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Distribution and Status of Bats at Ft. Irwin National Training Center

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The Distribution and Status of Bats at Fort Irwin National Training Center

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THE DISTRIBUTION AND STATUS OF BATS AT FORT IRWIN NATIONAL TRAINING CENTER

ABSTRACT: The research assessed bat roosting and foraging habitat on Fort Irwin National Training Center (NTC) as it relates to the environmental management objectives. Six long-term acoustic monitoring stations were deployed at water sources to establish baseline bat activity and species composition prior to the exclusion of burros or other management activities within and removed from troop training areas. Mist-netting at selected sites augmented the acoustic data, verifying species identification and providing information on age and reproductive condition. Roost surveys (primarily mines) verified resident species. The current research was compared to the results of the bat inventories performed by Dr. Patricia Brown on the NTC in 1993-94 and subsequent surveys of mines in 1995 and 2005-2006 in areas proposed for the Eastern and Western Expansions. Largely automated long-term acquisition of echolocation data can provide a seasonal and inter-annual perspective on bat activity as biologists at Ft. Irwin continue management interventions at these sites.

INTRODUCTION: The primary goals of this project were: 1) to sample bat activity and species composition using long-term acoustic recording techniques on the NTC in riparian and spring areas embedded in troop training areas and those where troop activity is excluded; 2) to provide baseline acoustic activity and capture data for comparison with ongoing or similar data accompanying future management activities at water sources 3) to compare bat use of mines in impacted and non-impacted areas and 4) to compare bat populations in selected mines that have had bat-compatible closures installed with pre-construction surveys conducted in 2005-2006.

Tools for recording and analysis of bat acoustic activity data have advanced substantially since the first bat survey of Ft. Irwin in 1993-1994 (Brown 1994). In the past, bat detectors were deployed usually for a few hours or perhaps one night in secure locations. If it was windy on a survey night, few bat calls were recorded. Uncommon species or seasonal events, such as migrations, were not usually detected, nor were long-term trends. With subsequent advances in electronics, low power drain detectors with internal or accessory removable digital storage can be combined with external batteries to collect data for weeks (e.g., Gorresen et al. 2008) or, with solar recharging and episodic maintenance, for a year or more (e.g., Johnson et al. 2011). Bat activity monitoring by varied techniques often shows large variation night to night, as noted, in response to weather and longer term trends correlated with seasonal resource variation (surface water for drinking, insect availability coupled to air temperature and other parameters). In an environment like the NTC, the very limited spring sites with surface water and localized mesic vegetation attract concentrations of wildlife, including bats. Resource availability at springs for native wildlife is influenced in both the short and long term by activity (browsing, trampling, drinking, excavation) of the substantial population of introduced burros. Extensive lower density desert vegetation on the range can be degraded in the long term by vehicular activity associated with troop training. Bats forage in these habitats and monitoring long-term activity trends at spring sites where bats are concentrated may offer a perspective on community response to habitat change.

Roosting and foraging habitat are closely related, although they can be spatially separated. Bats may have foraging habitats distant from the mine roosts that could be impacted by other management decisions. For example, a population of Allen's lappet-browed bat (*Idionycteris phyllotis*) in Arizona roost in abandoned mines in creosote bush scrub, and commute nightly to forage in pinyon juniper habitat in the next mountain range 40 km away (Brown and Berry 2004a&b, 2005). Radio-telemetry is currently the best tool to identify bat foraging habitats, but this method was outside the scope of the current research. However, surveying potential roost sites, particularly mines, can provide information on bat distribution. Townsend's big-eared bat (*Corynorhinus townsendii,* one of the most important species from a management perspective) is difficult to detect acoustically, and prefers to roost in caves and mines. The two factors that influence the choice of a roost are temperature and the amount of human intrusion. Identifying and protecting roosts with bat-compatible closures is one of the best tools to protect this sensitive species. From those mines visited in the1993-94 surveys, the more accessible mines in the Avawatz Mountains and the Desert King Mine in the Granite Mountains were resurveyed in the winter and summer.

METHODS:

The first field visit occurred in December 2010 and continued through August 2012 for a total of 53 field days. Table 1 summarizes the times of the surveys, activities, and areas visited.

