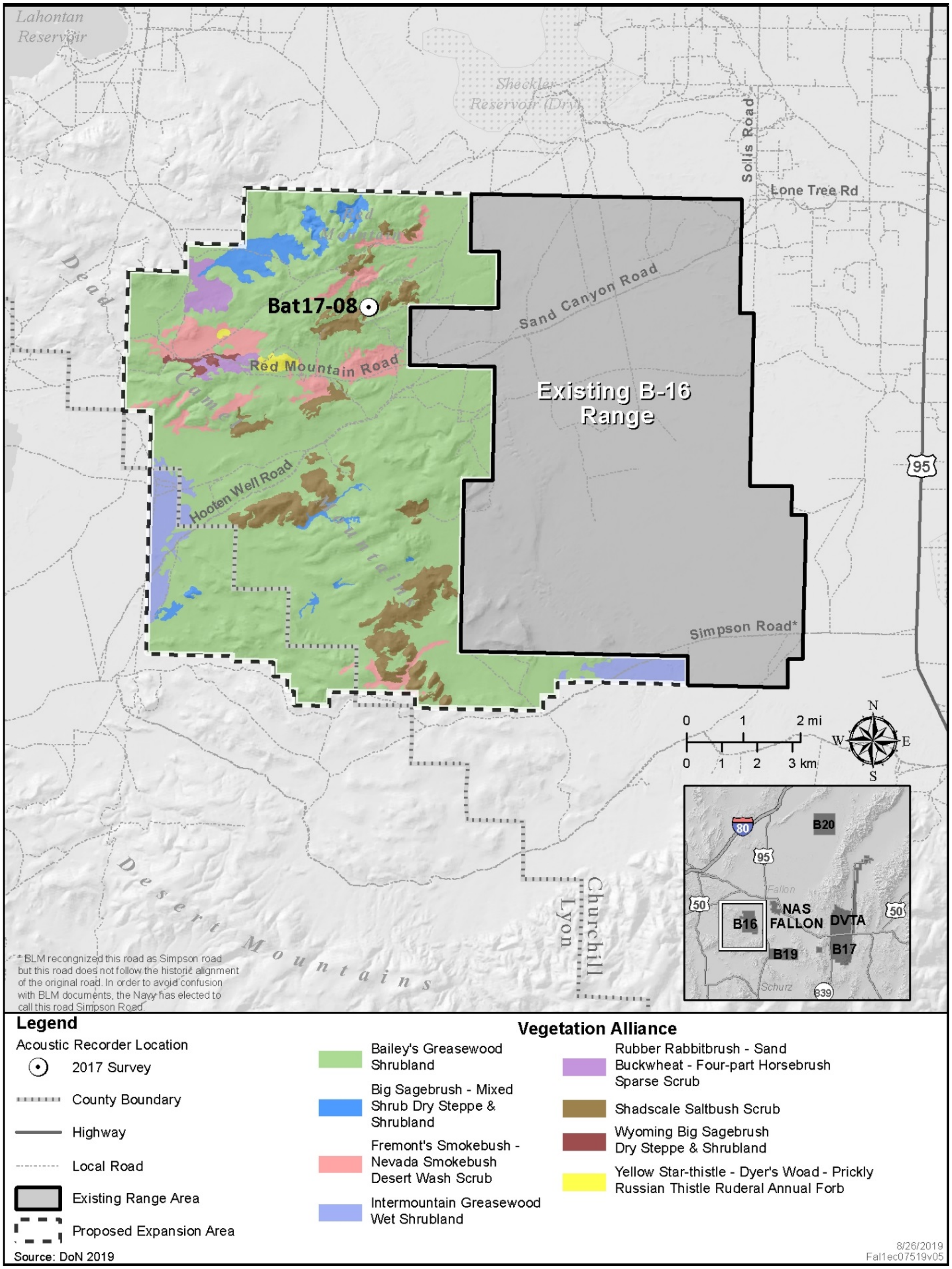

Figure 6. Location of the Acoustic Recorder Site within the Proposed B-16 Expansion Area

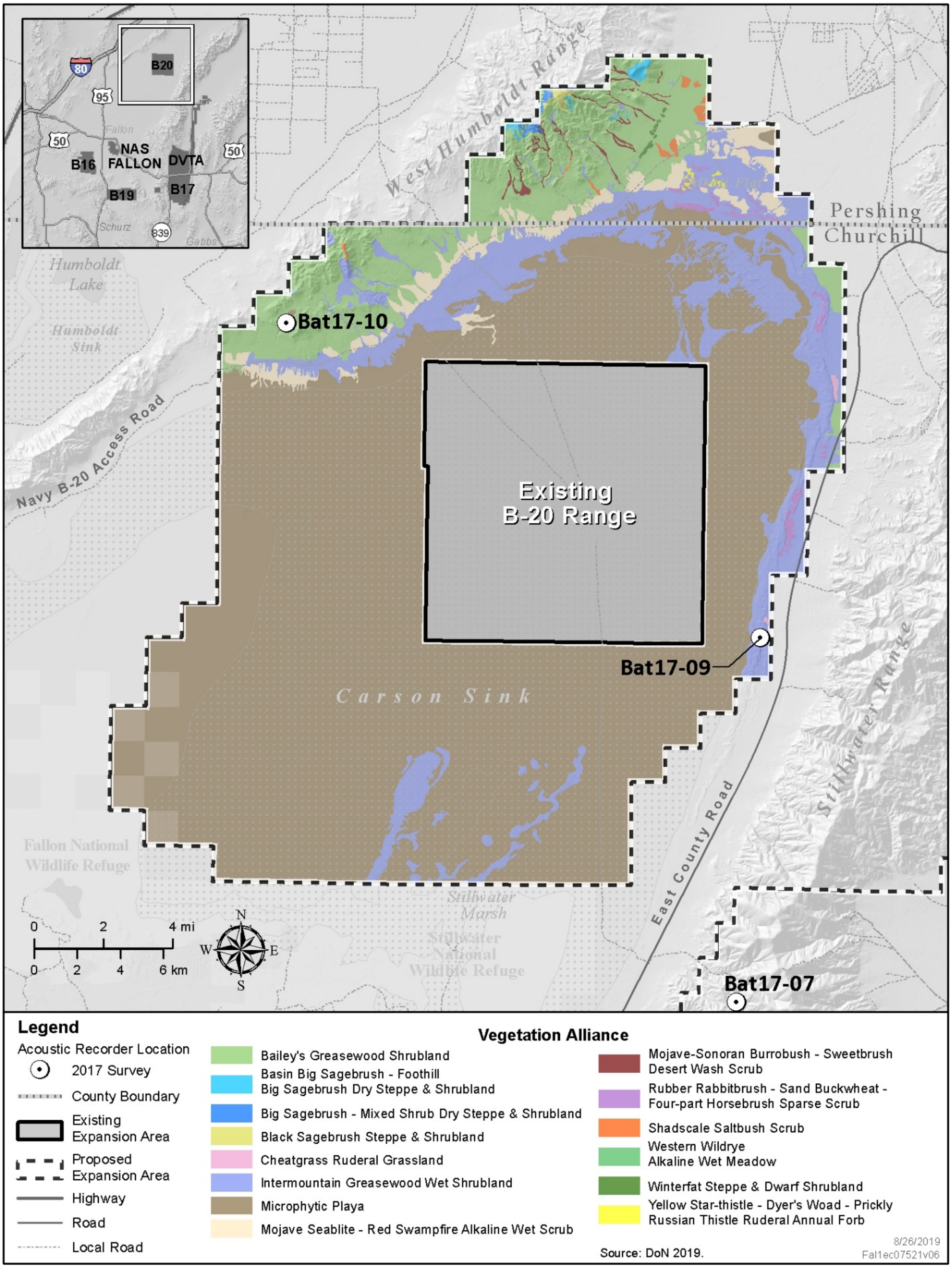

Figure 7. Location of Acoustic Recorder Sites within the Proposed B-20 Expansion Area

2.3.2.3 Acoustic Recorder Deployment

At each selected deployment location, units were mounted on 3-ft (1-m) high T-posts, which were hammered into the ground. Microphones were mounted on telescoping fiberglass tent poles (Figure 8). Based on recommendations from the SM4BAT FS manufacturer, grounding wires were installed from the top of the microphone (using pipe clamps for a 12-gauge standard grounding wire) running down the length of the pole and staked to the ground. This allows for any static electricity buildup on the tent pole to pass through the grounding wire instead of the microphone assembly and subsequently down through the cable wires into the recording unit. The grounding wire installation prevents electrical surges from static electricity into the recording unit, a concern with non-metallic poles in dry climates, and thereby allowing a path for any static surges to ground.

Left: An unassembled setup for packing and field deployment of an SM4BAT FS (metal box to deter animal damage to the recording unit, ultrasonic microphone, the SM4BAT FS unit, four D-size batteries, tent pole to hold up the microphone, and T-post). Not shown are mounting hardware (#8 screws), grounding wire, and zip-ties. **Right**: Deployed SMB4BAT FS unit on T-post.

Figure 8. SM4BAT FS Acoustic Recorder Unit Set-up

Orientation of a passive acoustic recorder is critical to obtaining useful data (Patriquin and Barclay 2003; Gorresen et al. 2008; Lemen et al. 2016). Recording units were placed at each location to sample the greatest concentration of bat activity. For a small water source, the microphones were orientated towards any water sources or mesic features in close proximity (e.g., tank, trough, riparian corridor). As a high concentration of bat activity is expected at water sources, units were never placed within 50 ft (15 m) of a feature that may pool water as this can produce an acoustically cluttered environment similar to a single individual flying near vegetation or a rock face. Placing the detector a minimum of 50 ft (15 m) from such clutter helps reduce the amount of echo and other extraneous noise. At streams and vegetation edges, or other linear habitats, microphones were orientated to sample along the long axis (parallel to the edge). Most activity will occur parallel to the edge, thus bats will be within the detection envelope longer than if the unit were oriented perpendicular to the edge.

3.0 RESULTS

Bat surveys were conducted from mid-September to early December 2017 to detect late summer and autumn resident and migrant bats, and from April through June 2019 to detect spring and summer resident and migrant bats within the proposed expansion areas.

3.1 DRIVING TRANSECTS

3.1.1 September 2017

The six driving transects conducted in September 2017 showed uneven results. Six bat species were detected across all transects: Yuma myotis (*Myotis yumanensis*), California myotis (*M. californicus*), Brazilian free-tailed bat, western pipistrelle, western red bat (*Lasiurus blossevillii*), and pallid bat (*Antrozous pallidus*) (Table 4). Across the total of 18 transect nights (i.e., 3 survey nights on 6 transects) in 2017, species detections along a transect ranged from a low of 1 (Transect 2) to a high of 5 (Transect 4). Of the 29 detections of an individual species across the 6 transects and 18 transect nights, Brazilian free-tailed bat was detected the most often (9 times on 5 transects on 9 nights), western pipistrelle was detected 7 times along 5 transects on 7 nights, Yuma myotis 5 times along 3 transects across 5 nights, western red bat 4 times along 2 transects across 4 nights, and California myotis 3 times along 3 transects across 2 nights. The pallid bat was only detected once on one night on one transect. The Brazilian free-tailed bat was detected on all transects except Transect 2 and western pipistrelle was detected on all transects except Transect 5.

3.1.2 May 2019

The 12 driving transects conducted in May 2019 also showed uneven results. Nine bat species were detected across all transects: Yuma myotis, California myotis, western pipistrelle, western red bat, little brown bat, silver-haired bat, western small-footed myotis, big brown bat, and hoary bat (Table 4). The silver-haired bat was detected the most (5 times along 5 transects on 4 nights); and little brown bat, Yuma myotis, and western red bat were each detected 3 times along 3 transects on 2-3 nights). California myotis and western small-footed myotis were each detected 2 times along 2 transects on 2 nights. The big brown bat, western pipistrelle, and hoary bat were only detected once each on a single transect. Across the total of 48 transect nights (i.e., 4 survey nights on 12 transects), species detections along a transect ranged from a low of one (Transects 14, 16, and 17) to a high of six (Transect 19).

The Brazilian free-tailed bat was not detected along any transect and no bats were detected on 4 of the 12 transects.

Table 4. Bat Acoustic Detections during September 2017 and May 2019 Driving Transects

Transect	Proposed Expansion Area	2017*			2019*				Totals	
		Sep 16	Sep 17	Sep 19	May 7	May 8-9	May 10-11	May 11-12	Species	Recordings
1	DVTA N	MYOCAL: 1 MYOYUM: 3	0	PIPHES: 4 TADBRA: 2					4	10
2	DVTA N	0	0	PIPHES: 6					1	6
3	DVTA N	0	0	LASBLO: 2 PIPHES: 4 TADBRA: 2					3	8
4	DVTA N	MYOYUM: 1 PIPHES: 4 TADBRA: 8	MYOCAL: 1 MYOYUM:2 TADBRA: 9	ANTPAL: 2 MYOYUM: 4 TADBRA: 5					5	35
5	DVTA S	0	MYOCAL: 2 TADBRA: 1	0					2	3
6	B-17	LASBLO: 5 PIPHES: 1 TADBRA: 12	LASBLO: 9 PIPHES: 4 TADBRA: 8	LASBLO: 6 MYOYUM: 2 PIPHES: 14 TADBRA: 5					4	66
7	DVTA N				0	MYOCAL: 1 MYOLUC: 5 MYOYUM: 1	0	0	3	7
8	DVTA N				0	LASNOC: 1 MYOYUM: 1	0	0	2	2
9	DVTA N				0	0	0	0	0	0
10	DVTA N				0	0	0	0	0	0
11	DVTA N				0	0	LASBLO: 1 MYOCAL: 1 MYOCIL: 3 MYOLUC: 1	0	4	6
12	DVTA N				0	0	0	0	0	0
14	DVTA N				0	0	LASNOC: 1	0	1	1
15	B-17				0	0	0	0	0	0
16	B-17				LASNOC: 1	0	0	0	1	1
17	B-17				0	0	0	LASNOC:1	1	1

Table 4. Bat Acoustic Detections during September 2017 and May 2019 Driving Transects

Transect	Proposed Expansion Area	2017*			2019*				Totals	
		Sep 16	Sep 17	Sep 19	May 7	May 8-9	May 10-11	May 11-12	Species	Recordings
18	B-17				0	0	0	LASBLO: 1 MYOCIL: 1 MYOLUC: 1	3	3
19	B-17				0	0	0	EPTFUS: 1 LASBLO: 2 LASCIN: 1 LASNOC: 4 MYOYUM: 2 PIPHES: 16	6	26

Notes: *Species Code: number of recordings.

Definitions of Species Codes

ANTPAL = Pallid bat (*Antrozous pallidus*)
EPTFUS = Big brown bat (*Eptesicus fuscus*)
LASBLO = Western red bat (*Lasiurus blossevillii*)
LASCIN = Hoary bat (*Lasiurus cinereus*)
LASNOC = Silver-haired bat (*Lasionycteris noctivagans*)
MYOCAL = California myotis (*M. californicus*)
MYOCIL = Western small-footed myotis (*Myotis ciliolabrum*)
MYOLUC = Little brown bat (*Myotis lucifugus*)
MYOYUM = Yuma myotis (*Myotis yumanensis*)
PIPHES = Western pipistrelle (*Pipistrellus hesperus*)
TADBRA = Brazilian free-tailed bat (*Tadarida brasiliensis*)

3.2 ACOUSTIC RECORDERS (FIXED LOCATIONS)

3.2.1 September – December 2017 Surveys

A total of 7,583 files were obtained from 9 SM4BAT FS acoustic recorders; 1 recorder (Bat02) was not found and presumed stolen. Of these 7,583 files, 1,049 (14%) were classified as noise or not identifiable. The remaining 6,533 (86%) were classified and identified to species (Figure 9 and Table 5). Based on the classified acoustic files, passive acoustic surveys conducted in September through early December 2017 within the proposed FRTC expansion areas documented the presence of 15 bat species: 1 species in the Family Molossidae (Brazilian free-tailed bat) and 14 species in the Family Vespertilionidae. Table 6 lists their status, seasonal occurrence, and associated roost types within the proposed expansion areas cross referenced from life history information (Bradley et al. 2006).

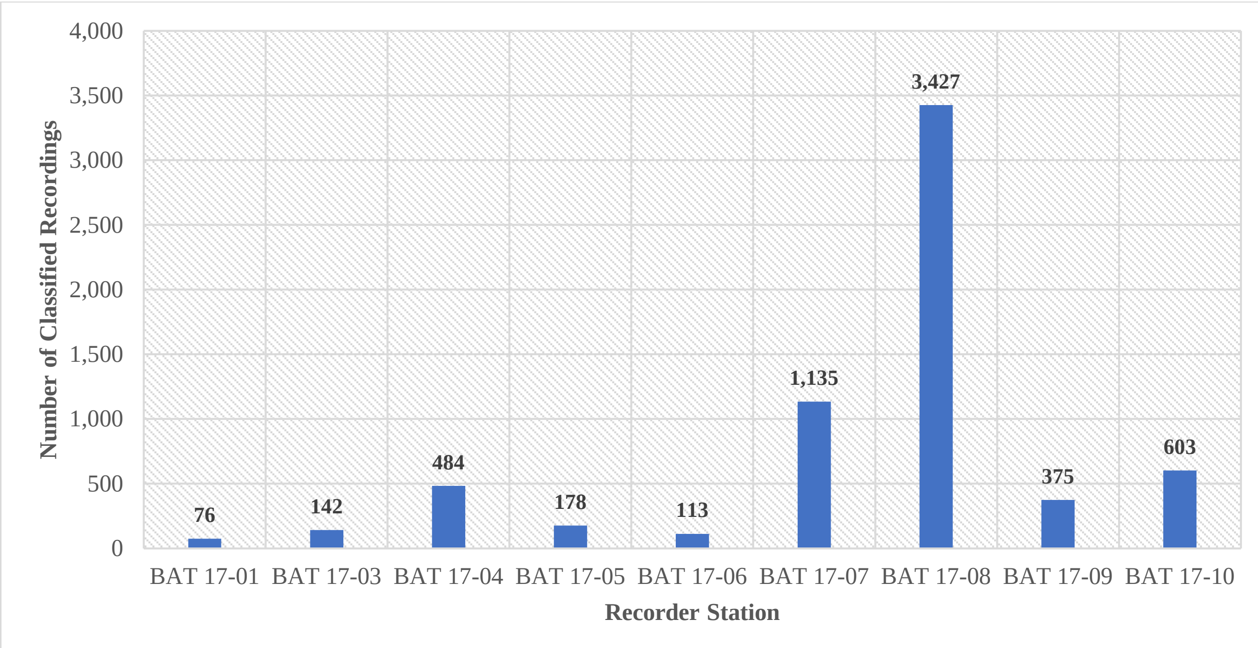

Figure 9. Number of Classified Bat Recordings by Recording Station (September – December 2017)

All species are listed as sensitive by the Bureau of Land Management (BLM), the State of Nevada lists three as Protected Mammals and two as Sensitive Mammals, and none are listed by the U.S. Fish and Wildlife Service under the Endangered Species Act (Nevada Wildlife Action Plan Team [NWAPT] 2013; BLM 2017) (Table 6).

As shown in Figure 9, the number of recordings retrieved from each location was not evenly distributed across the 2017 study area during the September – December survey period. The number of recordings ranged from a low of 76 at Bat17-01 to a high of 3,427 at Bat17-08. Species detections across recorder locations varied from a low of 9 to a high of 15 (Table 5).