Study Sites

After reviewing potential field sites (including management goals, proposed actions and access constraints) with NTC environmental staff, long-term detector stations were installed at six water sources (Table 2, Figure 1a&b). With the exception of the North Sewage Pond (see below), the other five sites were springs on the Range that had or were planned for manipulations to enhance wildlife access to surface water long-term. Three of the sites already had fencing for burro exclusion and fence installation is planned for one of the remaining sites, Panther Spring. Bitter and Garlic Springs are both near areas of high training activity. Acoustic monitoring for annual intervals provides a baseline on bat activity and diversity at this sample of sites. Mist-netting surveys were conducted at a number of these sites (see Mist-Netting Methods below)

Table 1. Summary of survey dates and research activites.

Survey Dates*	Personnel	Primary Purposes	Areas Visited	Mist Net	Mines	Acoustic	Notes
Dec 8-9, 2010	PB,AG	Select survey locations	BS,DVS,DKS,GS,PS,SP	0	DK	0	
Mar 31-April 1, 2011	PB,WR,AG	Select survey locations	BS, CS,DKS,GS,PS,SP	BS	0	BS, GS,SP	
May 3-6, 2011	PB,WR	Safety training; long-term anabat installation	BS, GS,NNS,SP	BS,GS		BS, GS,SP	
May 31-June 4, 2011	PB,WR	Long-term anabat installation and maintenance	BS, C, CS, DKS, GP, GS,PS, SP	BS, CS, PS	DK	BS, C, CS, DKS, GP, GS,PS, SP	
July 19-24,2011	PB,WR	Long-term anabat maintenance, mine surveys	BS, CS,DKS, DVS,GP, GS, PS,SP	BS, CS,PS	AV	BS, CS,DKS, DVS,GP, GS, PS,SP	
Sept 2-7,2011	PB,WR	Long-term anabat maintenance	BS, CS, DKS, DVS,GP,GS,NNS, PS,SP	BS, CS, DKS, NNS,PS		BS, CS, DKS, DVS,GP,GS,NNS, PS,SP	rain and wind some nights
Oct 2-6,2011	PB,WR	Long-term anabat maintenance	BS, CS, DKS, DVS,GP,GS,NNS,PS,SP	CS, PS		BS, CS, DKS, DVS,GP,GS,NNS, PS,SP	cold and windy, some rain
Dec 15-20, 2011	PB,WR	Long-term anabat maintenance,mine surveys	BS, CS,DKS, GP,GS,NNS,SP	0	AV, DK,EX,WX	BS, CS, DKS, GP,GS,NNS, PS,SP	very cold
Mar 30-April 3, 2012	PB,WR	safety training; long-term anabat maintenance	BS, CS, DKS, DVS,GP,GS,NNS, PS,SP	BS, PS		BS, CS, DKS, DVS,GP,GS,NNS, PS,SP	windy
June 24-30,2012	PB,WR	Training NTC personnel;long-term anabat maintenance	BS, CS, DKS, DVS,GP,GS,NNS, PS,SP	BS,CS,DKS,NNS, PS	AV,WX	BS, CS, DKS, DVS,GP,GS,NNS, PS,SP	
Aug 26-30, 2012	PB,WR	Training NTC personnel;long-term anabat maintenance	BS, CS, DKS, DVS,GP,GS,NNS, PS,SP	BS,CS,PS	WX	BS, CS, DKS, DVS,GP,GS,NNS, PS,SP	thunderstorms
*not including travel days	AG=Alan Grinnell		BS=Bitter Spring		DK=Desert King		
	PB=Patricia Brown		CS=Cave Spring		AV=Avawatz		
	WR=William Rainey		C=Cantonment		EX=Eastern Expansion		
			DKS=Desert King		WX-Western Expansion		
			DVS=Devouge Spring				
			GP=Granite Pass				
			GS= Garlic Springs				
			NNS=No Name Spring				
			PS=Panther Spring				
			SP=Sewage Pond				

Table 2. Locations of acoustic stations used in NTC bat survey.

Site	Map Label	Zone	Easting	Northing	Elev (m)
Long-term sites					
Bitter Spring	Bitter	11S	551927	3898290	400
Garlic Spring	Garlic	11S	532612	3898564	694
Desert King Spring	D King	11S	525917	3931214	907
Panther Springs	Panther	11S	539082	3925162	1163
Cave Spring	Cave	11S	551499	3933044	1096
North Sewage Pond	Pond	11S	530400	3901147	734
Short-term Sites					
No Name Spring	No Name	11S	537615	3923091	1384
Devouge Spring	Devouge	11S	538129	3925768	1130
Granite Pass West	GP West	11S	540581	3920315	1206
Granite Pass East	GP East	11S	541042	3920185	1187

Panther Spring: Several large cottonwood trees augment roosting and foraging habitat at the seasonal pools on the sandy floor of a boulder rimmed canyon (Figure 2a&b). A low empty concrete trough and fragmented pipe are remnants of former water development. Burros have unrestricted access and their sign (tracks, incised trails, droppings) is extensive,

Cave Spring: At the northern edge of the Avawatz Mountains in a narrow sand and gravel floored canyon, two manmade adjacent caves/mines intercept the same spring at different angles (Figure 2c). Both were fenced to restrict burro access. The more extensive mine/cave includes a large underground water pool providing both drinking water and a sheltered underground night roost to more maneuverable bats. The portal of the smaller cave is choked with cattails and there is an adjacent willow tree. Troop training activities are currently prohibited in this area.

Desert King Spring: This spring was originally developed for the mill and living area for the Desert King Mine 2.5 km to the northwest. The shallow pool varies in size, and is usually less than a meter in diameter (Figure 2d). At one time the flow from the pool was captured in a trough, but this is fragmented and filled with sand. The spring is fenced, although burros can crawl under to reach the water. There are a few shrubs within the fenced enclosure, but the spring is on a rock bench well above the wash channel and has the least woody vegetation among the long-term spring sites selected. Potential rock crevice bat refuges are abundant on the largely barren steeper canyon slopes.

Bitter Spring: Although dominated by tamarisk, riparian woodland extends for approximately 600m along braided channels below a hill slope (Figure 2e). In the spring, surface water flows through much of this habitat, with several seasonally persistent deep pools. Although adjacent to troop training areas, fencing (both barbed wire and concertina) and signage restricts human access. Burro use within the area is intense. Surrounding areas are largely fine soil mantled and offer minimal crevice roosting habitat in the immediate vicinity.

***Garlic Spring*:** This spring, 5.4 km southeast of the Cantonment area, is dominated by several large cottonwood trees (Figure 2f), a stand of willows and other shrubs. Like Bitter Spring, adjacent hillsides are soil mantled and offer few crevice roosts for bats. There is seasonally marshy area of low grass beneath the trees and an extensive dense cover of cattail over the surface pool. Surface water is largely hidden under vegetation and inaccessible to bats. A major military supply route (MSR) runs past the spring, which is off-limits to training and fenced with barbed and concertina wire. Burro sign within fenced areas indicated periodic access.

***Sewage Pond*:** A series of sewage ponds are located on the eastern edge of the Cantonment Area. After consultation with facility staff, a long-term detector was installed on the bermed margin of the northernmost and largest pond, alongside a perimeter fringe of willows (Figure 2g). Burro sign was absent. The hypothesis was that the extensive open water would be used by larger, less maneuverable bats that could not drink at spring sites with limited access to surface water. With reliable year-round water access this site could provide more information on seasonal activity of these species.

Acoustic monitors were deployed at four additional sites for shorter intervals (up to one week) during some of our active NTC surveys. These were locations with habitat features considered to be attractive to foraging or roosting bats.

Granite Pass: Two units (Figures 3a&b) were deployed, one on each slope of the crest at Granite Pass, adjacent to a major MSR. These sampled bat activity in extensive rocky open slope and bajada habitat distant from surface water where rock features potentially provided roosting habitat for larger crevice roosting bats such as western mastiff bats.

Devouge Spring: This small spring on the bajada, in an area of large creosote bush, was also developed by ranchers prior to the establishment of the military training facility. A fence excludes troops and burros, although training activities occur adjacent to the exclosure. The small water source is densely covered by cattails (Figure 3c) and is not accessible to bats drinking in flight.