Table 5. Number of Classified Bat Recordings by Species and Recording Station (September – December 2017)

Species		Number of Recording Files by Station (Bat)									
Scientific Name	**Common Name**	**17-01**	**17-03**	**17-04**	**17-05**	**17-06**	**17-07**	**17-08**	**17-09**	**17-10**	**Total**
Tadarida brasiliensis	Brazilian free-tailed bat	7	44	18	3	4	18	1,295	1	199	**1,589**
Pipistrellus hesperus	Western pipistrelle	41	25	240	77	24	143	309	94	116	**1,069**
Lasionycteris noctivagans	Silver-haired bat	4	14	12	4	2	20	919	13	12	**1,000**
Lasiurus cinereus	Hoary bat	12	22	30	14	17	55	352	11	238	**751**
Myotis californicus	California myotis	1	2	49	18	3	330	1	62	3	**469**
Myotis ciliolabrum	Western small-footed myotis	0	9	38	10	40	206	81	26	4	**414**
Myotis yumanensis	Yuma myotis	4	7	24	9	1	220	5	111	3	**384**
Eptesicus fuscus	Big brown bat	1	9	2	0	1	9	352	2	1	**377**
Lasiurus blossevillii	Western red bat	4	5	45	27	11	26	91	39	24	**272**
Myotis lucifugus	Little brown bat	0	1	1	4	6	48	6	14	3	**83**
Antrozous pallidus	Pallid bat	0	3	14	10	2	19	10	0	0	**58**
Corynorhinus townsendii	Townsend's big-eared bat	2	0	7	2	1	28	5	0	0	**45**
Myotis volans	Long-legged myotis	0	1	1	0	1	12	1	1	0	**17**
Myotis thysanodes	Fringed myotis	0	0	2	0	0	1	0	1	0	**4**
Myotis evotis	Long-eared myotis	0	0	1	0	0	0	0	0	0	**1**
	Total	**76**	**142**	**484**	**178**	**113**	**1,135**	**3,427**	**375**	**603**	**6,533**
	Number of Species	**9**	**12**	**15**	**11**	**13**	**14**	**13**	**12**	**10**	**15**

For the 2017 survey effort, classifications for individual recording stations are summarized in Figure 10. Of the 6,533 recordings, three species of bats accounted for 55% of all the recordings: Brazilian free-tailed bats accounted for 24% of all bat recordings (1,589 recordings), western pipistrelle accounted for 16% (1,069 recordings), and silver-haired bat (*Lasionycteris noctivagans*) accounted for 15% (1,000 recordings). Most of the recordings for these three species were obtained from the Bat17-08 location (1,295 recordings for Brazilian free-tailed bats [82%], 309 recordings for western pipistrelle [29%], and 919 recordings [92%] for silver-haired bat). Figure 10 also shows the uneven distribution of species diversity at each recording station.

Table 6. Summary of Regulatory Status and Roost Types for Bat Species Detected during 2017 and 2019 Passive Acoustic Survey Efforts

Species Code	Scientific Name	Common Name	BLM/ Nevada*	Population/ Habitats at Risk‡	Occurrence	Roost Type
PIPHES	*Pipistrellus hesperus*	Western pipistrelle	S/-	Medium	Resident	Rock crevices, mines, caves, buildings, and hollow trees.
TADBRA	*Tadarida brasiliensis*	Brazilian free-tailed bat	S/P	Medium	Possible resident	Cliff faces, mines, caves, buildings, bridges, and hollow trees.
LASNOC	*Lasionycteris noctivagans*	Silver-haired bat	S/-	Medium	Possible resident	Almost exclusively trees in summer, maternal roosts in trees.
LASCIN	*Lasiurus cinereus*	Hoary bat	S/-	Medium	Possible resident	Solitary roosts within trees
LASBLO	*Lasiurus blossevillii*	Western red bat	S/S	High	Summer	Possible migrant, roosts in trees, sometimes mines and caves.
MYOCAL	*Myotis californicus*	Californian myotis	S/-	Medium	Resident	Rock crevices, mines, caves, buildings, under exfoliating bark, hollow trees.
MYOCIL	*Myotis ciliolabrum*	Western small-footed myotis	S/-	Medium	Resident	Caves, mines, and trees
MYOEVO	*Myotis evotis*	Long-eared myotis	S/-	Medium	Resident	Hollow trees, under exfoliating bark, crevices in rock outcrops, and occasionally in mines, caves, and buildings.
MYOLUC	*Myotis lucifugus*	Little brown bat	S/-	Medium	Resident	Hollow trees, rock outcrops, buildings, and occasionally mines and caves.
MYOTHY	*Myotis thysanodes*	Fringed myotis	S/P	High	Resident	Mines, caves, trees, and buildings.
MYOVOL	*Myotis volans*	Long-legged myotis	S/-	Low	Resident	Hollow trees, rock crevices, caves, mines, and buildings; caves and mines used for night roosts; hibernacula in mines or caves.
MYOYUM	*Myotis yumanensis*	Yuma myotis	S/-	Medium	Resident	Day roosts in hollow trees, rock outcrops, buildings, and occasionally mines and caves.
EPTFUS	*Eptesicus fuscus*	Big brown bat	S/-	Low	Resident	Caves, trees, mines, buildings, and bridges.
ANTPAL	*Antrozous pallidus*	Pallid bat	S/P	Medium	Resident	*Day*: rock outcrops, mines, adits, caves, hollow trees, buildings, and bridges. *Night*: under bridges, caves, and mines.
CORTOW	*Corynorhinus townsendii*	Townsend's big-eared bat	S/S	High	Resident	Caves, mines, trees, buildings.

Source: Bradley et al. 2006.
Notes: *S = Sensitive (BLM 2017). P = Protected Mammal; S = Sensitive Mammal (NWAPT 2013). ‡High = those species considered the highest priority for funding, planning, and conservation actions. Information about status and threats to most species could result in effective conservation actions being implemented should a commitment to management exist. These species are imperiled or are at high risk of imperilment. Medium = a level of concern that should warrant closer evaluation, more research, and conservation actions of both the species and possible threats. A lack of meaningful information is a major obstacle in adequately assessing these species' status and should be considered a threat. Low = most of the existing data support stable populations of the species, and that the potential for major changes in status in the near future is considered unlikely. While there may be localized concerns, the overall status of the species is believed to be secure. Conservation actions would still apply for these bats, but limited resources are best used on species considered high and medium priority (Western Bat Working Group 1998).

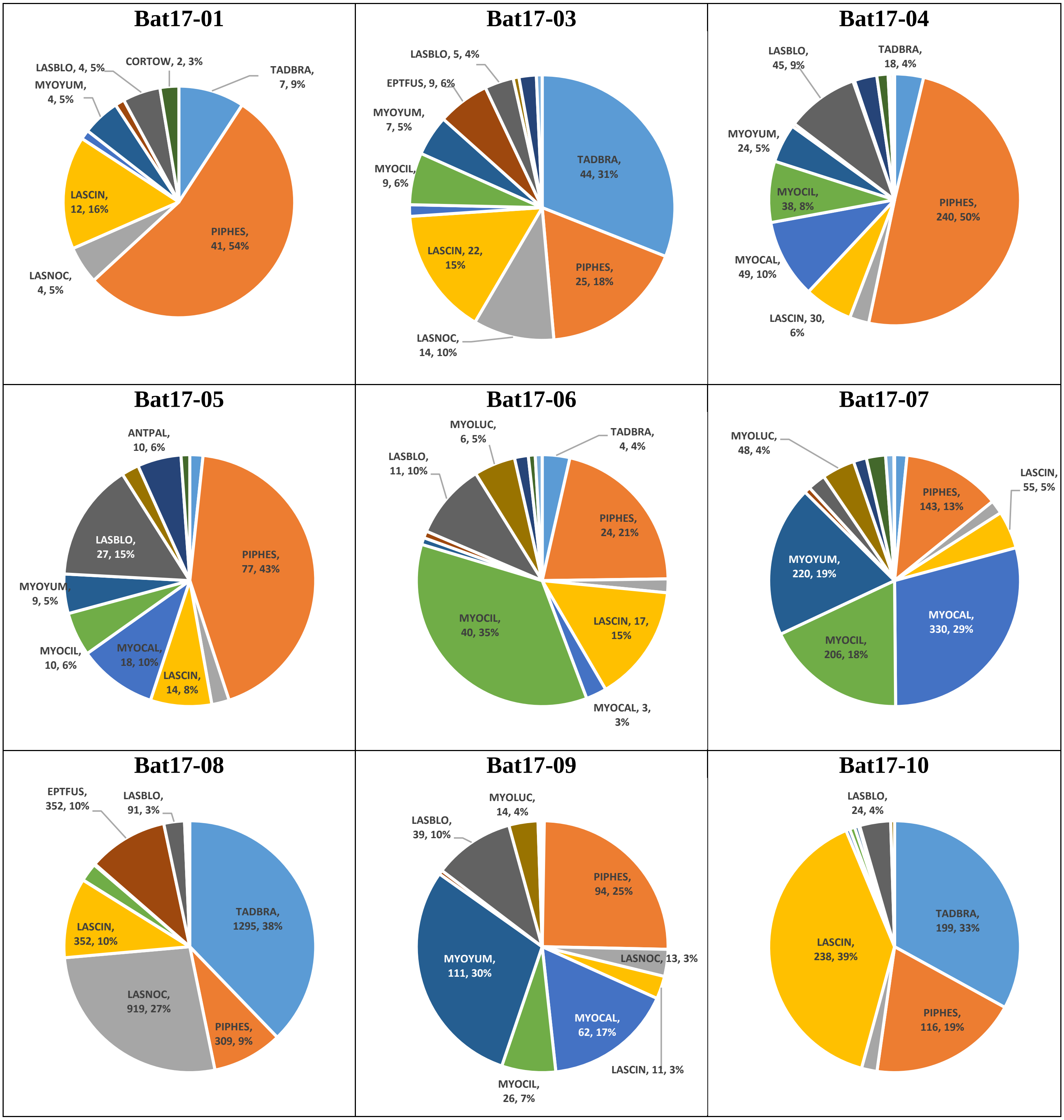

Figure 10. Total Number of Bat Recordings by Species and Recorder Station (September – December 2017)

Notes: Pie labels: Species Code (see Table 6), Number of Recordings, Percentage of the Total Recordings at the site. Species with recordings of less than 3% are not labeled. See Table 5 for numbers of all recordings for all species by recording location.

3.2.2 April – June 2019 Surveys

For the 2019 survey effort, a total of 8,376 recordings were collected from the 6 units deployed in the study area. Of these 8,376 files, 223 (3%) were classified as noise or not identifiable. The remaining 8,153 (97%) were classified and identified to species (Figure 11 and Table 7). Based on the classified acoustic files, passive acoustic surveys conducted in April through June 2019 within the proposed B-17 and DVTA expansion areas documented the presence of 12 bat species: 1 species in the Family Molossidae (Brazilian free-tailed bat) and 11 species in the Family Vespertilionidae. Table 6 lists their status, seasonal occurrence, and associated roost types within the proposed expansion areas cross referenced from life history information (Bradley et al. 2006).

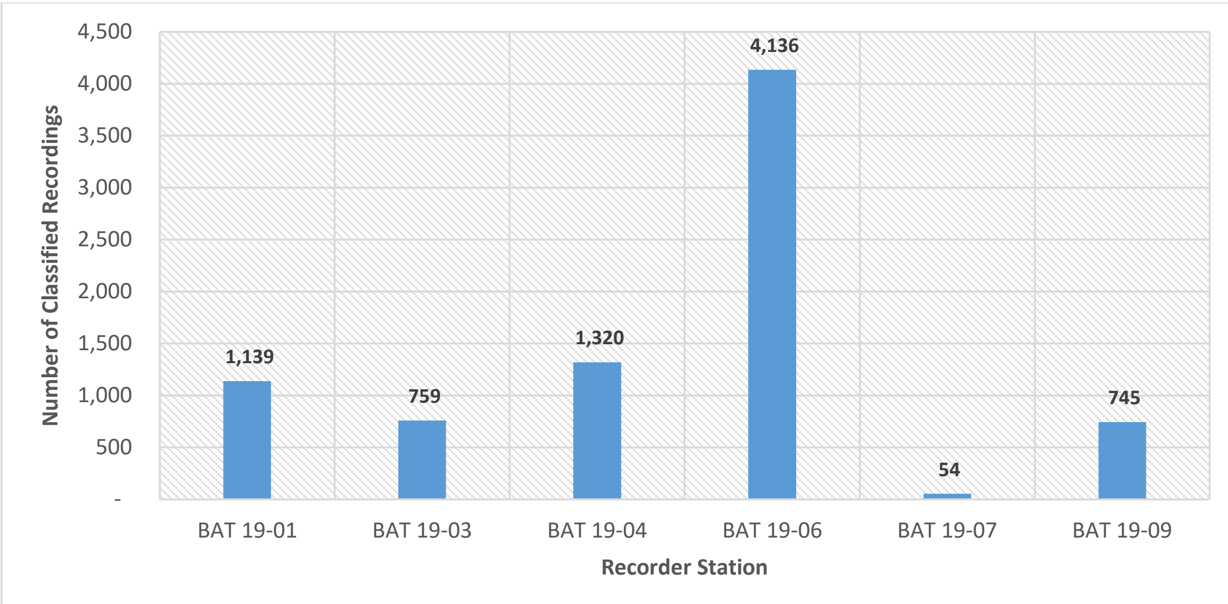

Figure 11. Number of Classified Bat Recordings by Recording Station (April – June 2019)

Table 7. Number of Classified Bat Recordings by Species and Recording Station (April – June 2019)

Species		Number of Recording Files by Station (Bat)						
Scientific Name	**Common Name**	**19-01**	**19-03**	**19-04**	**19-06**	**19-07**	**19-09**	**Total**
Pipistrellus hesperus	Western pipistrelle	152	360	692	3,055	0	327	**4,586**
Lasiurus blossevillii	Western red bat	115	204	314	840	3	277	**1,753**
Myotis ciliolabrum	Western small-footed myotis	651	43	73	10	31	57	**865**
Myotis lucifugus	Little brown bat	154	29	13	7	5	18	**226**
Myotis californicus	California myotis	31	31	33	57	4	44	**200**
Antrozous pallidus	Pallid bat	4	3	82	79	0	8	**176**
Myotis yumanensis	Yuma myotis	20	32	9	43	1	5	**110**
Tadarida brasiliensis	Brazilian free-tailed bat	0	2	69	1	0	0	**72**
Eptesicus fuscus	Big brown bat	2	4	20	41	0	2	**69**
Corynorhinus townsendii	Townsend's big-eared bat	0	49	0	0	1	0	**50**
Lasionycteris noctivagans	Silver-haired bat	7	2	7	3	1	3	**23**
Myotis volans	Long-legged myotis	3	0	8	0	8	4	**23**
	Total	**1,139**	**759**	**1,320**	**4,136**	**54**	**745**	**8,153**
	Number of Species	**10**	**11**	**11**	**10**	**8**	**10**	**12**

Over half of all the recordings were classified as western pipistrelles (54% or 4,586 recordings). Western red bats were also well represented, with 21% or 1,753 recordings and western small-footed myotis accounted for 10% (835 recordings). Most of the recordings were obtained from the Bat 19-06 location (4,165 recordings), with western pipistrelle comprising the majority of the recordings (73% or 3,055 recordings).

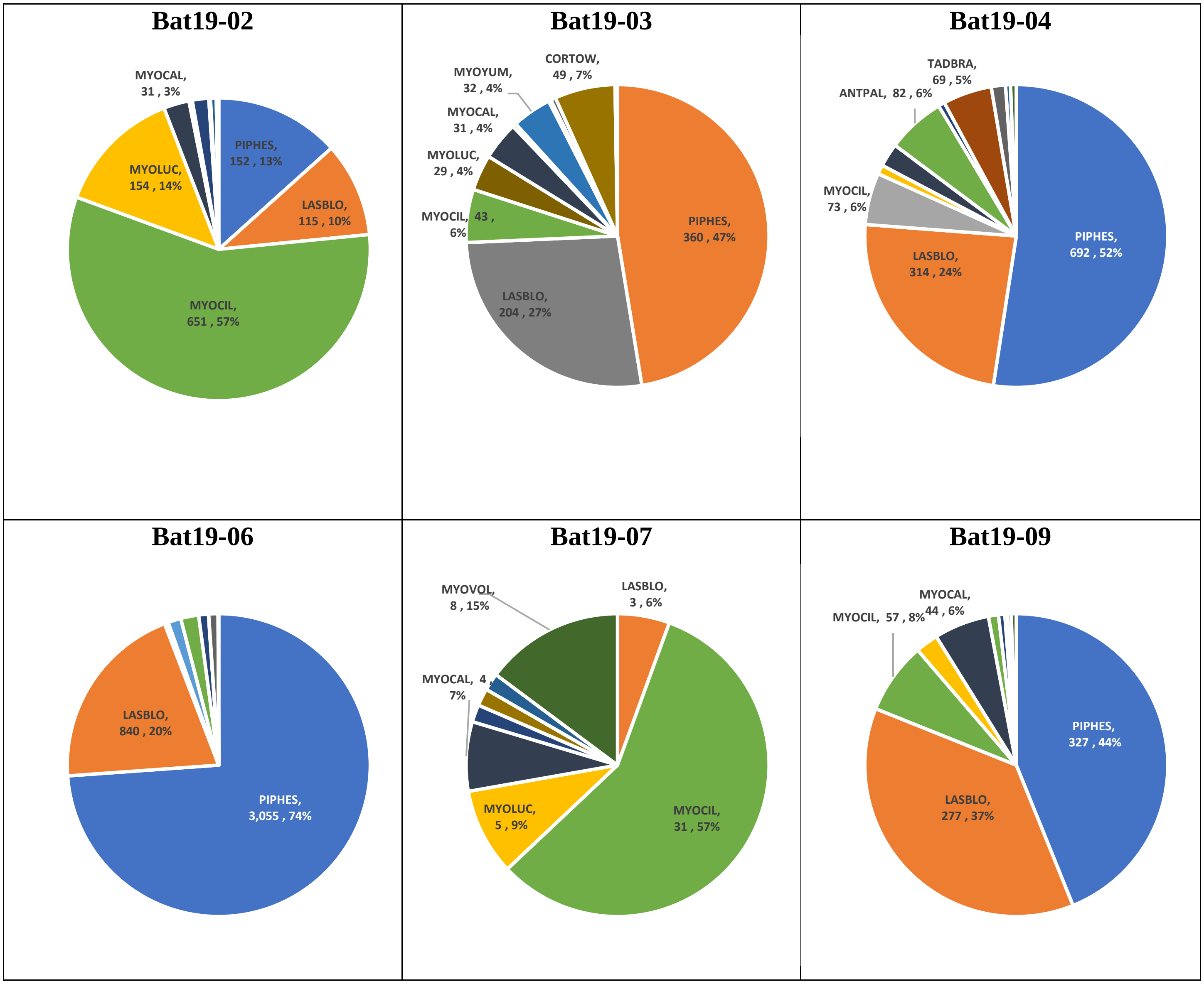

Figure 12. Total Number of Bat Recordings by Species and Recorder Station April- July 2019)

Notes: Pie labels: Species Code (see Table 6), Number of Recordings, Percentage of the Total Recordings at the site. Species with recordings less than 3% are not labeled. See Table 7 for numbers of all recordings for all species by recording location.

3.3 SPECIES DESCRIPTIONS

This section provides species descriptions, with species-specific life history information sourced from the Nevada Bat Conservation Plan (Bradley et al. 2006). Included with each species description are spectrographs obtained for each species from the recovered bat recorders. Figure 13 provides an example spectrograph and how to read the information provided for each species.