No Name Spring: This spring is down slope from an active communication installation, but no troop training occurs in the narrow rocky canyon. Rock crevice bat roosting habitat nearby appears extensive. The spring was also developed historically as a cattle water source, but pipes and retention structures down drainage are degraded and empty. Surface water varies seasonally but there is at times a 1m diameter pool (Figure

3d). There is no fencing and burros have heavy impact on the area (browsing, trail incision, droppings and pool alteration).

Long-term Acoustic Surveys

Long-term surveys used Anabat SD2 ultrasound detectors (Titley Electronics, Ballina, NSW, Australia) for signal capture and storage on 4Gb industrial grade compact flash cards. A weather tight (NEMA4) enclosure contained the detector, a 12V 7Ahr sealed lead acid battery, and a low power microcontroller/solar regulator/data logger (assembled by EME Systems, Berkeley, CA). Wiring with case wall seals extended to a 10 watt solar panel, a 5m detector microphone extension, a cup anemometer (Davis Instruments, Davis, CA) and a digital temperature/humidity sensor on the lower surface of the enclosure. The microphone socket in the shroud contains a preamplifier that eliminates high frequency attenuation from the 5 m extension cable.

The enclosure, solar panel, bracket with microphone shroud and reflector and anemometer were mounted one above the other on two stacked guyed 5 ft (1.5m) lengths of swaged antenna mast (RadioShack) with the microphone approximately 2.4 m above the mast base (Figure 4a&b). The arm carrying the cup anemometer was oriented north and the solar panel on its angled bracket approximately south. Stainless steel bird spike arrays were attached to the upper edges of the solar panels to lessen perching and guano deposition on the panel. The microphone protective shroud was pointed down (to avoid precipitation and membrane solar degradation) toward a clear polycarbonate rectangular sheet that reflected sounds from above and partially blocked those from below. This reflector was pitched at 15 degrees below horizontal for rain runoff. The angle to the microphone axis to the reflector was 45 degrees, so that the axis of the detection volume was oriented upward at 30 degrees. The detector division ratio was set at 8 to enhance retention of call structure detail.

The Owl multi-channel logger in the enclosure had firmware for user programming (by serial link) of the detector operating schedule and logging intervals for the sensors. Based on geographical coordinates, the firmware calculates local sunset and rise times. A user controlled offset of 20 minutes was added so that acoustic monitoring started 20 minutes before sunset and continued 20 minutes after sunrise. During the course of the project, the firmware was updated several times, but these basic functions were constant.

Echolocation calls of most North American bats are wholly or largely in the ultrasonic, *i.e.*, above 20 kHz, nominally the upper limit of normal human hearing. To avoid recording and filling limited data storage with frequent audible sounds of low interest (bird calls, insects, leaf rustle) bat detector microphones typically include components that increasingly reduce sensitivity as frequency decreases from 20 kHz. For example, 18 kHz sensitivity is lowered somewhat, while 8 kHz sensitivity is lowered much more strongly. The detectors used in this study do not record signals below about 4 kHz.

In the Southwestern U.S, however, there are several species (western mastiff bat, spotted bat, big freetail bat) with audible fundamental call frequencies. To improve the likelihood of detecting low frequency species, we began the study with the optional Anabat microphone (LoMic) that lacks the low frequency roll-off filter and is more sensitive to both these species and other audio range sound. A trial revealed that the nightly data accumulation rate from non-bat audio range sound (notably vegetation and wind noise) would require more frequent downloads than was feasible, so we substituted standard microphones with sensitivity roll off below 20kHz.

During resurveys at intervals of about 1-3 months, call data from the detector flash card and, similarly, environmental sensor data from a removable USB storage ‘drive’ were downloaded. System performance was evaluated on site by reviewing call files with a laptop. Crystal controlled clocks in the detector and the enclosure logger were checked and updated as needed. Solar panels were also cleaned and other maintenance conducted, commonly re-anchoring dislodged mast guy wires for systems in areas accessible to burros. Instances of damage to or failure of microphone cables required replacement and caused intervals of data loss at several stations.

Short-term Acoustic Surveys

At four additional sites noted above, portable passive detectors were deployed for several nights during some active field surveys. These had storage batteries and similar bat detector components to the long-term monitors, but did not use solar panels or meteorological sensors. The microphone and reflector assembly was placed on a temporary 3 ft. stake, again connected to a watertight enclosure by cable (Figure 5). All these units were equipped with low frequency microphones to enhance the likelihood of detecting audible frequency bats. At mine portals and other locations monitoring for intervals of a few hours employed Anabat detectors powered by AA batteries.

Acoustic Data Analysis

Anabat format files were obtained by downloading and interpreting the compressed files stored on the detector flash cards with the program CFC read, using the default parameter settings. Subsequent locality labeling, filter based identification, visual screening to evaluate filter identifications, species labeling and extraction of time of activity by species was conducted with Analook W. The most current version of both programs is available from the author, Chris Corben (www.hoarybat.com/Beta). Call measurement parameters, variation in calls, and other aspects of data collection and analysis are treated in Gannon et al. (2003) and Corben (2004) (for extended terminology discussion, see http://users.lmi.net/corben/glossary.htm). The primary set of filters used for the Ft. Irwin data are individually discussed in Rainey et al. (2009), though some additional filters originating with Chris Corben were also used. Known species voucher files were used for comparison as needed (O'Farrell et al. 1999). After frequently observing rodent calls in early Ft. Irwin data sets a simple, inclusive filter was designed to select these. Electronic copies of all filters have been provided to Ft. Irwin staff. Many of the filters are designed to recognize single species. A few recognize only particular call types of a species, *e.g.*, *Antrozous pallidus* (pallid bat) directive calls (Brown 1976), *C. townsendii* (Townsend's big-eared bat) first harmonic.

Other filters identify acoustic categories, typically calls with similar frequency range and slope that may include more than one species that cannot currently be separated on traits of this call type. In this study a widely used filter labeled M50 selects high slope, frequency modulated (FM) calls with characteristic frequencies around 50 kHz. Similarly, the Q25 filter selects calls with characteristic frequencies from 25 to above 30 kHz. Characteristic frequency is the frequency of lowest slope near the (temporal) end of the call (Corben 2004). In this study, both these filters were applicable at the species level because only one of the bats species producing similar calls was present or common in the study area (see species accounts). Images of identified sample calls from NTC are provided in Appendix I and also discussed in the species accounts below.

The maximum duration of individual sequence files generated from the stored flash card data is 15 seconds. While there are a variety of indices developed to measure bat activity, this analysis uses the activity index of Miller (2001). This is the count of minutes during a night (or other interval) in which one or more sequence files assigned to a species or acoustic category were detected --- essentially presence/absence by minute.

There are inevitably call sequences recorded from the margins of the detection volume that are visually recognizable as bats or assignable to species or acoustic category, but are sufficiently degraded that they are not recognized by a filter. The more stringent the filter (*e.g.*, requiring more complete pulses meeting filter criteria to identify a sequence), the fewer files it will recognize. Visual review of all files when there are low millions in a sample set is impractical, so measures of activity should be seen as conservative. However, counts of identified files or resulting minutes of activity are a replicable sample of the data. All data are retained as digital files and can be re-analyzed with other methods if desired.

Mist Netting Methods: Mist-nets were spread across the springs with open water and little vegetation interference where acoustic recording stations had been deployed (Bitter, Cave, Panther, No Name, and Desert King) (Figure 6). The number and size of nets set at a given location was determined by the area of open water at that season. For most springs, the amount of open water varied dramatically between seasons and years. During some surveys at Panther and Bitter Springs, surface water was very limited or absent, and mist nets were spread across flyways that had been successful net capture sites in the presence of water. The water at Devouge and Garlic Springs was covered with vegetation and not amenable to netting, while the sewage ponds are too large to spread mist nets across. On nights with high winds or inclement weather, mist-netting was not attempted or was sometimes truncated.