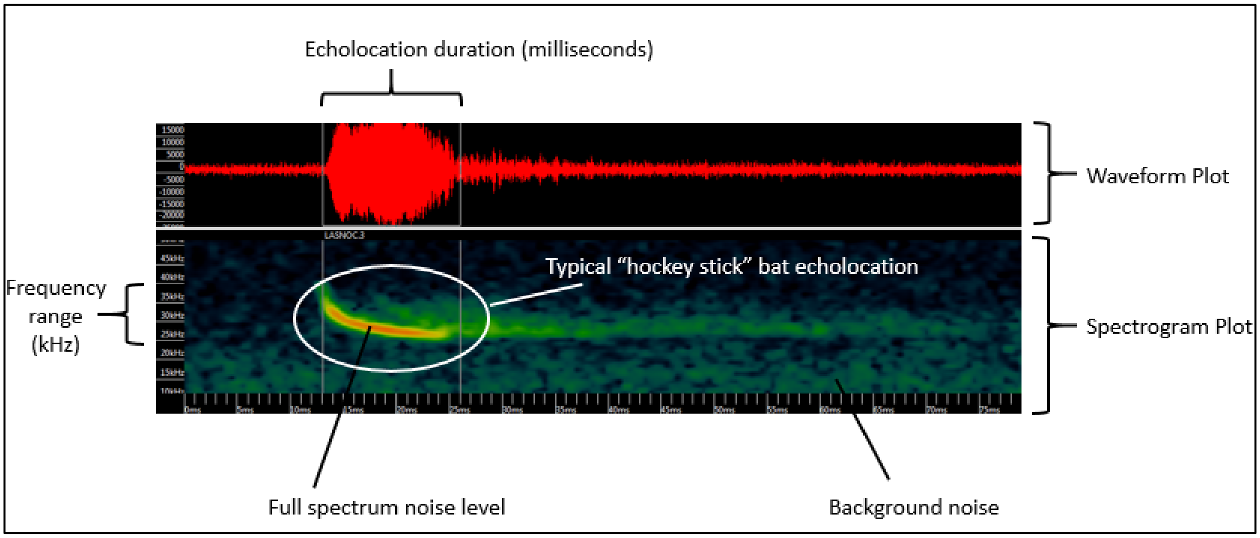

Figure 13. Example of a Bat Spectrograph

Also included with each species identified through the software's auto-classification process and manual call interpretation is a figure showing the number of recordings identified for the species plotted with the date of recording (black dots), with linear trend in detections through the survey period (black dashed line) (Figure 14). Minimum temperatures were also obtained from the units over each nightly recording period (blue line), depicted with the linear trend in decreasing minimum temperatures throughout the survey period (dotted green line).

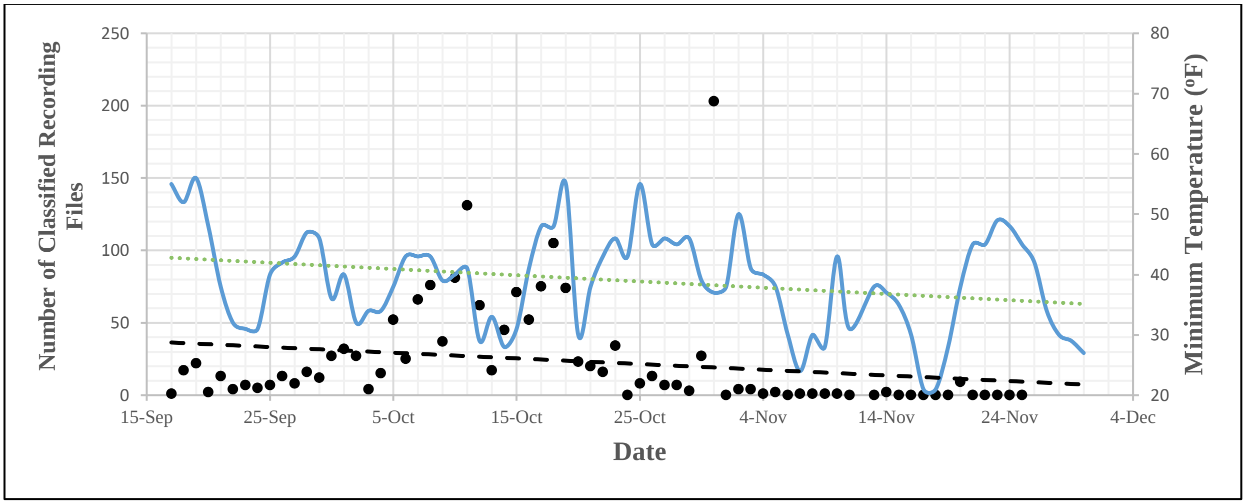

Figure 14. Example Graph Illustrating Recordings, Dates, Linear Trends in Detections, and Minimum Ambient Temperature

3.3.1 Family Molossidae

Members in the family Molossidae are commonly referred to as "free-tailed bats" because of a tail that extends beyond the membrane that connects the base of the tail to the hind legs.

Brazilian Free-tailed Bat (*Tadarida brasiliensis*). Brazilian free-tailed bats have no federal protections; however, the State of Nevada lists this species as a "protected mammal" under Nevada Administrative Code (NWAPT 2013). Although Brazilian free-tails are one of the most common species in much of the west, their numbers may be well below what they were historically. This species is a summer resident throughout Nevada, although they hibernate in the warmer areas of southern Nevada (e.g., Las Vegas valley). They use a variety of day roosts including cliff faces, mines, caves, buildings, bridges, and hollow trees. Although colonies number in the millions in some areas, colonies in Nevada are generally several hundred to several thousand (largest known colonies have been estimated at approximately 70,000-100,000). Some caves may be used as long-term transient stopover roosts during migration. For example, some evidence suggests that the colony at Rose Cave, Nevada arrives in July and departs in mid-October (Bradley et al. 2006; NWAPT 2013).

Within the 2017 and 2019 study areas, this species accounted for 24% and 1%, respectively, of all the classified recordings. Significant numbers of Brazilian free-tailed bats were recorded at Bat17-08 on October 31. A large rock crack is approximately 330 ft (100 m) to the north of Bat17-08, and possibly supports a large colony. The night of this recording may be an example of Brazilian free-tailed bat swarming (see Section 1.3 for an explanation of swarming behavior).

Figure 15 shows the number of Brazilian free-tailed bats recordings from all stations throughout the 2017 survey period. Figure 16 shows the number of Brazilian free-tailed bats recordings from all stations throughout the 2019 survey period. Figure 17 shows an example of an echolocation spectograph.

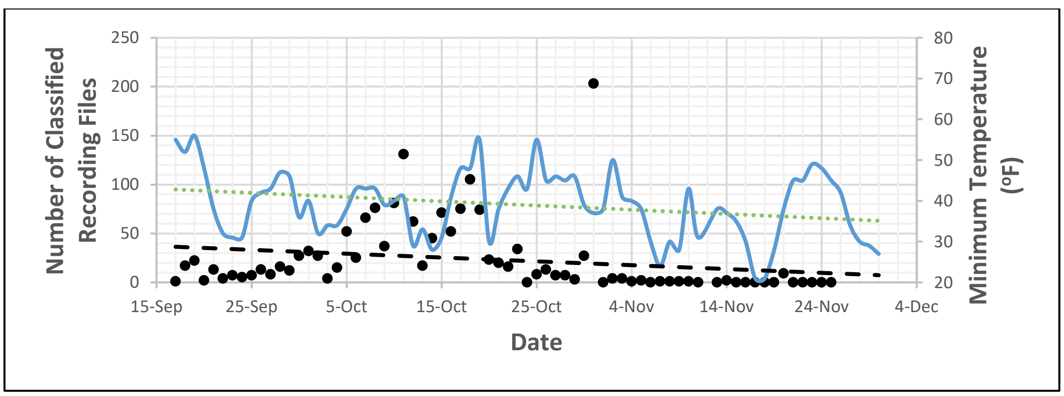

Figure 15. Brazilian Free-tailed Bat Classified Recordings during the 2017 Survey Period

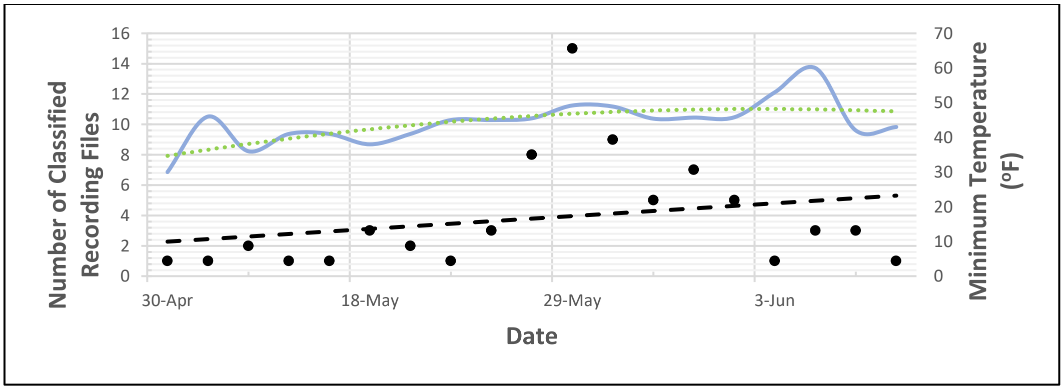

Figure 16. Brazilian Free-tailed Bat Classified Recordings during the 2019 Survey Period

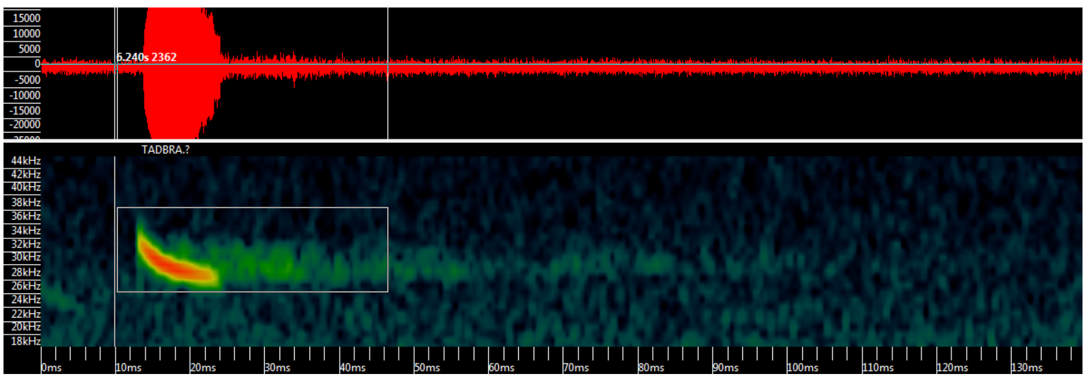

Figure 17. Brazilian Free-tailed Bat Echolocation Spectrograph

3.3.2 Family Vespertilionidae

Members of family Vespertilionidae, more commonly known as "evening bats" or "vesper bats", form the largest family in the order Chiroptera, containing as many as 407 known species and 48 genera. A total of 18 species within this family are found in Nevada.

Western Pipistrelle (*Pipistrellus hesperus*). There are no federal or state protections for this species. The western pipistrelle is found throughout most of the state, primarily in the southern and western portions. These bats are most common in low and middle elevations (5,900 ft [1,800 m]), although occasionally at higher elevations, and is thought to be a year-round resident. This species hibernates in winter, but periodically arouse to actively forage and drink. Day roosts are primarily associated with rock crevices but may include mines, caves, or occasional buildings and vegetation. Food items include small moths, leafhoppers, mosquitoes, and flying ants. Foraging occurs in the open and is characterized by slow, erratic flight. Primary threats include the destruction of roosting and foraging habitat by urban development; water impoundments; mine closure and reclamation (Bradley et al. 2006).

Within the 2017 and 2019 study areas, this species accounted for 16% and 56%, respectively, of all the classified recordings. Within the 2017 study area, this species was recorded from all stations, with the highest number of recordings at Bat17-08 and Bat17-04. Figure 18 shows the number of western pipistrelle recordings from all stations throughout the 2017 survey period. Figure 19 shows the number of western pipistrelle recordings obtained from all stations throughout the 2019 survey period. This species was recorded from all survey locations within the 2019 study area, and the number of classified recordings remained roughly even throughout the survey period, except for a noticeable dip in mid- to late May. Figure 20 shows an example of an echolocation spectograph for this species.

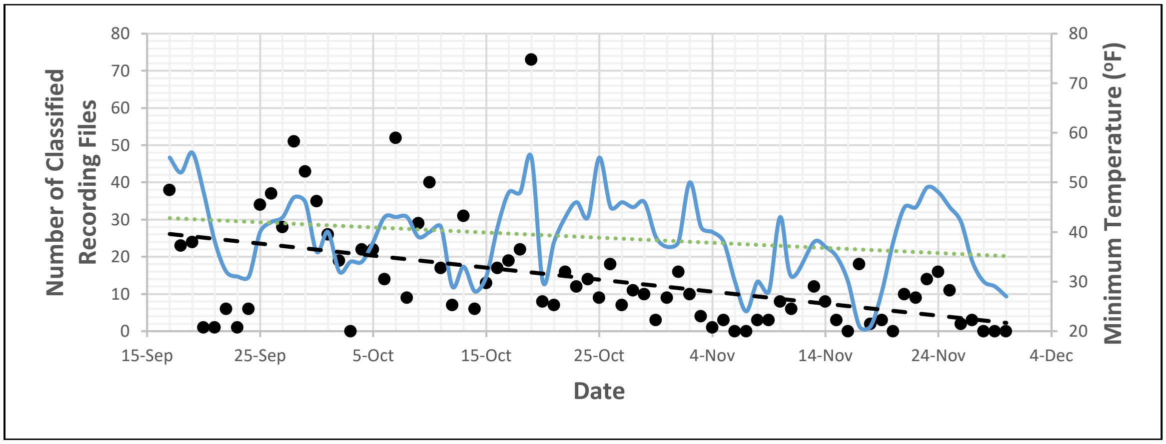

Figure 18. Western Pipistrelle Classified Recordings during the 2017 Survey Period

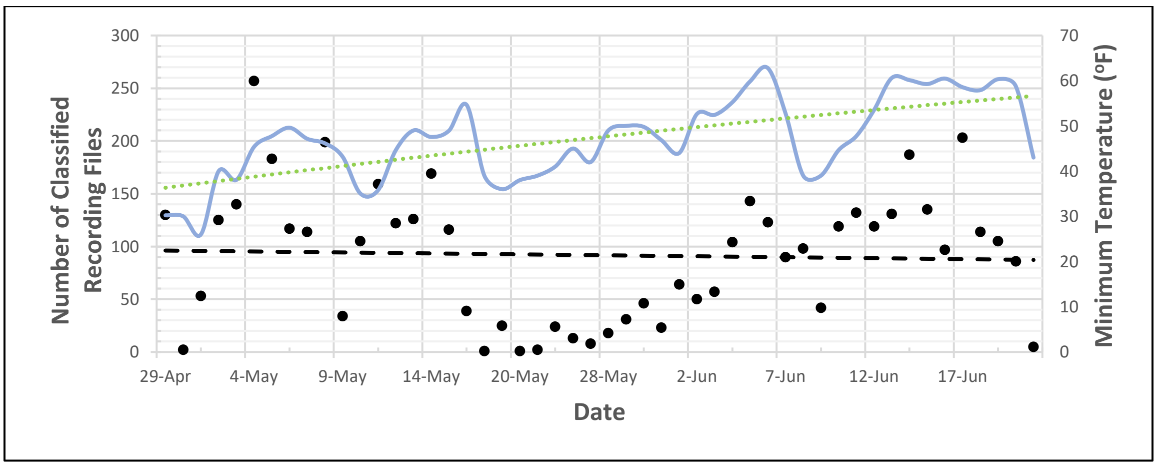

Figure 19. Western Pipistrelle Classified Recordings during the 2019 Survey Period

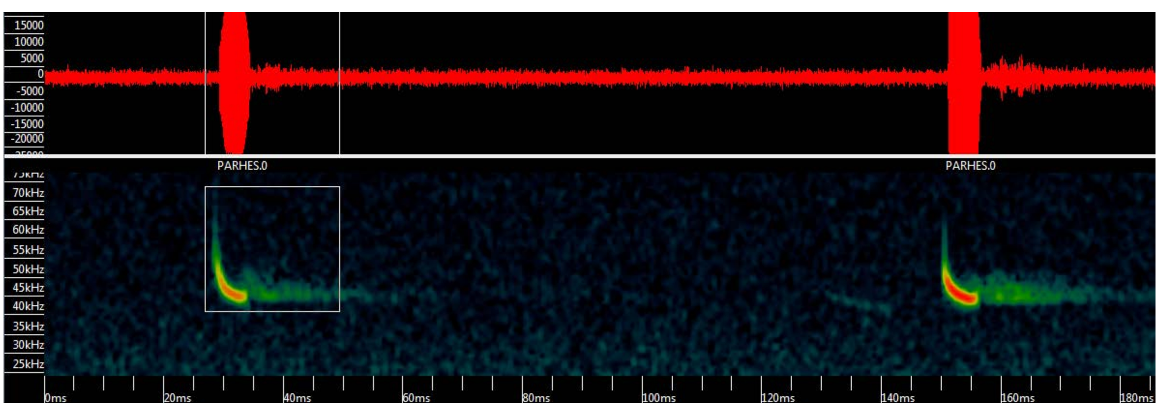

Figure 20. Western Pipistrelle Echolocation Spectrograph

Silver-haired Bat (*Lasionycteris noctivagans*). There are no federal or state protections for this species. Silver-haired bats are widely distributed in Nevada, but confined primarily to forested habitats. A forest-associated species, silver-haired bats are thought to be more common in mature forests, especially coniferous and mixed deciduous/coniferous forests of pinyon-juniper, subalpine fir, white fir, limber pine, aspen, cottonwood, and willow. Current Nevada records indicate this species occurs at 1,575-8,270 ft (480-2,520 m). Roosting occurs almost exclusively in trees in summer. Maternity roosts are generally in woodpecker hollows and under the loose bark of large diameter snags. Small groups and single animals will roost under exfoliating bark; it has also been found roosting under leaf litter. Winter roosts include hollow trees, rock crevices, mines, caves, and houses. The silver-haired bat's diet consists of a variety of insects but moths feature prominently. Foraging is generally above the canopy layer in or near wooded areas and along edges of roads, streams or water bodies. Foraging areas may be far from roost sites (up to 9 mi [15 km]) (Bradley et al. 2006).

Within the 2017 and 2019 study areas, this species accounted for 15% and 0.3%, respectively, of all the classified recordings. Within the 2017 study area, silver-haired bats occurred most frequently at Bat17-08, accounting for over 90% of the 1,000 files captured during passive acoustic surveys. Figure 21 shows the number of silver-haired bat recordings obtained from all stations throughout the survey period. Within the 2019 study area, silver-haried bat classified recordings were obtained from a relatively brief period in mid-to late May (Figure 22). The relatively low number of recordings for this species in both survey periods, with a relatively large number obtained in October, may suggest that this species primarily migrates through the area. Figure 23 shows an example of an echolocation spectograph for this species.