Roost Surveys: Following MSHA safety protocol, mines were entered during the day to look for bats, guano and other wildlife. In addition to bat species and/or guano present, data was recorded on mine features, such as configuration, crevices, airflow, stability, temperature, and evidence of human visitation. When encountered, bats were captured in hand nets in the mines in order to obtain information on sex and reproductive status.

Some mines that could not be safely and/or completely accessed internally were monitored at dusk with night vision equipment (augmented with infra-red light sources) and finger tallies, to obtain accurate exit counts. Sony “Nightshot” video cameras (sensitive in the infrared) with auxiliary IR lights were used to remotely monitor mines, and to obtain permanent records of bat and other wildlife activity. Most bats in mines (with the exception of *C. townsendii*) roost in crevices and may not be detected by internal surveys. For some complex mines with internal crevices, exit surveys were performed even if an internal survey did not discover bats or guano.

RESULTS

Table 3 summarizes the bat survey results for the three sampling methods used in this study. A total of seven species were detected acoustically. Roost sites were located for five of these species, and six were captured in mist net surveys.

Table 3. Summary of species detected, methods and seasonality of detection, and relative abundance.

Common name	Scientific name	Acronym	ID Method	Evidence of Reproduction	Month	Acoustic Station	Relative Activity
Plain-nosed bat family	***Vespertilionidae***						
California myotis	*Myotis californicus*	**Myca**	A, R, M	Y	All	All	H
Canyon Bat	*Parastrellus hesperus*	**Pahe**	A, R, M	Y	All	All	H
Red bat	*Lasiurus blossevillii*	**Labl**	A		Ap,My,Ju,Jy, Au,S,O,	BS,DKS,GS,PS,SP	L
Hoary bat	*Lasiurus cinereus*	**Laci**	A,M		Ap,My,Ju,Jy,Au,S,O,N	BS,CS,DKS,GP,GS,PS,SP	L
Townsend's big eared bat	*Corynorhinus townsendii*	**Coto**	A, R , M		All	BS,CS,GS,NNS,PS	L
Pallid bat	*Antrozous pallidus*	**Anpa**	A, R, M	Y	All	All	M
Free-tailed bat family	***Molossidae***						
Mexican free-tailed bat	*Tadarida brasiliensis*	**Tabr**	A, R,M		All	BS,CS,DKS,GP,GS,PS,SP	H
Western mastiff bat	*Eumops perotis*	**Eupe**	A		Mr,Ap, My	(1993-94 audible)	L

ID Method
A = acoustic
  ie: audible call or computer file
M = caught in mist net
R = roost found
  ie: guano, hand net, outflight

Evidence of Reproduction
Y = yes
ie : pregnant or lactating
females or juveniles caught

Month
All
Ja = January
F = February
Mr= March
Ap=April
My = May
Ju = June
Jy = July
Au = August
S = September
O = October
N=November
D=December

Station
BS=Bitter Spring
CS=Cave Spring
DKS=Desert King
DVS=Devouge Spring
GP=Granite Pass
GS= Garlic Spring
NNS=NoName Spring
PS=Panther Spring
SP=Sewage Pond

Mean Acoustic Minutes for One Year
High = > 2500
M edium = 100-2500
Low = < 100

Acoustic:

Summary plots of activity by species at long-term sites are shown at 3 levels of aggregation to display different aspects of the data (Figures 7-8, Appendix II). Figure 7 shows total minutes of activity through the entire data set for all sites. 50 kHz Myotis detections (attributed at NTC to *M. californicus* [see species account]) are the most common at all sites. The second most common detection class is *P. hesperus*. These two species call in the same frequency range (ca 40-55 kHz) and are readily distinguishable as individuals in open air flight. However, in concentrations of bats or near obstacles or prey, many bat species emit shorter duration and higher slope (steeper) calls. Consequently calls of several species with the same frequency range converge in characteristics and are less readily distinguished by eye or analytic software. In this case, *P. hesperus* calls in high activity episodes converge on the steeper 50 kHz Myotis calls, so that some fraction of the *Myotis* count could be *P. hesperus* clutter calls. Acoustic activity from other species is markedly lower with the exception of *T. brasiliensis* at the North Sewage Pond. The sewage ponds are the only sampled site with an area of water throughout the year large enough to allow drinking in flight by this typically high and fast flying species. This species may also seasonally encounter drinking water in open channels at Bitter Spring (the only site where they were captured in mist nets).