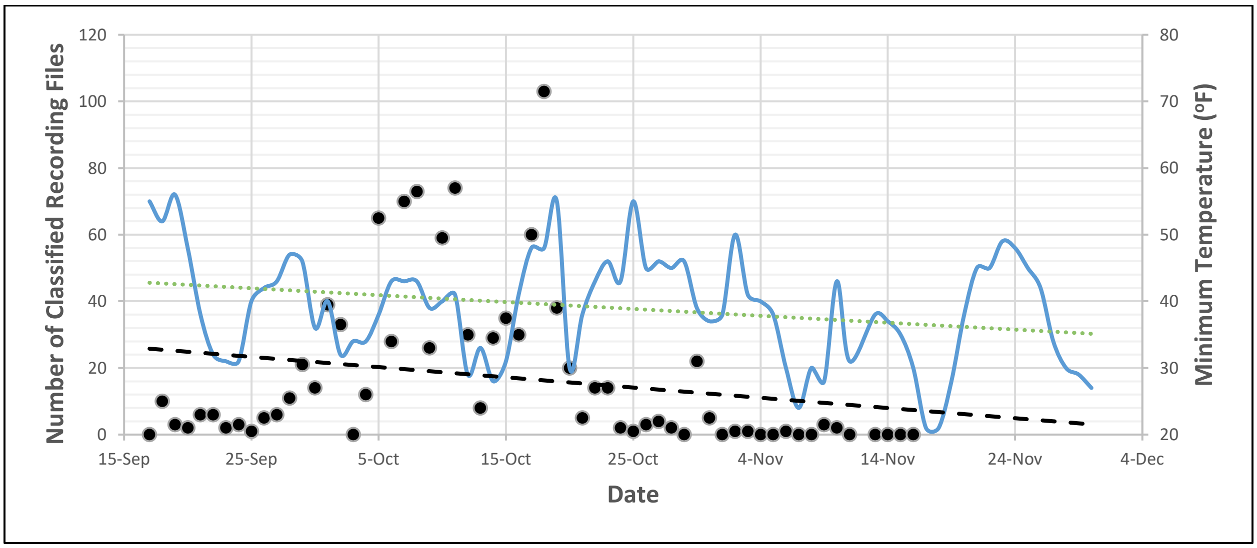

Figure 21. Silver-haired Bat Classified Recordings during the 2017 Survey Period

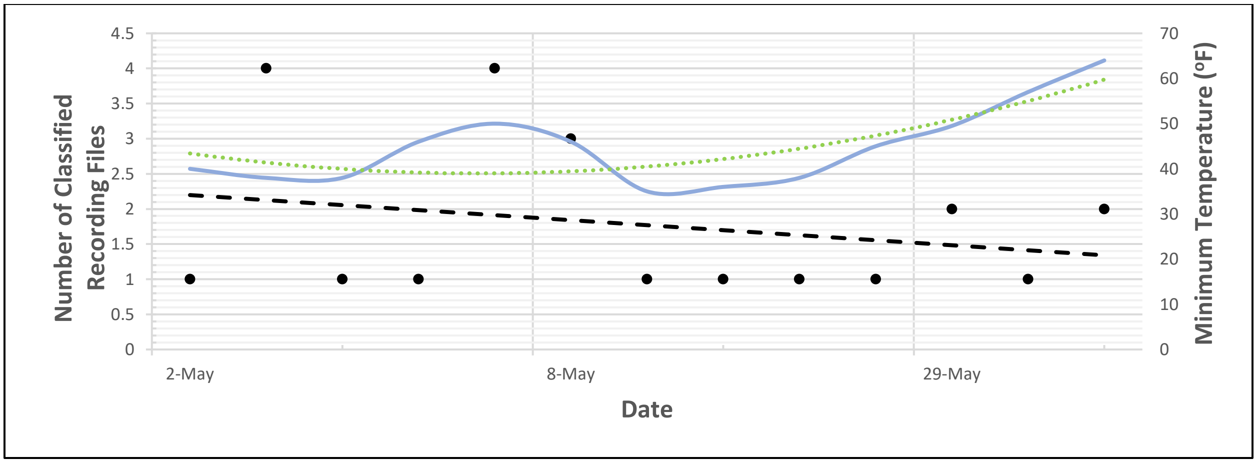

Figure 22: Silver-haired Bat Classified Recordings during the 2019 Survey Period

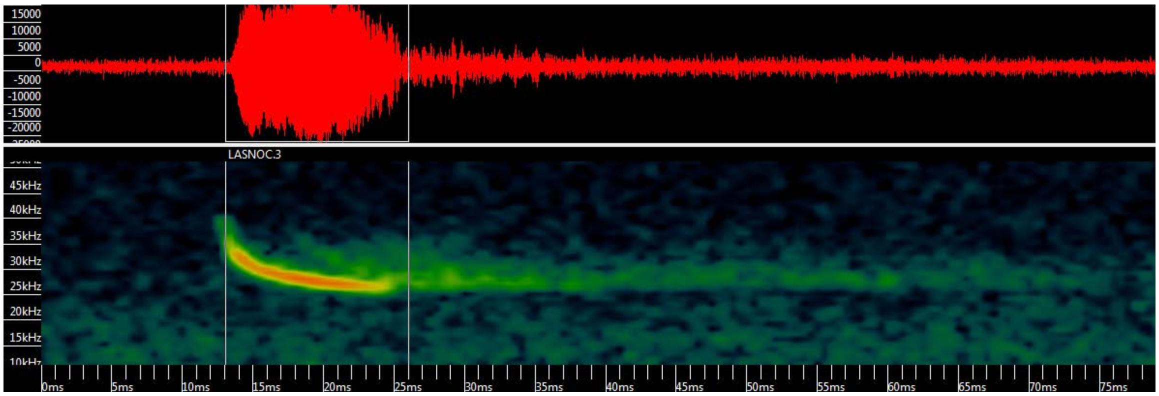

Figure 23. Silver-haired Bat Echolocation Spectrograph

Hoary Bat (*Lasiurus cinereus*). The hoary bat is thought to be extremely rare in Nevada. There are no state or federal protections for this species. Hoary bats have been documented in Nevada primarily in wooded habitats, including mesquite bosque and cottonwood/willow riparian areas. Current Nevada records indicate this species is distributed between 1,380-6,595 ft (420-2,010 m) elevation. This species is thought to be a migrant but may be a summer resident in the Fallon and Muddy River areas. A solitary rooster, the hoary bat day roosts in trees, within the foliage and presumably in leaf litter on the ground. Food items consist of a wide variety of insects, taken opportunistically apparently based on size rather than type. Foraging is generally at high altitude over the tree canopy. Primary threats include the loss and degradation of riparian habitats due to overgrazing, agricultural conversion to upland habitat, agricultural spraying, water impoundments, fire, and predation, particularly by jays (Bradley et al. 2006).

Within the 2017 study area, this species accounted for 11% of all the classified recordings; it was not detected within the 2019 study area. Figure 24 shows the number of hoary bat recordings obtained from all stations throughout the survey period. During the 2019 surveys, no recordings were classified as hoary bat echolocations. Figure 25 shows an example of an echolocation spectograph.

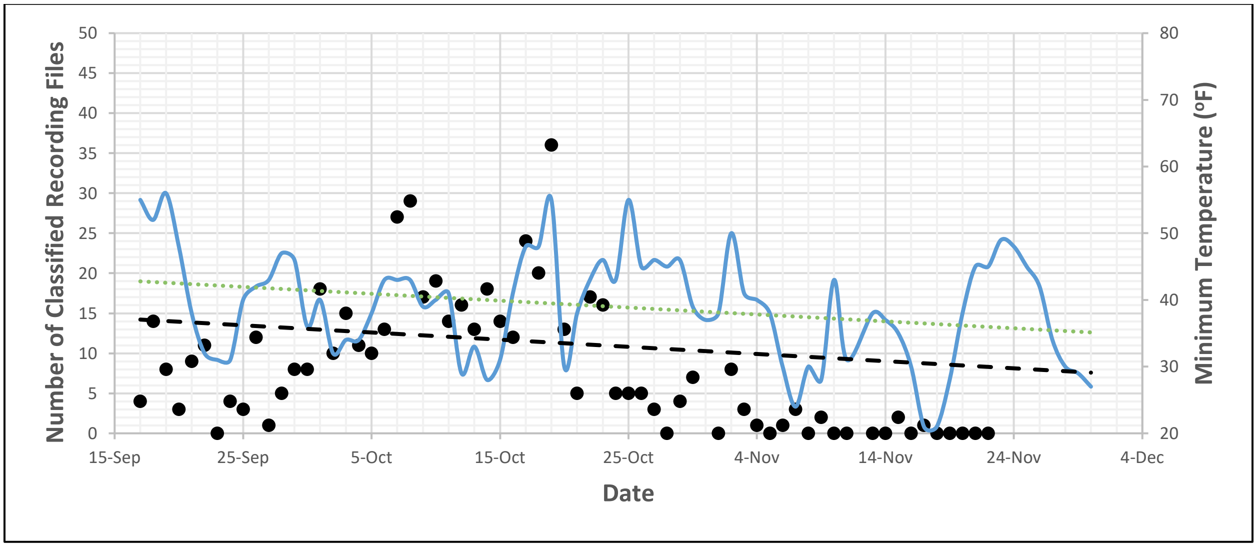

Figure 24. Hoary Bat Classified Recordings during the 2017 Survey Period

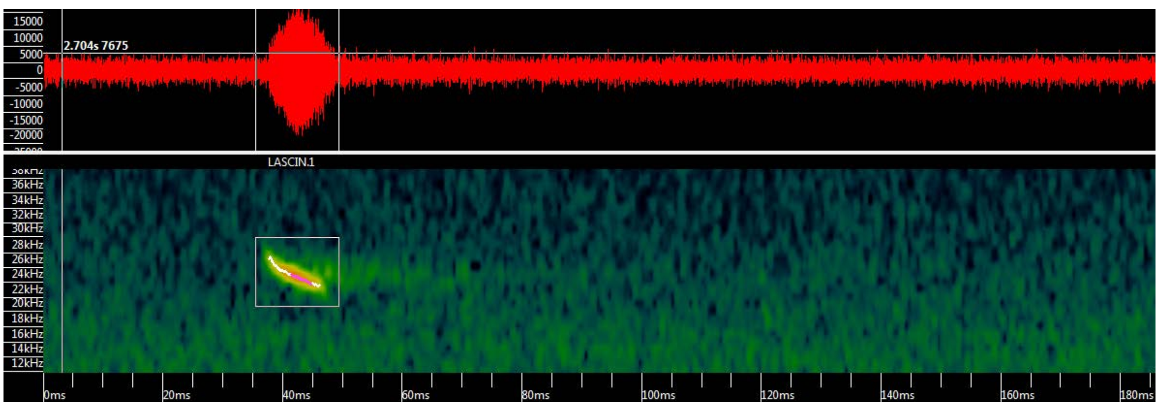

Figure 25. Hoary Bat Echolocation Spectrograph

California Myotis (*Myotis californicus*). The California myotis is found throughout Nevada, primarily at the low and middle elevations to 5,900 ft (1,800 m), although occasionally found at higher elevations and is thought to roost primarily in crevices. This species of *Myotis* is more common in the southern half of the state. Other day roosts may include mines, caves, buildings, hollow trees, and under exfoliating bark, and night roost sites may occur in a wider variety of structures. California myotis generally roost singly or in small groups, although some mines in the Mojave Desert shelter colonies of over 100 in both the summer and winter. Food items include small moths, flies and beetles. Foraging occurs in the open, but some individuals have been observed entering mines at dusk presumably to feed on resident insects (Bradley et al. 2006).

Within the 2017 and 2019 study areas, this species accounted for 7% and 2.5%, respectively, of all the classified recordings. Figure 26 shows the number of California myotis recordings obtained from all stations throughout the 2017 survey period. Within the 2017 study area, California myotis detections were most prevalent at Bat17-07, located in the range of mountains on the western side of Dixie Valley. Within the 2019 study area, California myotis classified recordings were obtained from a relatively brief period in mid- to late May (Figure 27). Throughout the survey period, recordings were few without noticeable sustained peaks that may indicate increased abundance or movements through the area in large numbers. Figure 28 shows an example of an echolocation spectrograph.

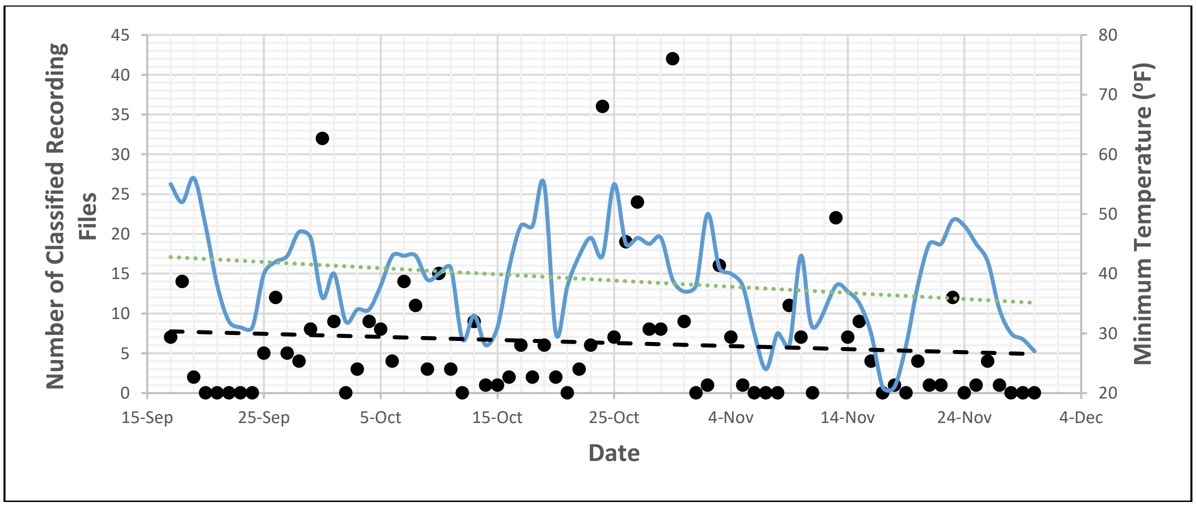

Figure 26. California Myotis Classified Recordings during the 2017 Survey Period

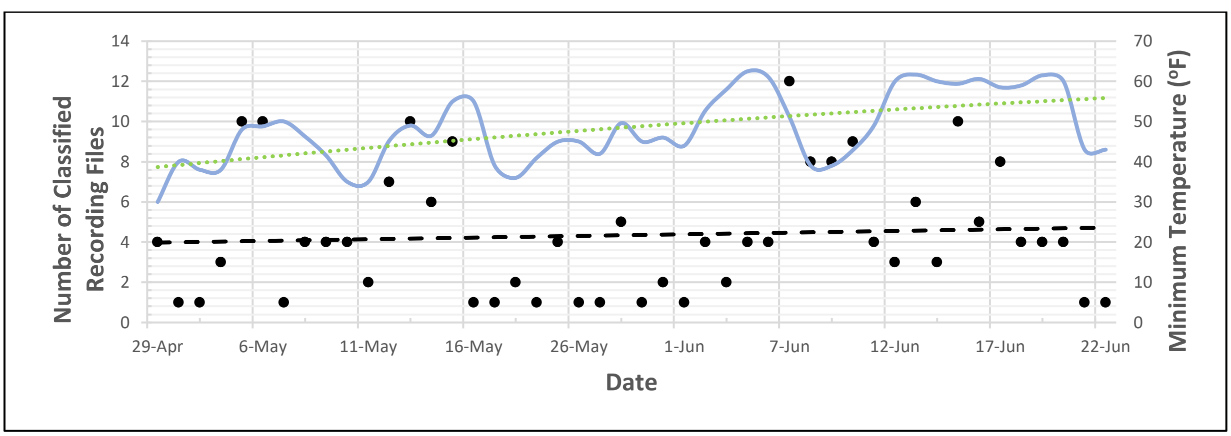

Figure 27. California Myotis Classified Recordings during the 2019 Survey Period

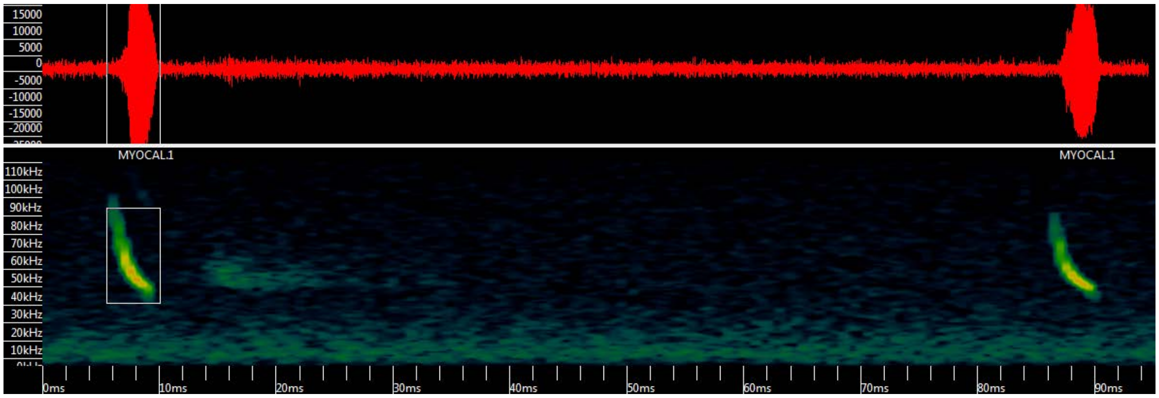

Figure 28. California Myotis Echolocation Spectrograph

Western Small-footed Myotis (*Myotis ciliolabrum*). The western small-footed myotis is not protected under state or federal regulations. The species is found throughout the state. In the south, it is primarily found at the middle and higher elevations (>5,900 ft [1,800 m]), although occasionally found at lower elevations. In central and northern Nevada, it is more common at valley bottoms (3,445-5,900 ft [1,050-1,800 m]). This bat typically inhabits a variety of habitats including desert scrub, grasslands, sagebrush steppe, blackbrush, greasewood, pinyon-juniper woodlands, pine-fir forests, agriculture, and urban areas. Roosts have been found in caves, mines, and trees. Roosting preferences expected to be similar to those for California myotis. Food items include small moths, flies, ants, and beetles, and foraging activities typically occur in the open. In winter, western small-footed hibernates individually or in large colonies (Bradley et al. 2006).

Within the 2017 and 2019 study areas, this species accounted for 6% and 11%, respectively, of all the classified recordings. Figure 29 shows the number of western small-footed myotis recordings obtained from all stations throughout the 2017 survey period. Within the 2017 study area, western small-footed myotis were most prevalent at Bat17-07, located in the range of mountains on the western side of Dixie Valley. During the 2019 survey period, the number of classified recordings for the western small-footed myotis increased in mid-May, decreased in late-May through early June, and increased again in mid- to late June (Figure 30). Figure 31 shows an example of an echolocation spectrograph.

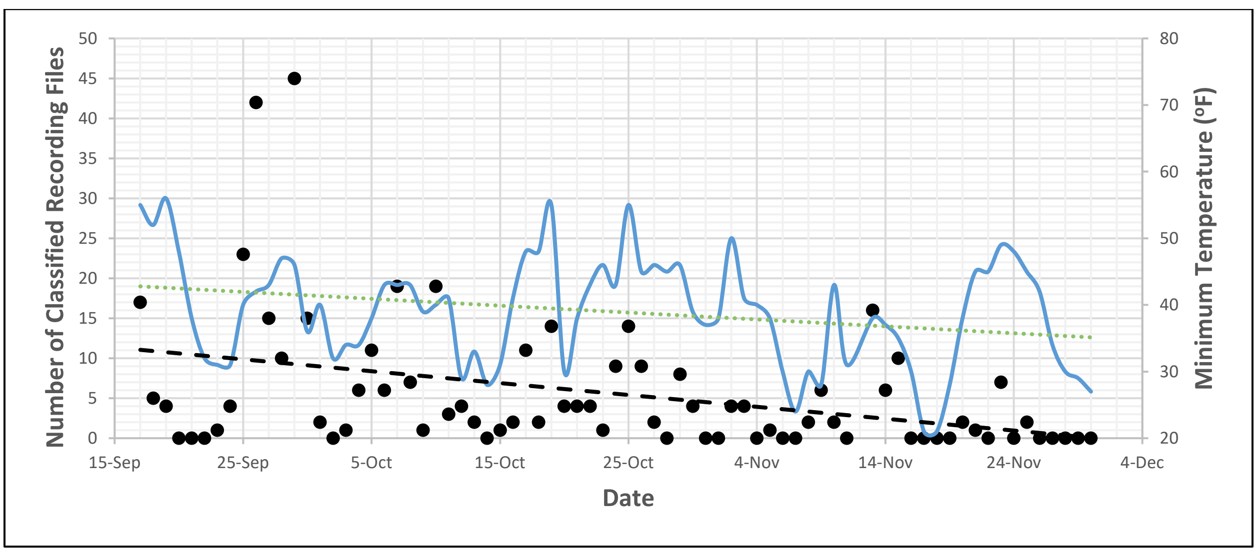

Figure 29. Western Small-footed Myotis Classified Recordings during the 2017 Survey Period

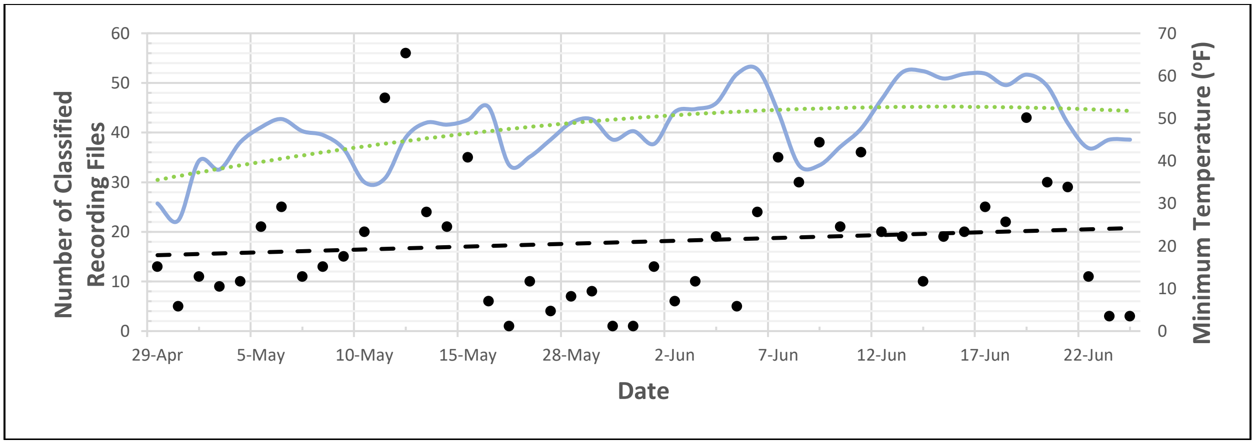

Figure 30. Western Small-footed Myotis Classified Recordings during the 2019 Survey Period

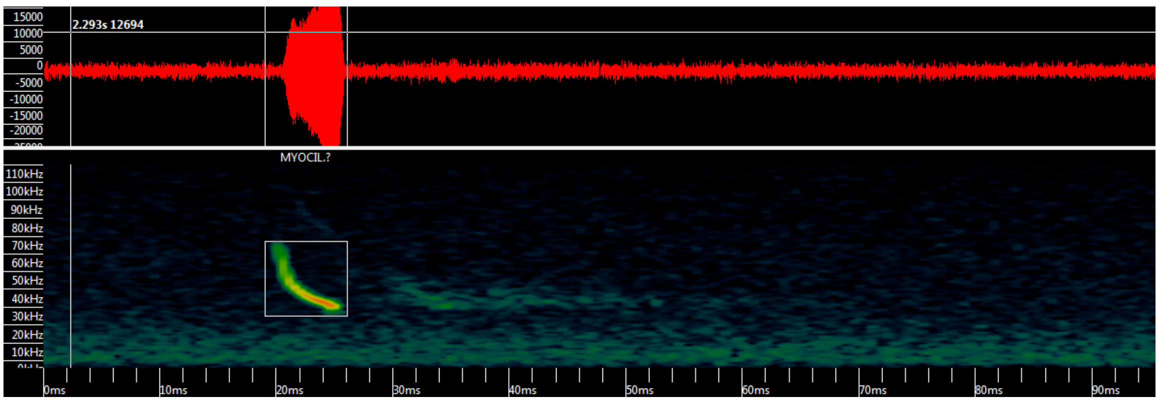

Figure 31. Western Small-footed Myotis Echolocation Spectrograph

Yuma Myotis (*Myotis yumanensis*). The Yuma myotis is not protected under state or federal regulations. It is found at least in the southern and western half of the state, primarily at low to middle elevations, and uses a wide variety of habitats including sagebrush, salt desert scrub, agriculture, playa, and riparian. The Yuma myotis appears to be tolerant of human disturbance relative to other bat species, and is one of the few bat species that thrives in a relatively urbanized environment. Although often considered to be a "building" bat, it is also found in heavily forested settings. Current Nevada records indicate this species is distributed between 1,476-7,677 ft (450-2,340 m) elevation. This species day roosts in buildings, trees, mines, caves, bridges, and rock crevices. Night roosts are usually associated with buildings, bridges, or other man-made structures. Yuma myotis primarily feeds on emergent aquatic insects, such as midges and caddis flies. Foraging occurs directly over the surface of open water and above vegetation (Bradley et al. 2006).

Within the 2017 and 2019 study areas, this species accounted for 6% and 1%, respectively, of all the classified recordings. Figure 32 shows the number of Yuma myotis recordings obtained from all stations throughout the 2017 survey period. Within the 2017 study area, Yuma mytotis were most prevalent at Bat17-07, located in the range of mountains on the western side of Dixie Valley, and at Bat17-09, located in an open dune landscape on the western edge of the Stillwater Range. The number of classified recordings for this species in the 2019 survey period was generally low, with a decreasing trend throughout the survey period (Figure 33). Figure 34 shows an example of an echolocation spectrograph.

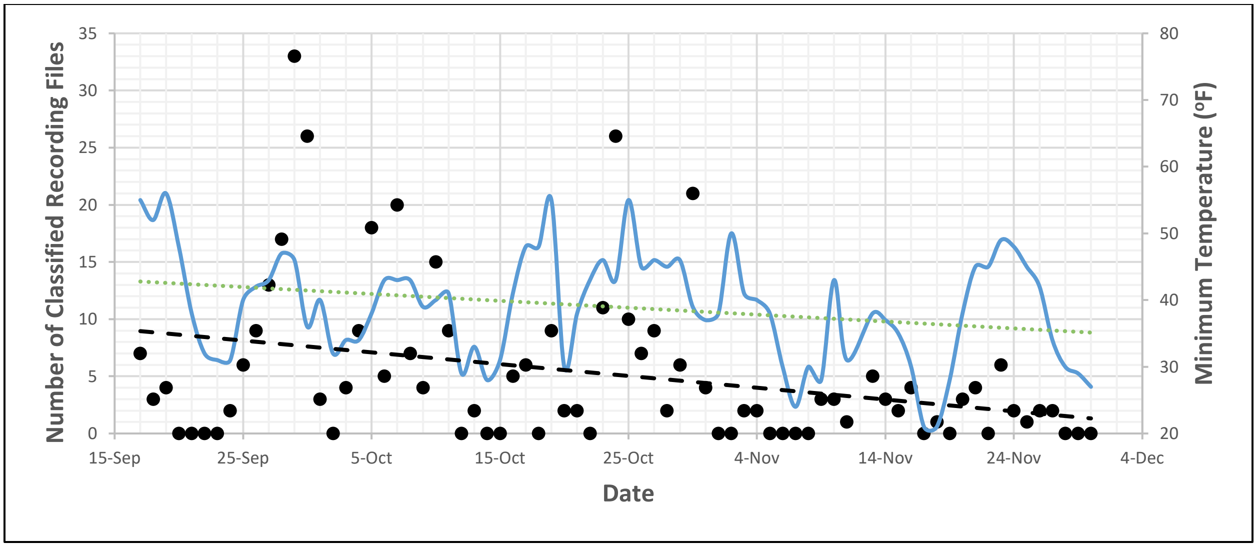

Figure 32. Yuma Myotis Classified Recordings during the 2017 Survey Period

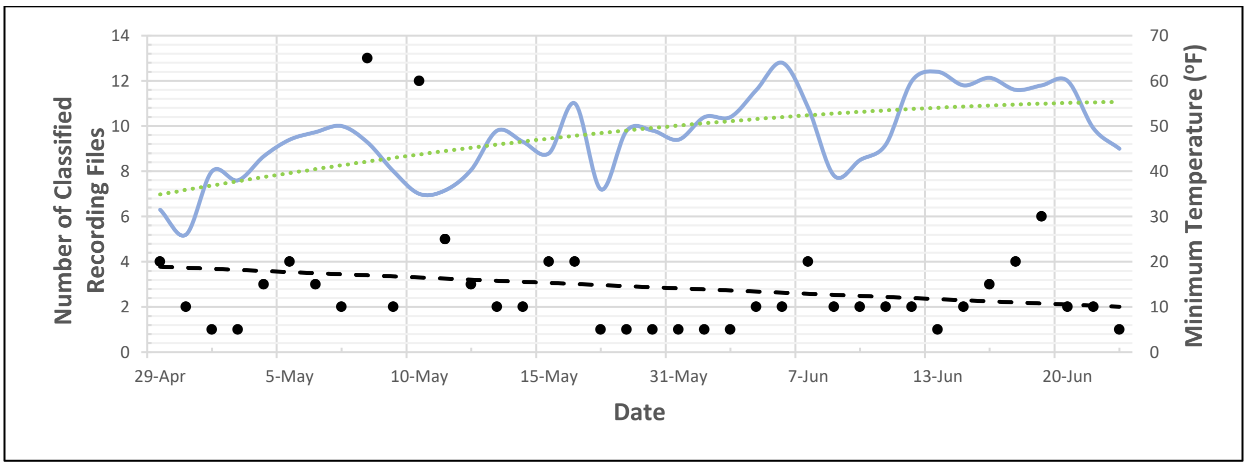

Figure 33. Yuma Myotis Classified Recordings during the 2019 Survey Period

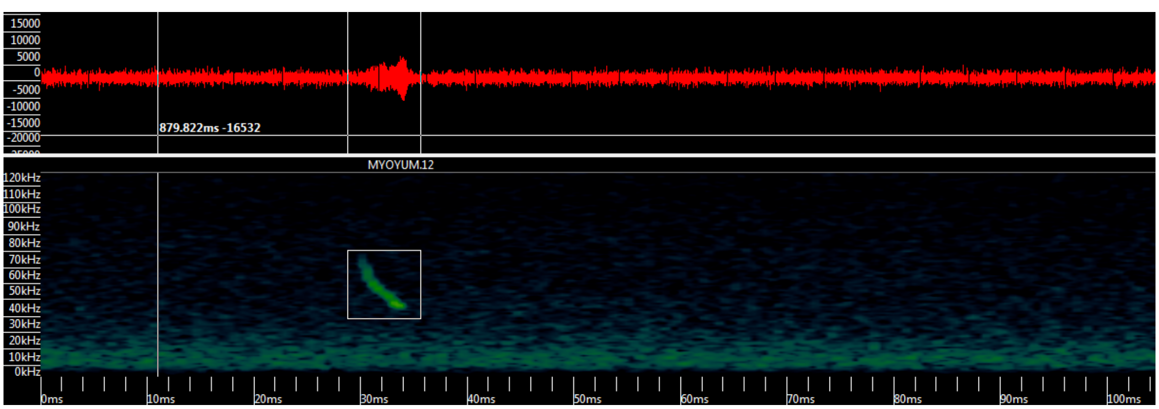

Figure 34. Yuma Myotis Echolocation Spectrograph

Big Brown Bat (*Eptesicus fuscus*). The big brown bat is not protected under state or federal regualtions. A year-round resident, big brown bats hibernate in Nevada but periodically arouse to actively forage and drink in the winter. Characteristics and locations of winter hibernacula in Nevada are completely unknown, and poorly understood throughout this species range. Big brown bats select a variety of day roosts including caves, trees, mines, buildings, and bridges. Often night roosts in more open settings in buildings, mines and bridges, and may roost in groups up to several hundred individuals (Bradley et al. 2006).

Within the 2017 and 2019 study areas, this species accounted for 6% and 1%, respectively, of all the classified recordings. Figure 35 shows the number of big brown bat recordings obtained from all stations throughout the 2017 survey period. Within the 2017 study area, big brown bats were most prevalent at Bat17-08, located in the vicinity of the Dead Camel Mountains near a large rock outcrop. Numbers were generally low throughout the 2019 survey period, without increases or decreases to suggest seasonal movements in spring and summer months (Figure 36); the 2017 survey period also shows generally low numbers except in certain periods in October. Figure 37 shows an example of an echolocation spectrograph.

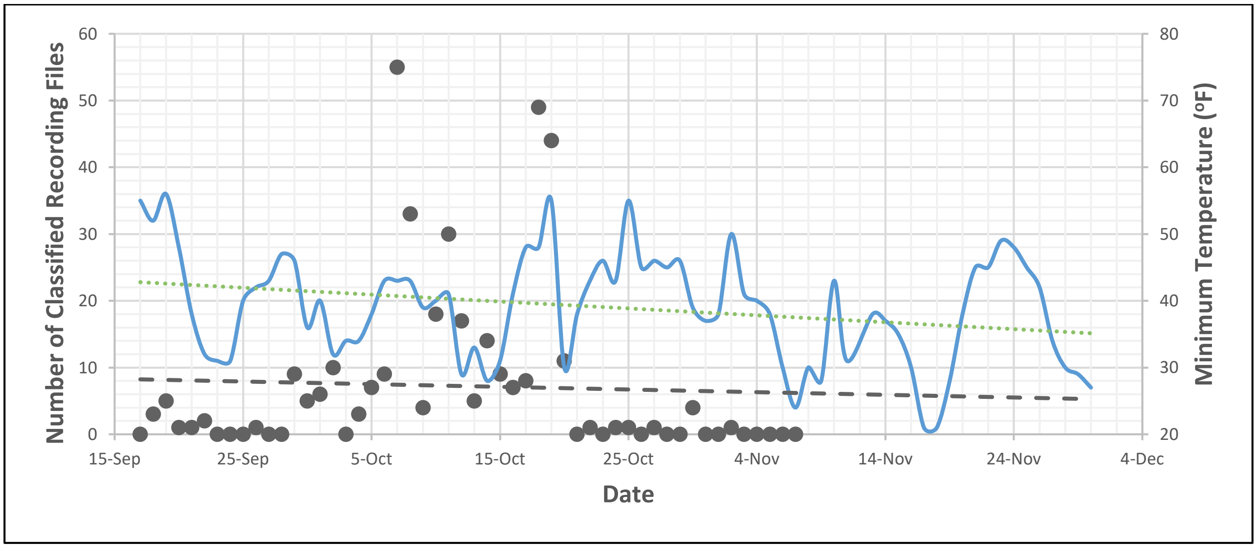

Figure 35. Big Brown Bat Classified Recordings during the 2017 Survey Period

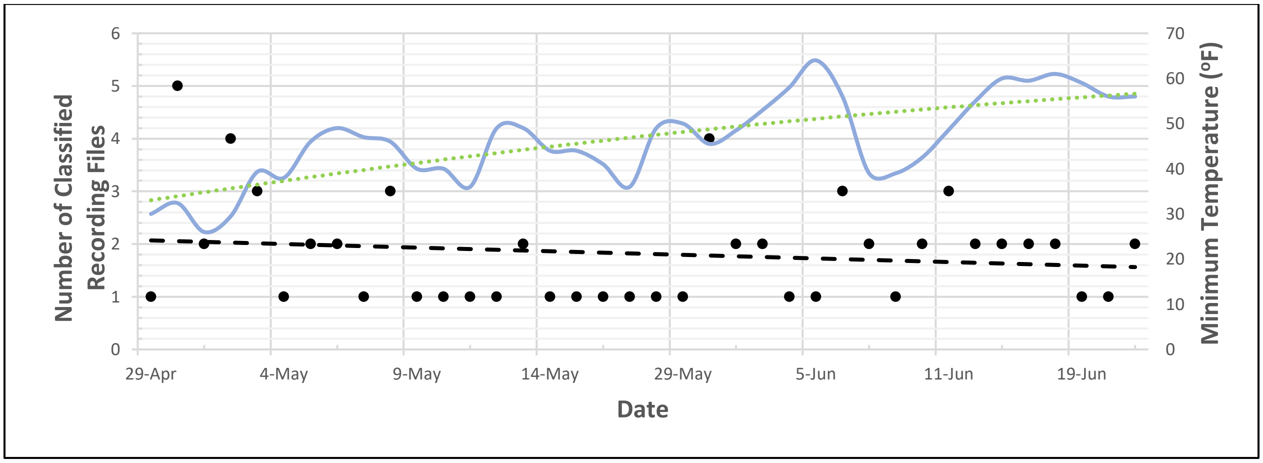

Figure 36. Big Brown Bat Classified Recordings during the 2019 Survey Period

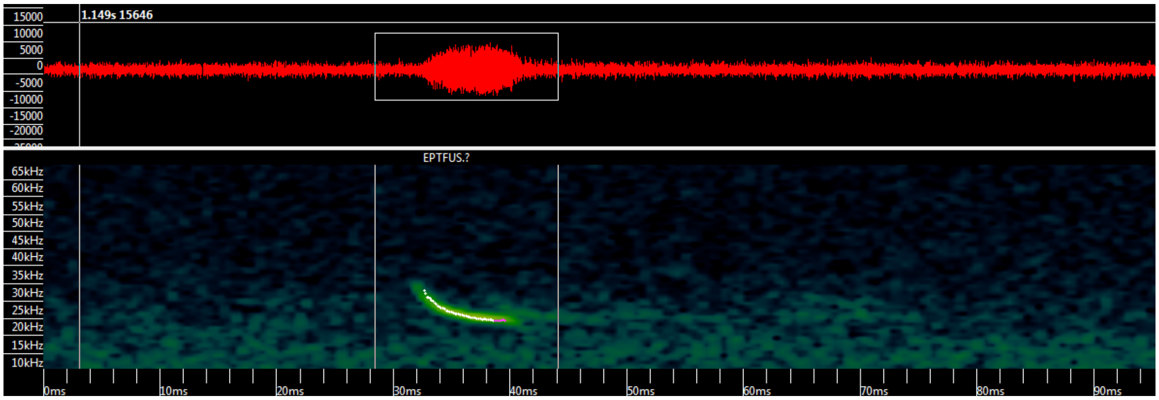

Figure 37. Big Brown Bat Echolocation Spectrograph

Western Red Bat (*Lasiurus blossevillii*). This species is thought to be extremely rare in Nevada, and is historically known from only two locations (one of which is in the Fallon area). These bats have no state or federal protections. The Western Bat Working Group determined this species to have the highest priority for funding, planning, and conservation actions because of the downward population trends, loss of both roosting and foraging habitat within riparian zones, primarily due to agricultural conversion and creation of water storage reservoirs. The intensive use of pesticides in fruit orchards may constitute a threat to roosting bats and may significantly reduce the amount of insect prey available. Controlled burns may be another significant mortality factor for red bats that roost in leaf litter during cool temperatures (Western Bat Working Group 1998). The western red bat is found primarily in wooded habitats, including mesquite bosque and cottonwood/willow riparian areas. A solitary rooster, western red bats roosts in trees during the day, within the foliage and presumably in leaf litter on the ground. Food items consist of a wide variety of insects, taken opportunistically apparently based on size rather than type. Foraging is generally high over the tree canopy (Bradley et al. 2006).