Counts of nights with any acoustic activity by species at each station (Figure 8) show that while *M. californicus* and *P. hesperus* constitute most of the activity at all sites, and other less active species are detected briefly on many nights. *A. pallidus* is notably frequent at Cave, Bitter and Panther Springs. *C. townsendii* was detected on several nights at four sites, but was most consistently observed at Cave Spring which has an underground refuge with a flight entrance (see Figure 6). Frequent detection of mice of the genus *Peromyscus* at several sites (despite detectors configured to reduce signals from terrestrial sources) is an interesting opportunity for passively monitoring another vertebrate assemblage.

For comparison of seasonal patterns, plots for minutes of activity per night for all taxa by site for the duration of the study are in Appendix II. The less common species are plotted with a maximum ordinate of 50 minutes. For common species this value is 1000, set by high *M. californicus* activity at some sites. Marked seasonality is evident with low activity for most species from October through March. The seasonal distribution of scattered detections of tree-roosting lasiurine bats (*L. blossevillii*, *L. cinereus* and possibly *L. xanthinus,* [see *L. cinereus* species account]) is generally consistent with low numbers of spring and fall migrants at sites with some arborescent vegetation.

Tables 4 and 5 summarize the species recorded at four stations from temporary (1-7 nights) detector deployments during surveys on site. These were equipped with microphones sensitive to audio frequencies that substantially increase detection rates for *Eumops perotis* (Western mastiff bat). No mastiffs were detected during this survey, although they were detected in 1993-1994. The relative levels of activity by species at these sites generally resemble data from the long-term spring sites in that *P. hesperus* and *M. californicus* are most active and all others infrequent or absent in these comparatively short duration samples. For these species, the two spring sites (No Name, Devouge) had much higher activity than the two dry, rocky habitat sites near Granite Pass. Activity at No Name with a small open water pool was greater than Devouge with a small dense *Typha* stand, but no accessible surface water. *A. pallidus* and *Peromyscus* sp. were detected at all four sites. Seasonally dispersed *C. townsendii* detections at No Name suggest a roost in the vicinity. *T. brasiliensis* were detected on several seasonally dispersed nights at both Granite Pass sites, but not at either spring.

Table 4. Summary of bat species detected ("X") at short-term passive acoustic stations.

Site	Anpa	Coto	Laci	Myca	Pahe	Pero	Tabr
No Name Spring	X	X		X	X	X	
Devouge Spring	X			X	X	X	
Granite Pass West	X		X	X	X	X	X
Granite Pass East	X			X	X	X	X

Table 5. Minutes of activity by sample night at four temporary passive detector stations on the range. Sampling duration for dates marked with grey was 0.5 night or less. Blue indicates no data available.

	No Name Spring							Devouge Spring							Granite Pass West							Granite Pass East						
Date	**Anpa**	**Coto**	**Laci**	**Myca**	**Pahe**	**Pero**	**Tabr**	**Anpa**	**Coto**	**Laci**	**Myca**	**Pahe**	**Pero**	**Tabr**	**Anpa**	**Coto**	**Laci**	**Myca**	**Pahe**	**Pero**	**Tabr**	**Anpa**	**Coto**	**Laci**	**Myca**	**Pahe**	**Pero**	**Tabr**
6/1/11																												
6/2/11																									3	3	1	10
6/3/11																									8	2		6
7/19/11																		5	7									
7/20/11																		2	5									
7/21/11																		1	2									
7/22/11																		10	31									
7/23/11																		9	13	1	1							
9/2/11											149	10	2												5	23		
9/3/11											208	39	2		1			20	9						13	37		1
9/4/11																		4	20			1			2	19		
9/5/11																		20	33			2			6	21	1	
9/6/11	2	5		288	93													17	26						9	25		
9/7/11																		12	19						4	12		
10/2/11											12		1					2	4	1	1							
10/3/11				16	2													1	1									
10/4/11				2																								
10/5/11																												
10/6/11																												
12/15/11				2																								
12/16/11				3																							2	1
12/17/11				67		1												1										
12/18/11				23																								
12/19/11				31																								
12/20/11																												
3/30/12	11	5		100	26														1	3	3				2	1		2
3/31/12				1																								
4/1/12																												
4/2/12		10		29																								
6/24/12											43	5							5							3		
6/25/12				109	13						10	7							1							1		
6/26/12				180	45						48	6						1	13			1			1	13		
6/27/12				141	31						26	3						1	8	1	1	2			2	18		
6/28/12				111	15						13	1						4	5						2	2		
6/29/12				50	40						6							1	3							1		
8/26/12	2			79	37			2			47	5			1			15	18	4	4	3			28	10		1
8/27/12				61	18						30	6						7	11			1			11	8		
8/28/12				59	51						12	5						5	15						17	30		1
8/29/12				3	11												1		2	1	1					7		