Within the 2017 and 2019 study areas, this species accounted for 4% and 22%, respectively, of all the classified recordings. Figure 38 shows the number of western red bat recordings obtained from all stations throughout the 2017 survey period. Within the study area, the big brown bat was most prevalent at Bat17-08, located in the vicinity of the Dead Camel Mountains near a large rock outcrop. During the 2019 survey period, the number of classified recordings for the western red bat increased in mid-May, decreased in late-May through early June, and increased again in mid- to late June (Figure 39). Figure 40 shows an example of an echolocation spectrograph.

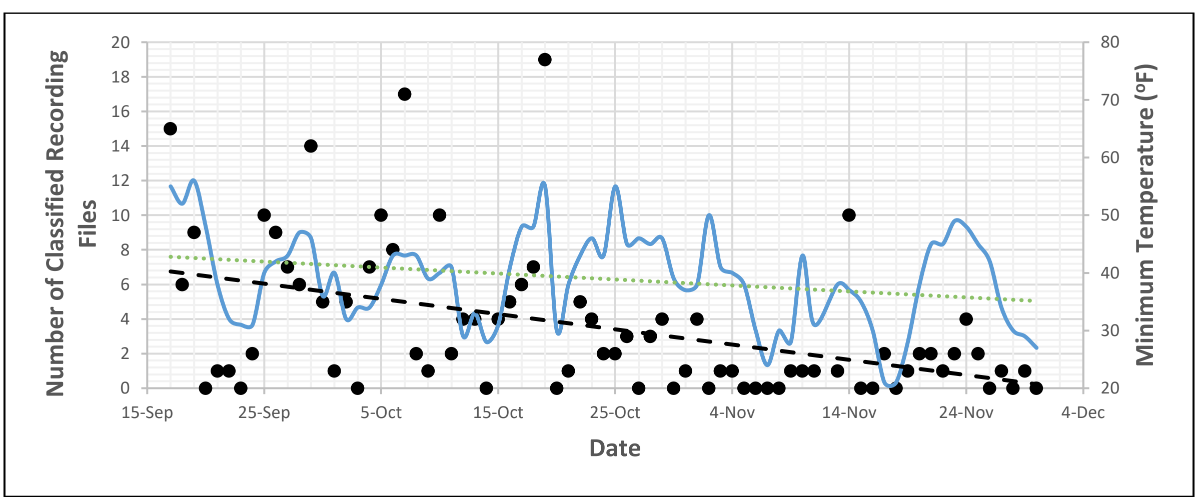

Figure 38. Western Red Bat Classified Recordings during the 2017 Survey Period

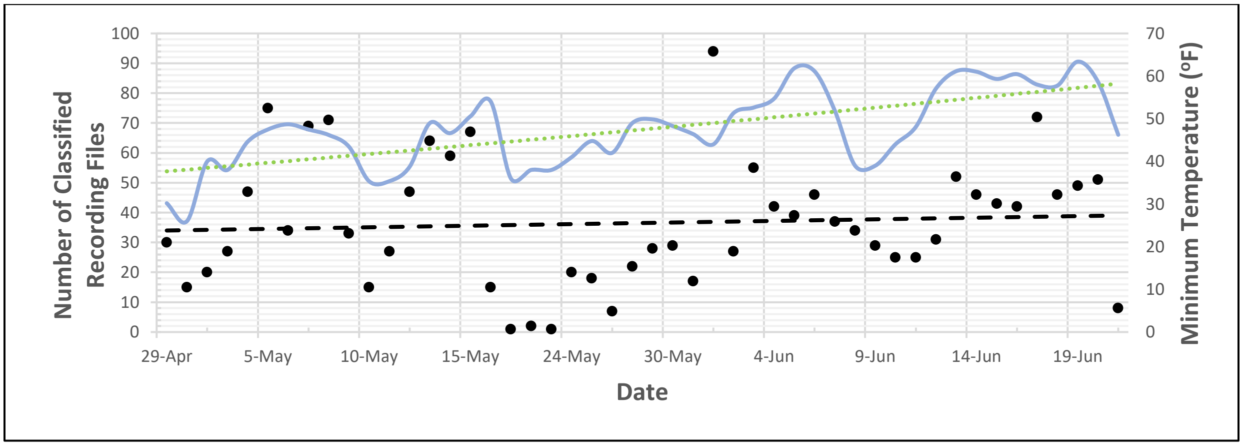

Figure 39. Western Red Bat Classified Recordings during the 2019 Survey Period

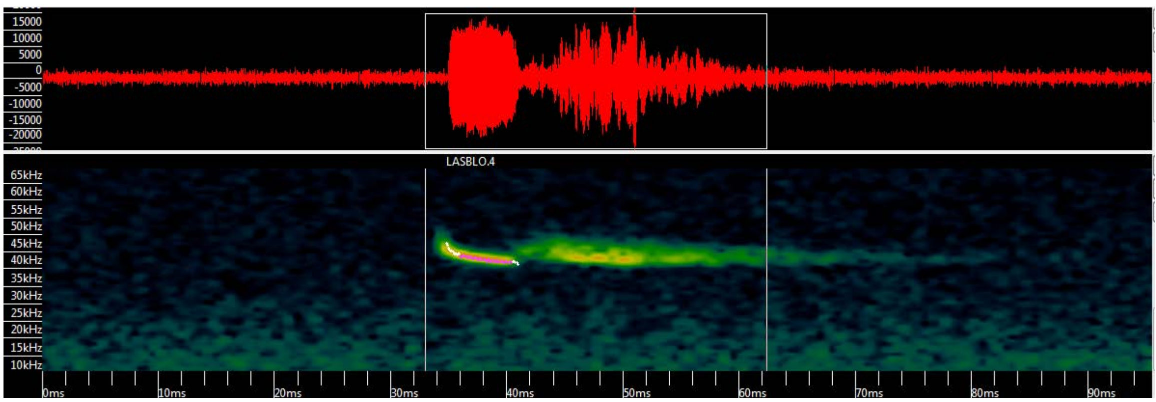

Figure 40. Western Red Bat Echolocation Spectrograph

Little Brown Bat (*Myotis lucifugus*). The little brown bat is not protected under state or federal regualtions. Found primarily at higher elevations and higher latitudes and often associated with coniferous forest, little brown bats require water sources near day roosts. They day roost in hollow trees, rock outcrops, buildings, and occasionally mines and caves, and are often found in the same roost sites with Yuma myotis. Little brown bat diet includes small aquatic insects (such as caddis flies, midges, and mayflies); a variety of other terrestrial insects are also eaten. Foraging occurs in open areas among vegetation, along water margins, and sometimes about 3 ft (1 m) above water surface. When young begin to fly, adults move to more cluttered habitats and leave open foraging areas to the juveniles (Bradley et al. 2006).

Within the 2017 and 2019 study areas, this species accounted for 1% and 3%, respectively, of all the classified recordings. Figure 41 shows the number of little brown bat recordings obtained from all stations throughout the 2017 survey period. Within the 2017 study area, the little brown bat was most prevalent at Bat17-07, located in the range of mountains on the western side of Dixie Valley. In the 2019 survey period, the number of little brown bat recordings were also very low (Figure 42). Figure 43 shows an example of an echolocation spectrograph.

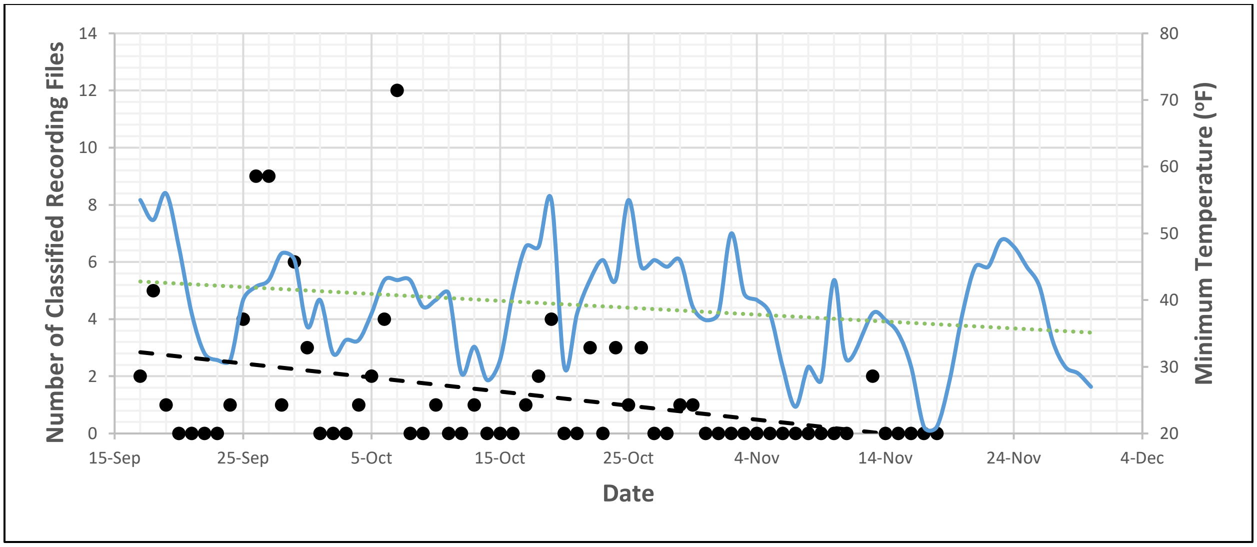

Figure 41. Little Brown Bat Classified Recordings during the 2017 Survey Period

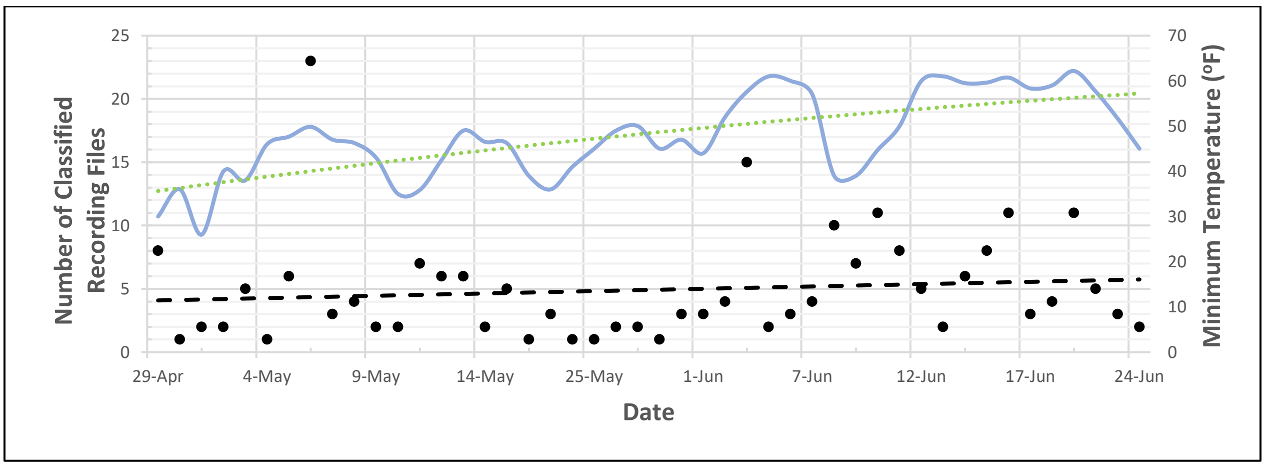

Figure 42. Little Brown Bat Classified Recordings during the 2019 Survey Period

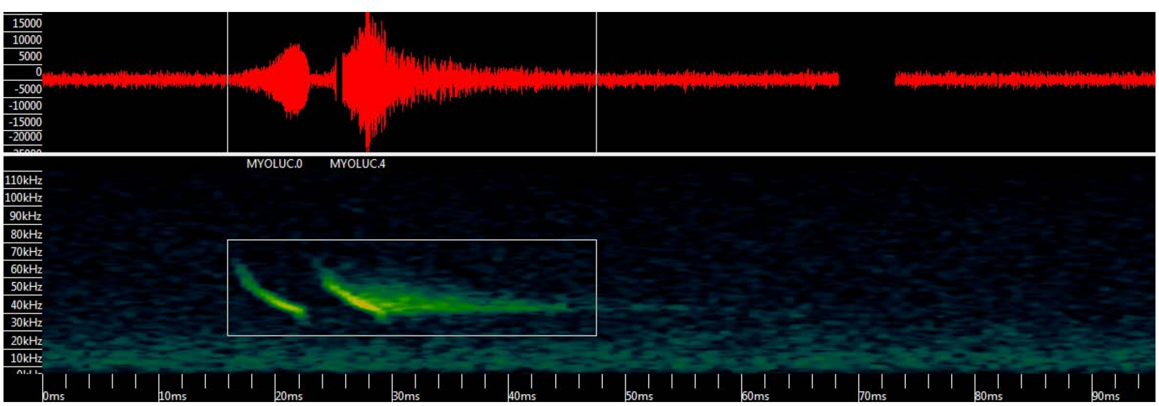

Figure 43. Little Brown Bat Echolocation Spectrograph

Pallid Bat (*Antrozous pallidus*). Pallid bats are found throughout the state, primarily in the low and middle elevations (5,900 ft [1,800 m]), although it has been found at over 10,170 ft (3,100 m). Found in a variety of habitats from low desert to brushy terrain to coniferous forest and non-coniferous woodlands, such as pinyon-juniper, blackbrush, creosote, sagebrush, and salt desert scrub habitats. Food items are primarily large ground-dwelling arthropods (scorpions, centipedes, millipedes, grasshoppers, long-horned beetles, Jerusalem crickets), but also large moths. Foraging occurs in and among vegetation as well on the ground surface. Pallid bats may actually land and take prey. In winter, pallid bats hibernate but periodically arouse to actively forage and drink (Bradley et al. 2006).

Pallid bat populations have been declining in California, apparently due to roost disturbance. This stress upon pallid bat populations is likely similar in Nevada. Few roost sites, however, have been identified in Nevada and no population studies have been conducted. The largest known maternity roost in Nevada is in a moderately unstable mine adit that has been gated, although other smaller maternity colonies are known. Pallid bats also use boulders for roost sites, including maternity roosts. However, few of these types of roosts have been identified in Nevada (Bradley et al. 2006).

Within the 2017 and 2019 study areas, this species accounted for 1% and 2%, respectively, of all the classified recordings. Figure 44 shows the number of pallid bat recordings obtained from all stations throughout the 2017 survey period. Within the 2017 study area, the palid bat was most prevalent at Bat17-07, located in the range of mountains on the western side of Dixie Valley, and Bat17-04, located near a cluster of mine shafts on the southwestern edge of the Clan Alpine Mountains. In the 2019 survey period, the number of little brown bat recordings were also very low (Figure 45). Figure 46 shows an example of an echolcation spectrograph.

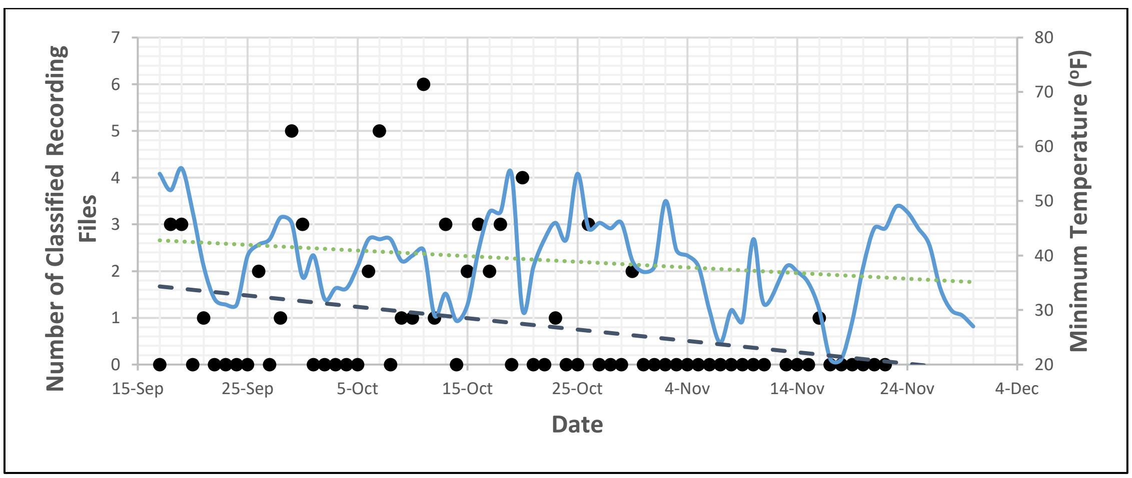

Figure 44. Pallid Bat Classified Recordings during the 2017 Survey Period

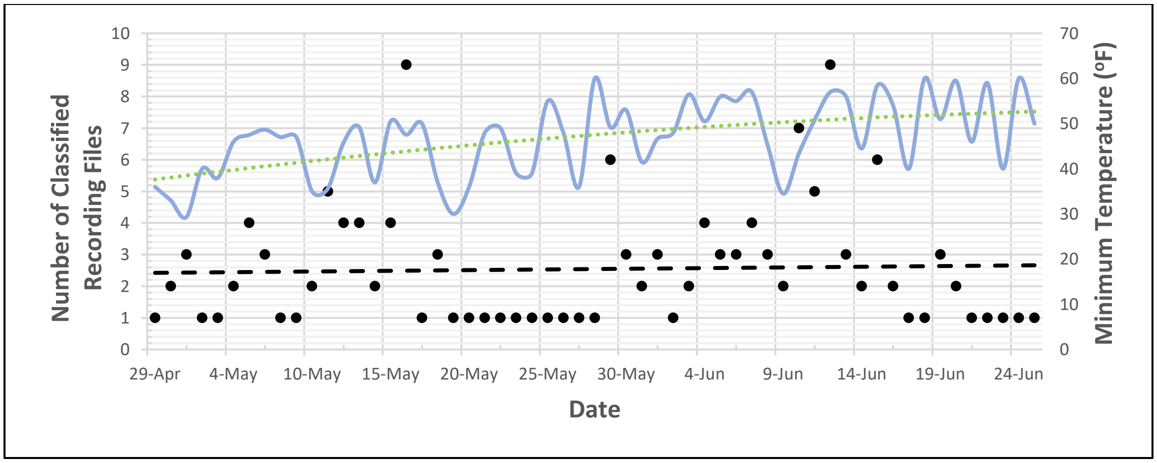

Figure 45. Pallid Bat Classified Recordings during the 2019 Survey Period

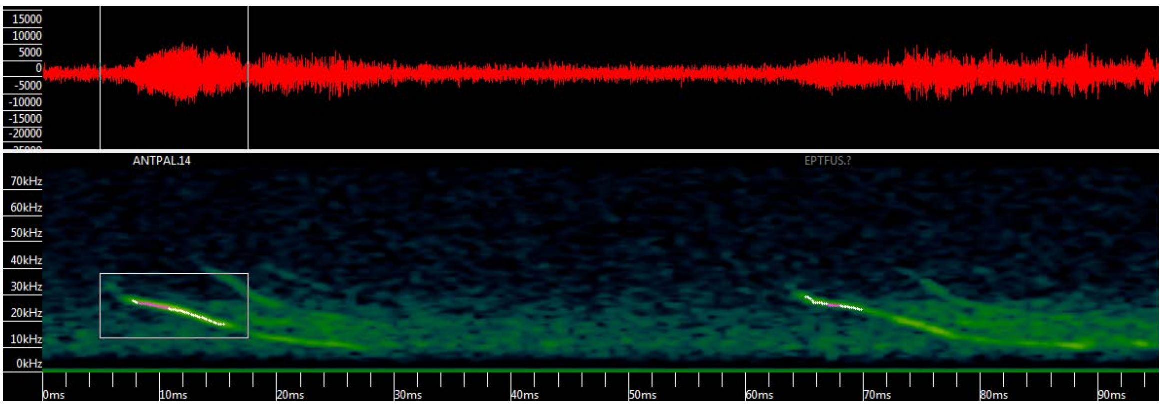

Figure 46. Pallid Bat Echolocation Spectrograph

Townsend's Big-eared Bat (*Corynorhinus townsendii*). The State of Nevada considers Townsend's big-eared bat as "sensitive." The Western Bat Working Group determined this species to have the highest priority for funding, planning, and conservation actions because of the downward population trend documented in the surrounding states of California, Oregon, Washington, New Mexico and Idaho; documented roost population declines in Nevada; and the well-documented sensitive nature of this species to human disturbance of roost sites (Western Bat Working Group 1998). Townsend's big-eared bats are found throughout the state, from low desert to high mountain habitats. It has been observed foraging in krumholtz bristlecone pine as high as 11,500 ft (3,500 m) in the Snake Range of eastern White Pine County. Distribution is strongly correlated with the availability of caves and abandoned mines and is considered one of the species most dependent on mines and caves. This species is a moth specialist and gleans its prey from vegetation and other surfaces. Trees and buildings must offer "cave-like" spaces in order to be suitable, and will night roost in more open settings, including under bridges. Colony size is typically 35-150 individuals, with a few larger (>200) colonies known (Bradley et al. 2006).

Within the 2017 and 2019 study areas, this species accounted for less than 1% of all the classified recordings. Figure 47 shows the number of Townsend's big-eared bat recordings obtained from all stations throughout the 2017 survey period. Within the 2017 study area, Townsend's big-eared bat was most prevalent at Bat17-07, located in the range of mountains on the western side of Dixie Valley. In the 2019 survey period, the number of classified Townsend's big-eared bat recordings were also very low (Figure 48). Figure 49 shows an example of an echolocation spectrograph.

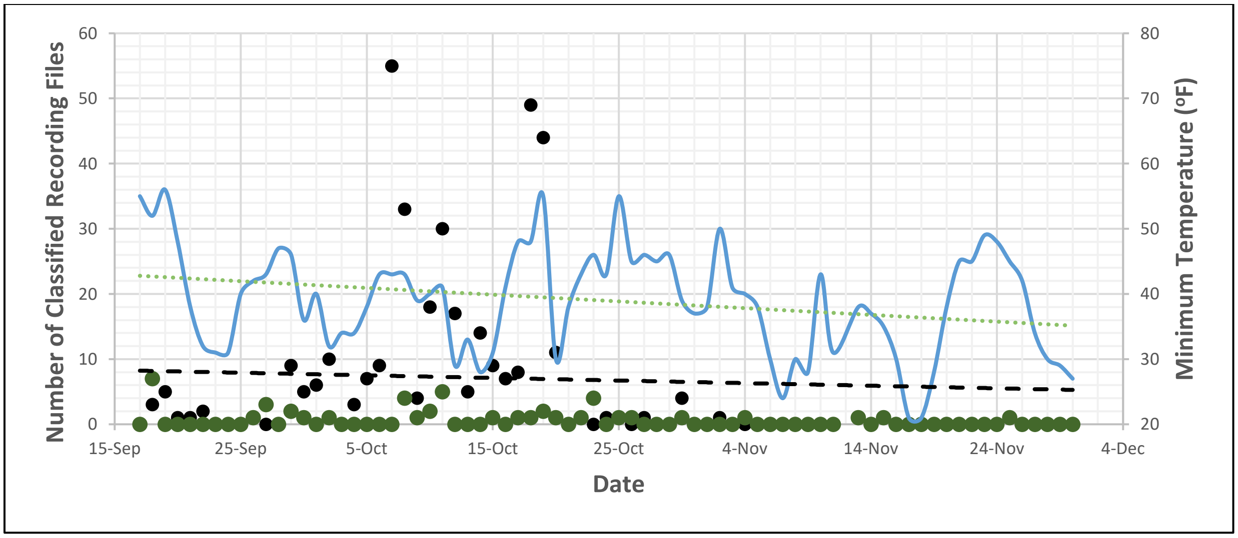

Figure 47. Townsend's Big-eared Bat Classified Recordings during the 2017 Survey Period

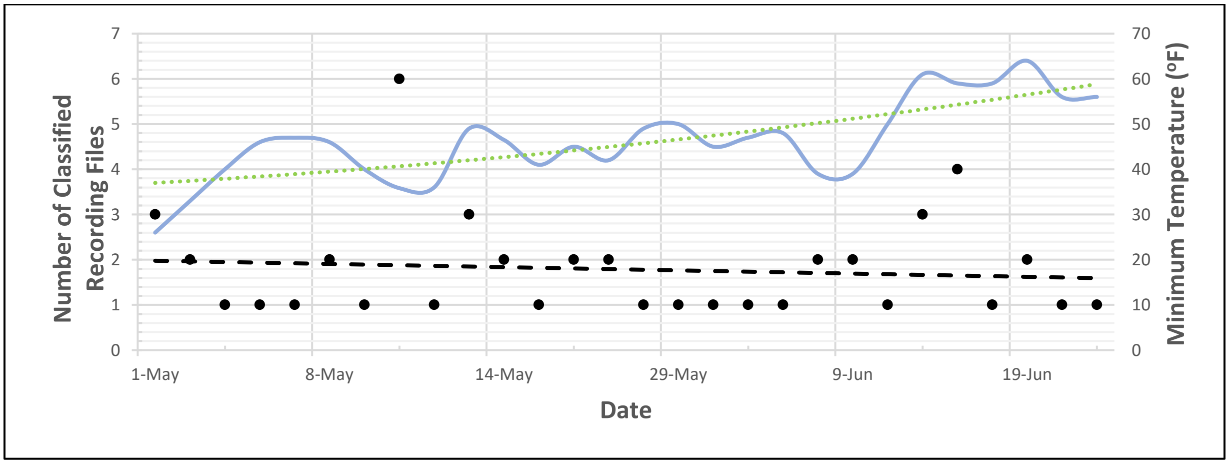

Figure 48. Townsend's Big-eared Bat Classified Recordings during the 2019 Survey Period

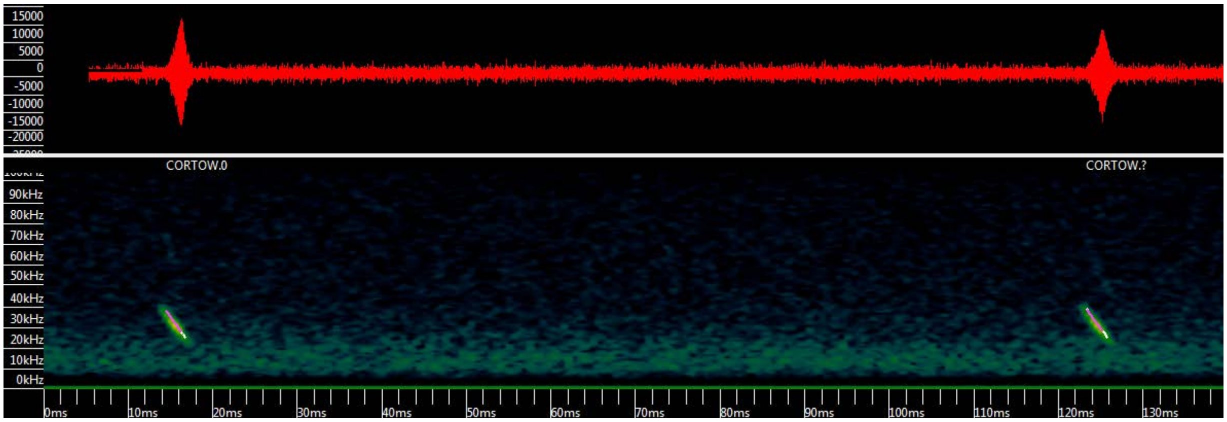

Figure 49. Townsend's Big-eared Bat Echolocation Spectrograph

Long-legged Myotis (*Myotis volans*). The long-legged myotis is not protected under state or federal regualtions. This species is typically found throughout Nevada but more widespread and common in the northern half of the state, occuring from mid to high elevations. Long-legged myotis are found in pinyon-juniper, Joshua tree woodland, and montane coniferous forest habitats. This species is occasionally found in Mojave and salt desert scrub, and blackbrush, mountain shrub, and sagebrush. Day roosts primarily in hollow trees, particularly large diameter snags or live trees with lightning scars. Long-legged myotis also use rock crevices, caves, mines, and buildings when available. Caves and mines may be used for night roosts. Long-legged myotis feed primarily on moths but also feeds on beetles, flies and termites. Foraging occurs in open areas, often at canopy height (Bradley et al. 2006).

Within the 2017 and 2019 study areas, this species accounted for less than 1% of all the classified recordings. Figure 50 shows the number of long-legged myotis recordings obtained from all stations throughout the 2017 survey period. Within the 2017 study area, the long-legged myotis was most prevalent at Bat17-07, located in the range of mountains on the western side of Dixie Valley, and Bat17-04, located near a cluster of mine shafts on the southwestern edge of the Clan Alpine Mountains. Within the 2019 survey period, the number of classified recordings were also very few (Figure 51). Figure 52 shows an example of an echolocation spectrograph.

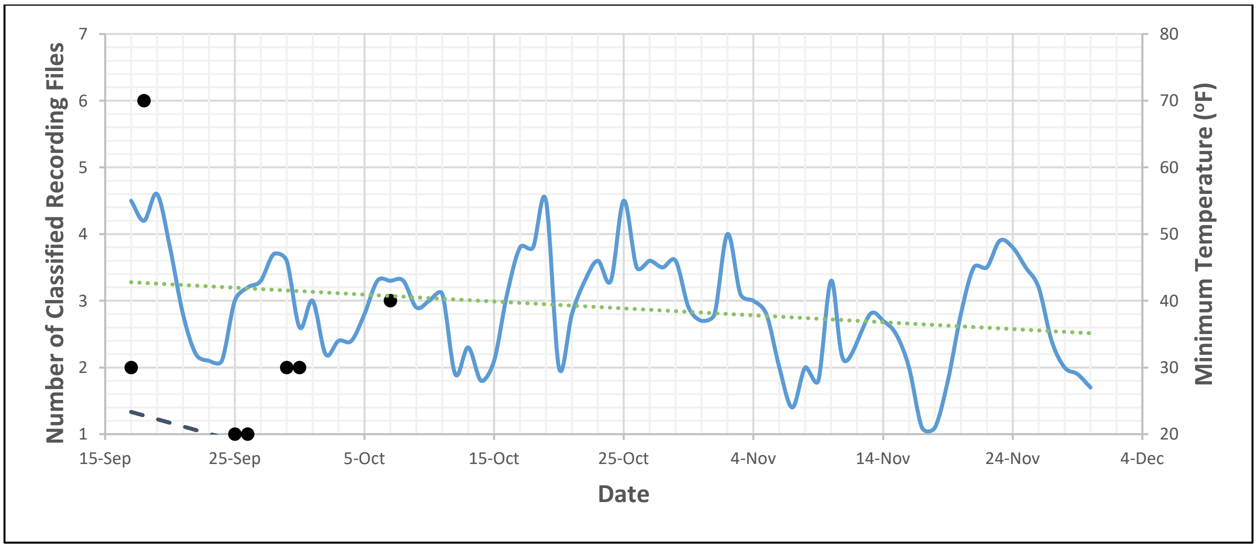

Figure 50. Long-legged Myotis Classified Recordings during the 2017 Survey Period

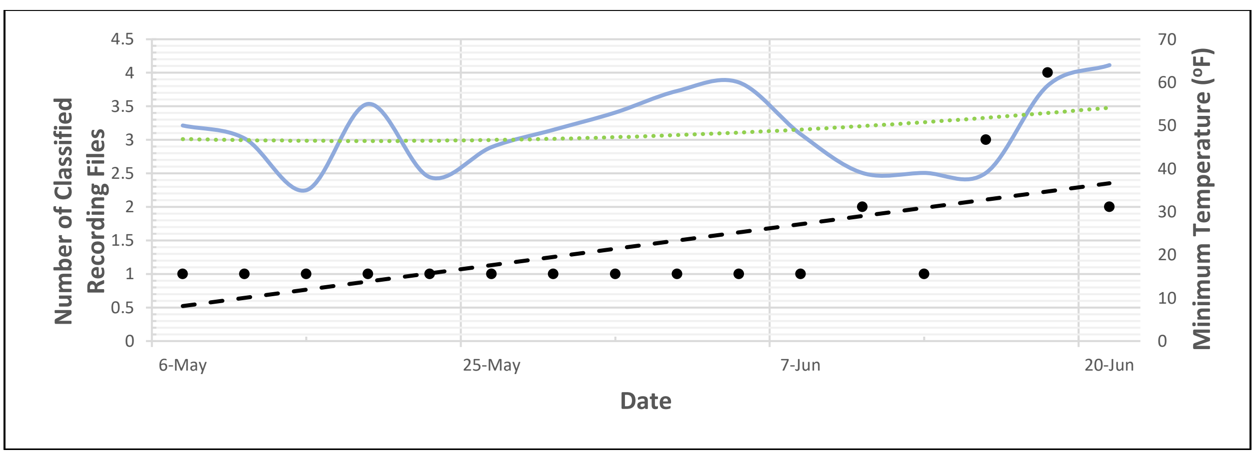

Figure 51. Long-legged Myotis Classified Recordings during the 2019 Survey Period

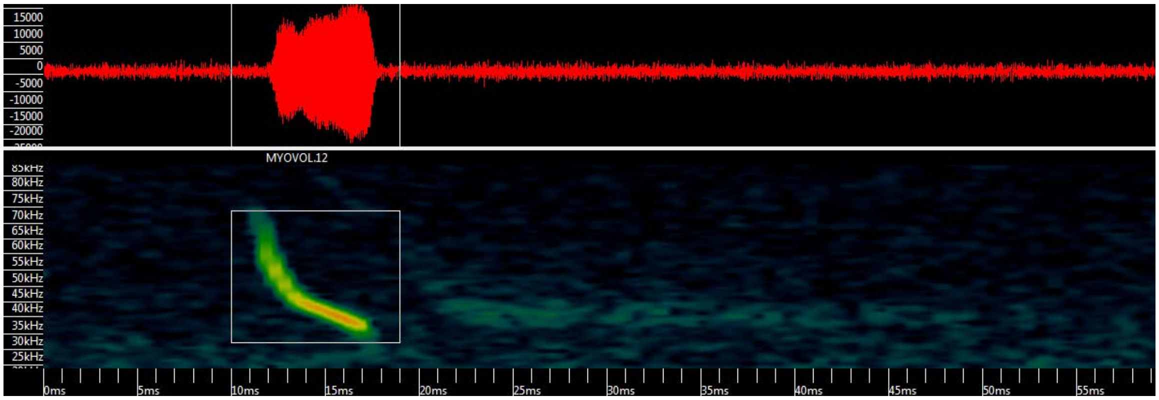

Figure 52. Long-legged Myotis Echolocation Spectrograph

Fringed Myotis (*Myotis thysanodes*). Fringed myotis are widely distributed but rare in Nevada. Caves and mines are not only used as roost sites but also may be used for foraging sites. Little is known about the cliff and crevice roosting behavior of this species in Nevada. There are relatively few records but an apparent increase in numbers or area occupied in southern Nevada over the past 20 years. Food items vary but there appears to be a selection for small beetles. Foraging occurs in and among vegetation, with some gleaning activity. Diet is primarily beetles, but includes a variety of other taxa including moths. They are found in a wide range of habitats from low desert scrub habitats to high elevation coniferous forests, and from upper elevation creosote bush desert to pinyon-juniper and white fir (2,150 m) in the White Pine Range (White Pine County) (Bradley et al. 2006). In the 2017 survey period, only four recordings were logged for the fringed myotis which may indicate transient individuals moving through the study area during the survey period: two recordings at Bat17-04, one recording at Bat17-07, and one recording at Bat17-09. No recordings were classified as fringed myotis in the 2019 survey period,

Long-eared Myotis (*Myotis evotis*). Long-eared myotis are widespread throughout Nevada in upper elevation woodlands and forests. However, they tend to be abundant only in areas of pinyon-juniper woodlands in limestone mountains. They do not appear to form large roosts and seem to alternate roosts frequently. Population declines have been noted in the Spring Mountains of Clark County, potentially due to degradation of water sources. Additional information is needed on the specific needs of the long-eared myotis as they relate to the structure and condition of pinyon-juniper forests in Nevada. Food items include moths, small beetles, and flies. Foraging occurs near vegetation and the ground. Long-eared myotis appear to have a flexible foraging strategy, catching insects by both substrate and aerial pursuit. Forages along rivers and streams, over ponds, and within cluttered forest environment. Night roost use of caves and mines may involve feeding within the structure, gleaning moths from the rock walls (Bradley et al. 2006). Only one recording of long-eared myotis was logged at Bat17-04 within the 2017 and 2019 study areas. This low number may indicate transient individuals moving through the area during the survey period.

4.0 CONCLUSIONS

Passive acoustic surveys for bats were conducted in late summer and autumn using fixed-location ultrasonic recording stations. Surveys began on 17 September 2017 and the last recordings were logged on 4 December 2017, for 77 continuous days of recording. Based on acoustic recordings from nine recorders deployed throughout the 2017 study area, 6,533 files were classified using auto-classification software and spot checked against species-specific bat echolocation characteristics. During the 2019 survey period, 8,423 files were classified using auto-classification software and spot checked against species-specific bat echolocation characteristics. The passive acoustic surveys documented 15 species within the study area during the two survey periods. Species of note include high numbers of Brazilian free-free tailed bats (State of Nevada protected species), and presence of the western red bat (extremely rare in Nevada, considered by the State of Nevada as a sensitive species, and by the Western Bat Working Group to be the highest priority for funding, planning, and conservation actions), the pallid bat (State of Nevada protected species), and Townsend's big-eared bat and fringed myotis (both State of Nevada sensitive species and considered by Western Bat Working Group to be the highest conservation priority).

Driving transects were intended to supplement fixed-location acoustic recording efforts with additional opportunistic observations. In other words, surveyors were at FRTC either to place acoustic recorders or to conduct other wildlife surveys, and used the time at the study sites to obtain additional bat observations through night-time driving transects. The fixed-location efforts offer the best available passive methods to inventory bat species, due to the technology (the microphones and recording hardware are much more advanced on SMB4BAT units than hand-held recorders used on driving transects) and on-effort time (SMB4BAT recorders are used continuously throughout a survey season as opposed to driving transects occurring over 1-2 nights).

Similar passive acoustic bat surveys conducted in 2007 in support of an ecological inventory of NAS Fallon lands within Churchill County, detected the same species as the current survey effort (NAS Fallon 2008). However, the current surveys detected one additional species not detected in 2007, the fringed myotis.

Some survey locations appeared to support high numbers of bats and may warrant further investigations, such as continued passive acoustic monitoring, subterranean surveys, and mist netting to monitor populations and provide additional baseline information for bats in the region. These locations include:

- Bat17-08, located near the Dead Camel Mountains adjacent to a large crevice and several abandoned mines;
- Bat17-07, located on the range of mountains to the west of Dixie Valley and adjacent to several abandoned mines; and
- Bat17-04, located on the southwestern fringes of the Clan Alpine Mountains and adjacent to several abandoned mines, mines that may be active, and in areas close to Highway 50 that are more easily accessible (and damaged) by camping and vandalism.

5.0 REFERENCES

Ammerman, L.K., C.L. Hice, and D.J. Schmidly. 2012. Bats of Texas. Texas A&M University Press.

Arnett, E.B. and E.F. Baerwald. 2013. Impacts of Wind Energy Development on Bats: Implications for Conservation. Pages 435-456 in R. Adams & S. Pedersen (Eds.), Bat Evolution, Ecology, and Conservation. Springer International Publishing, New York, NY.

Bat Conservation International. 2018. White-nose Syndrome: A Deadly Disease. http://www.batcon.org/our-work/regions/contact-bci/usa-canada/white-nose-syndrome. Accessed March 2.

BLM. 2017. Updated Bureau of Land Management (BLM) Sensitive Species List for Nevada. Instruction Memorandum No. NV-IM-2018-003. Nevada State Office, Reno, NV. November 22.

Bradley, P.V., M.J. O'Farrell, J.A. Williams, and J.E. Newmark. 2006. The Revised Nevada Bat Conservation Plan. Nevada Bat Working Group, Reno, NV.

Brigham, R., E. Kalko, G. Jones, S. Parsons, and H. Limpens. 2002. Bat echolocation research: tools, techniques and analysis. Bat Conservation International, Austin, TX.

Burkholder, B., B. Maxell, S. Hilty, S. Blum, L. Hanauska-Brown, A. Shovlain, and J. Chaffin. 2015. Montana's Bat Acoustic Surveillance Efforts: Pre-White-Nose Syndrome (Oral Presentation and Poster). Intermountain Journal of Sciences 21(1-4): 59.

CDFW. 2019. Epidemic Disease of Bats: White-nose Syndrome. https://wildlife.ca.gov/Conservation/Laboratories/Wildlife-Investigations/Monitoring/WNS. Accessed January 5, 2020.

DoN. 2019. Final Plant Community Surveys and Mapping Report in Support of the Proposed Fallon Range Training Complex Expansion, Nevada. Prepared for NAVFAC Southwest, San Diego, CA by ManTech International Corporation, Lompoc and Solana Beach, CA. July.

Furey, N.M. and P.A. Racey. 2016. Conservation Ecology of Cave Bats. Pages 463-500 *in* C.C. Voigt & T.Kingston, eds. Bats in the Anthropocene: Conservation of Bats in a Changing World. Springer International Publishing, New York, NY.

Gorresen, P.M., A.C. Miles, C.M. Todd, F.J. Bonaccorso, and T.J. Weller. 2008. Assessing bat detectability and occupancy with multiple automated echolocation detectors. Journal of Mammalogy 89: 11-17.

Hilty, S., B. Burkholder, B. Maxell, S. Blum, L. Hanauska-Brown, A. Shovlain, and J. Chaffin. 2016. Montana's Bat Acoustic Surveillance Efforts: an Update (Poster). Intermountain Journal of Sciences 22(4): 127.

Ingersoll, T.E., K.W. Navo, and P. de Valpine. 2010. Microclimate preferences during swarming and hibernation in the Townsend's big-eared bat, *Corynorhinus townsendii*. Journal of Mammalogy, 91: 1242–1250.

Kuenzi, A.J., G.T. Downard, and M.L. Morrison. 1999. Bat distribution and hibernacula use in west central Nevada. Great Basin Naturalist 59: 213-220.

Lemen, C.A., P.W. Freeman, and J.A. White. 2016. Acoustic evidence of bats using rock crevices in winter: A call for more research on winter roosts in North America. Transactions of the Nebraska Academy of Sciences 36: 9–13.

Lorch, J.M., J.M. Palmer, D.L. Lindner, A.E. Ballmann, K.G. George, K. Griffin, S. Knowles, J.R. Huckabee, K.H. Haman, and C.D. Anderson. 2016. First detection of bat white-nose syndrome in western North America. mSphere 1(4), e00148-00116.

Mac Aodha, O., R. Gibb, K. Barlow, E. Browning, M. Firman, R. Freeman, B. Harder, L. Kinsey, G. Mead, and S. Newson. 2017. Bat Detective-Deep Learning Tools for Bat Acoustic Signal Detection. bioRxiv, 156869.

MacMahon, J. 1985. Deserts. Alfred Knopf, Inc., New York, NY.

Morrison, M.L. and S. Fox. 2009. Bats associated with inactive mines in the western Great Basin. Western North American Naturalist 69: 134-137.

NAS Fallon. 2008. Ecological Inventory Update Naval Air Station Fallon. Prepared for Fallon Range Training Complex, NAS Fallon, NV by Tierra Data, Escondido, CA.

NWAPT. 2013. Nevada Wildlife Action Plan. Nevada Department of Wildlife, Reno, NV. Submitted September 6, 2012, approved March 1, 2013.

Neubaum, D.J., K.W. Navo, and J.L. Siemers. 2017. Guidelines for defining biologically important bat roosts: A case study from Colorado. Journal of Fish and Wildlife Management 8: 272-282.

O'Shea, T.J., C. Klinger, L.A. Smythe, L. Wilkinson, and J.P. Dumbacher. 2016. Survey of the Bat Fauna, Desert National Wildlife Refuge, Nevada. Western North American Naturalist 76: 501-508.

Patriquin, K.J., and R.M. Barclay. 2003. Foraging by bats in cleared, thinned and unharvested boreal forest. Journal of Applied Ecology 40: 646-657.

Ports, M.A. and P.V. Bradley. 1996. Habitat affinities of bats from northeastern Nevada. Great Basin Naturalist 56: 48-53.

Sherwin, R.E., W.L. Gannon, J.S. Altenbach, and D. Stricklan. 2000. Roost fidelity of Townsend's big-eared bat in Utah and Nevada. Transactions of the Western Section of the Wildlife Society 36: 15-20.

Sowell, J. 2001. Desert Ecology: An Introduction to Life in the Arid Southwest. University of Utah Press, Salt Lake City.

Veith, M., N. Beer, A. Kiefer, J. Johannesen, and A. Seitz. 2004. The role of swarming sites for maintaining gene flow in the brown long-eared bat (*Plecotus auritus*). Heredity 93: 342.

Weller, T.J., K.T. Castle, F. Liechti, C.D. Hein, M.R. Schirmacher, and P.M. Cryan. 2016. First direct evidence of long-distance seasonal movements and hibernation in a migratory bat. Scientific Reports 6: 34585.

Western Bat Working Group. 1998. Western Bat Species Priority Matrix. http://wbwg.org/matrices/species-matrix/. Accessed February 15, 2018.

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Appendix A: General Discussion of Capture and Acoustic Surveys from Bradley et al. (2006)

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Inventory and Capturing Bats at Water Sources

Many survey techniques can be employed at water sources. Population trends and changes in species composition over time can be evaluated at these sites using acoustic, night vision, infrared camera and capture techniques. A statewide survey grid is proposed in the Water Source section of this volume.

General Discussion of Capture and Acoustic Surveys

In order to obtain the most thorough inventory of bats, it is necessary to use as many techniques as possible. If time permits, a thorough search for available roosts (e.g. tree snags, caves, abandoned mines, buildings, bridges) should be conducted. Concomitantly, other features known or suspected to be attractants to bats should be evaluated (e.g., troughs, ponds, streams, riparian corridors, springs). This presurvey information may be accomplished by examination of detailed topographic maps, consultation with local resource agencies, and conversation with local residents or others familiar with the area. There is also no substitute for a preliminary trip to a site to gain personal knowledge of the existing variability in terrain and habitat mosaic.

Standard capture methods can be used at any designated attractive feature. This can entail a variety of equipment and ingenuity but usually consists of a combination of mist nets and double frame harp traps. Some situations are best suited for one or the other, but combined use can yield better success because of differential trap success among bat species. Depending on the type and configuration of a roost site, other types of capture devices may be more effective. A review of capture devices is given in Kunz and Kurta (1988).

Capture techniques provide animals in hand, which is often thought to provide definitive identification. In truth, this is not necessarily the case. Some species can be very difficult to identify, particularly in the field. In Nevada, two sets of species are difficult to distinguish in hand (California myotis from western small-footed Myotis and Yuma myotis from little brown bat). It is not uncommon for animals to be processed, identified and released during the night. Performing the necessary measurements and assessment of coloration can be difficult on a live animal in artificial light. Taking proper and repeated measurements on a live animal requires experience. The accompanying form data sheet for capture surveys provides a template for ensuring that critical measurements are obtained for the species identification. This form should be used to provide the minimum necessary for a competent capture survey. Voucher specimens should be taken for unusual captures (e.g., range extensions), animals of questionable identity, or those from areas with no previous surveys. Such specimens must be housed at a recognized, actively curated museum. Under no circumstances, can voucher specimen numbers exceed specifications on one's Scientific Collection Permit.

Acoustic survey methods provide a powerful tool for obtaining an inventory of bats as well as more detailed information on habitat use and activity patterns. Equal to its power is the ability for this method to be misused. As with any survey method, if it is done correctly, the results will accurately reflect existing conditions. The reverse can also be true. The following protocol entails the use of the Anabat detector and analysis system (Titley Electronics, Ballina, NSW, Australia). The Anabat provides the ability to monitor in real time, allows low memory storage of all detected bat activity, provides digital storage on a computer hard drive, and has the ability to examine, edit and measure all calls in a sequence simultaneously. The small digital files are easily archived and provide a permanent voucher record. Thus, any errors in identification can be determined and corrected as new information/knowledge becomes available. There are other detectors available commercially.

The first question for any proposed survey is: "How many sampling periods should be surveyed?". The answer is as many as possible. Multi-season sampling is important for understanding the broad dynamics of species composition. Bats are highly mobile and exhibit a wide range of use strategies throughout the year. At a minimum, a location should be examined during each season. Is a single night sufficient? Not usually. Ample evidence exists to document that nightly patterns of activity can vary significantly. This is true for the number of individuals active within a species as well as for species composition. Examining multiple, consecutive nights of data provide a much more accurate indication of bat use. A minimum of three consecutive nights for each sampling period is recommended. Capture devices should be re-arranged from night to night as bats learn to avoid new obstacles encountered. Acoustic devices are not intrusive and can be left in place each night.

Acoustic Surveys (Active vs. Passive)

Acoustic sampling can be conducted actively (observer present) or passively (observer absent). Data recording should be directly to either a laptop computer or a Compact Flash card depending upon acoustic equipment used, and not to a tape recorder. Cassette tapes introduce extraneous noise and frequency determination is affected by change in battery voltage. Additionally, important information, such as exact time of activity, can be lost. Both active and passive methods are important and should be employed simultaneously where feasible. Without an external battery source, duration of active monitoring is limited to the life of the internal battery, usually two to three hours. It is desirable to actively monitor the general area being sampled by one or more passive units. This allows the observer the opportunity to get first hand knowledge of existing conditions and activity, which aids in interpreting and identifying vocalizations. Observing calls during the monitoring process, noting where bat activity is occurring, and getting visual feedback through spotlighting provide needed context critical to the identification of some species. Detailed methods for recording vocalizations, visual identification and interpretation of recorded vocalizations can be found in the Anabat User's Manual (Corben and O'Farrell; available at www.mammalogist.org). O'Farrell et al., (1999) present methods for identification as well.

Passive acoustic monitoring may be done several ways. An Anabat laptop setup can be set in monitor mode (automatic record), the detector propped up to monitor the desired space, and then left to record. This is often done during short periods when capture devices must be checked and captured bats processed. Simply leaving the equipment exposed to the elements and passing animals does have inherent risks. An ideal compact and weatherproof setup contains a detector, CF ZCAIM, and an external battery for long-term use. These units are portable and easily deployed in remote situations. To use this setup to monitor a location on more of a permanent basis, the addition of a solar panel is all that is needed. Multiple units can be operated simultaneously in order to monitor different habitats or other features geographically isolated from each other. Passive systems can generate huge quantities of data, which can present a problem when it comes time to review and identify species composition and activity. Improper detector placement and/or sensitivity settings can result in files full of echo and other noise (insects, etc.) that can interfere with the identification process.

Acoustic Surveys (Fixed-Point vs. Mobile)

Acoustic surveys can be conducted at fixed points or they can be mobile. Fixed points can yield detailed information about a particular habitat feature. Both active and passive monitoring is appropriate. To be most effective, fixed points should be selected randomly. The same type of decision-making for capture devices should be applied to fixed-point acoustic sampling. Because the volume of space actually sampled by the equipment is finite, it is imperative that locations be selected where bats should be expected to occur (e.g., water sources, riparian corridors, suspected flyways, habitat edges, and roosting sites). As with capture devices, proper placement of the acoustic device will maximize the quantity and quality of data obtained.

The Anabat detector is relatively directional with an apparent cone of reception of approximately 45 degrees. In reality, the envelope of detection is irregular and lobed within those 45 degrees. During active monitoring, it is best to pass the detector in a slow arc while searching for bats. Once detected, then the echolocation calls should be followed as best as possible. This maximizes the number of calls obtained in a sequence.

Orientation of a passive setup is critical to obtaining useful data (Patriquin et al. 2003). It is necessary to place the unit to sample the greatest concentration of bat activity. For a small water source, such as a tank or trough, the microphone should be oriented toward the space above the water and placed at least 15 m away. Although it is best to know one's detector and the nuances of its sensitivity setting, a good default sensitivity setting is six to seven. At a water source, a high concentration of bat activity can be expected. This can produce an acoustically cluttered environment similar to a single individual flying near vegetation or a rock face. Placing the detector a minimum of 15 m from such clutter helps reduce the amount of echo and other extraneous noise. At streams, vegetation edges, riparian corridors, or other linear habitats, place the unit to sample the long axis (parallel to the edge). Most activity will occur parallel to the edge, thus bats will be within the detection envelope longer than if the unit were oriented perpendicular to the edge.

Acoustic monitoring at roost sites can be useful but caution needs to be exercised. Any activity around a roost entrance involves a certain amount of clutter (physical or the presence of other bats). In some cases, the calls of bats exiting a roost are similar to those immediately given during hand release and bear no resemblance to calls given in free flight in the open. Thus, they are of no value in identifying species present. Active monitoring at a roost allows visual feedback and the ability to assess quality of calls. Immediate adjustment in sensitivity and/or changing position in relation to the entrance can be made. Passive monitoring does not allow this adjustment. Therefore, it is imperative to place the unit a sufficient distance away from the entrance (minimum of 15 m) to minimize clutter interference. The greater the amount of physical clutter around the entrance to a roost, the greater the distance the passive unit should be placed away from the entrance.

In clutter, bat calls tend to be reduced in frequency range and duration. Thus, much of the diagnostic structure necessary for species identification is lost. This is particularly significant when dealing with species that can be confused. For example, California myotis and Yuma myotis are both 50 kHz bats (characteristic frequency approximately 50 kilohertz). In free flight and away from clutter, these bats are readily distinguishable. However, in clutter their vocal signatures are virtually identical. They can be found roosting in the same structures, which can compound the problem. Capture methods would need to be used to assist in determining whether both species are present. If clutter cannot be avoided, it is best to limit identification to a group of species rather than risk misidentification.

Simply because bats are recorded at a roost, specifically a mine or cave entrance, does not mean the bats are using the structure. Likewise, simply because bats are not recorded at an entrance does not mean that bats are not using the structure (e.g., there may be unknown and/or multiple entrances). Also, actively monitoring near an entrance can inhibit bats from exiting the structure. This is particularly true for the Townsend's big-eared bat. Placing a passive unit can circumvent this problem, although a bat flying overhead could be perceived as using the entrance. Visual verification is sometimes necessary. Placement of a camcorder with infrared capabilities (e.g., Sony DCR-TRV 120 with Nightshot and hot shoe IR light source) focused on the entrance will verify specific ingress or egress by bats. Acoustic data will allow species identification, although Townsend's big-eared bats emit faint calls and may not be recorded.

A detailed knowledge of species composition and activity at a fixed point provides a necessary understanding of use of that particular habitat feature or resource. However, this cannot be extrapolated to the landscape level. Further, the sites selected for sampling are those known or suspected of having attractant qualities. Therefore, bat presence should be concentrated at those sites. Because of sampling restrictions, little is known about how bats disperse and use the landscape away from these specialized habitat features. Mobile acoustic sampling, similar to radio-telemetry in this context, can be used to examine landscape level bat use.

Routes should be selected carefully. Any road with night traffic can be dangerous and should be avoided. For mobile surveys, it is imperative that the time, mileage and GPS coordinate be taken at the beginning and end of each transect. The standard protocol for conducting a mobile survey includes driving between five and ten mph. The area ahead, to the side, and behind the vehicle should be scanned continuously while driving. When a bat is encountered, stop the vehicle immediately and actively monitor the surroundings for one minute. Mileage and/or a GPS fix should be taken. If no further vocalizations are detected, continue driving. If more bat activity is detected, continue monitoring for five minutes, and then proceed with driving. Visual techniques (e.g., spotlight) should be incorporated to assist in verifying species identity. Visual verification should be noted for specific files and that information incorporated into the text header. A single recording would indicate a commuting bat. More prolonged activity may indicate a foraging site or other habitat feature resulting in concentrated use. Each location resulting in a vehicle stop should be examined during the day and characterized by habitat and any features that might provide insight into bat use. A specific transect should stay within a specific habitat type. Multiple transects can be conducted in a single night. Although large areas of habitat can be examined, recognize that away from water or other attractant features, there may be relatively little bat use. For example, surveys through broad desert valleys without development may not yield a single encounter. However, with sufficient effort, it should be possible to locate movement corridors and localized feeding areas. These sites may be constant or they may change through time. Such knowledge is critical to the understanding and subsequent management of bats and is unattainable through most other field survey methods.

The form data sheet for acoustic sampling provides the minimum data that should be collected when conducting either fixed-point or mobile monitoring. If passive and active sampling is conducted simultaneously, multiple computers will be used. Number each computer and associated detector and ZCAIM so that all the equipment in a given setup remains constant. Also record which computers were assigned to the active and passive positions (e.g., STATIONARY LINE: Active #2, Passive #1 and #3 etc). If each is sampling different habitats, that information would be provided in the next two lines, separated by semicolons, respectively. If they are at widely divergent locations, UTM or Lat/Lon coordinates need to be provided for each (that information is always incorporated in the default text header in Anabat6).

As soon after collecting the data as possible, recorded files should be examined and species identity assigned (species codes entered for the species field in the text header). A representative file name (indicating a time date stamp as assigned by Anabat6) for each species encountered must be entered on the form. These files should be selected as the best representation of that species providing the basis for identification.

Any report of the results of capture or acoustic surveys should include copies of the completed data sheets in an appendix. Agency reports (e.g., annual report to NDOW for Scientific Collection Permit) should also include copies of acoustic voucher files. At least one would be required per species. However, if available, at least ten of the best quality files should be included for each species identified from each locality surveyed.