Mist Netting: Good mist-netting opportunities were limited to the areas around the springs that were acoustically monitored where 349 bats of six species were captured during this survey (Table 6) in approximately 115 mist net hours (#nets x #hours) over 29 nights in six locations.

Table 6. Numbers of individuals of each species captured in each mist-netting session, 2011-2012.

Locality	Date	Net Hours	*Anpa*	*Coto*	*Laci*	*Myca*	*Pahe*	*Tabr*	TOTAL
Bitter Spring	1-Apr-11	9.0	4		4				8
	4-May-11	9.9	8			5	4	4	21
	31-May-11	7.5	2			1	8		11
	22-Jul-11	7.5	7			2	20		29
	5-Sep-11	6.0	1			1	11		13
	2-Apr-12	4.0				6			6
	28-Jun-12	3.3	1			12	5		18
	27-Aug-12	7.5				5	9		14
Cave Spring	21-Jul-11	2.5		1		19	36		56
	24-Jul-11	4.3				6	2		8
	3-Sep-11	2.0				6	1		7
	7-Sep-11	1.5				5			5
	3-Oct-11	2.25				4			4
	25-Jun-12	2.0				36	1		37
	28-Aug-12	2.0				8	4		12
Desert King Spring	4-Sep-11	1.25							0
	27-Jun-12	2.0				3	5		8
No Name Srping	6-Sep-11	5.0		1		7	5		13
	29-Jun-12	5.0				3	5		8
Garlic Spring	3-May-11	1.3							0
Panther Spring	3-Jun-11	6.6		1		9	1		11
	19-Jul-11	4.0				3	5		8
	20-Jul-11	4.0				3	7		10
	23-Jul-11	4.5	4			8	6		18
	2-Sep-11	3.0					2		2
	2-Oct-11	2.5							0
	30-Mar-12	1.5				1	3		4
	24-Jun-12	1.6				12	6		18
	26-Aug-12	1.5							0
	TOTALS	**115.0**	**27**	**3**	**4**	**165**	**146**	**4**	**349**

Cave, Bitter and Panther Springs were the most frequently netted since the capture conditions were more productive. Five species were netted at Bitter Springs, and it was the only location where *L. cinereus* and *T. brasiliensis* were captured. In general, mist-netting favors the capture of low-flying species (such as *M. californicus, P. hesperus* and *A. pallidus*), while the free-tailed bats (including *T. brasiliensis*) rarely fly low enough for capture. A single 3 meter net spread across the Cave Springs mine portal (with water pool inside) captured the most bats (129 total for all dates) as they were entering the mine in the evening to drink. Captures in all locations were dominated by *M. californicus* and *P. hesperus*. Mist netting occurred between late March and early October during periods of greatest bat activity and favorable weather. Cold nights or those with wind and/or rain were avoided. Evidence of reproduction (juveniles or reproductive females) was found in three species (*M. californicus*, *P. hesperus* and *A. pallidus*), while only male *C. townsendii* were captured (Table 7).

Table 7. All net capture records by species by date for all localities, including information on age, sex, and reproductive condition when known. Pr = Pregnant; Lc = lactating; Pl = post-lactating; Nl = nulliparous; M = male; F = female; Unk = unknown.

Species	Date	Locality	Adult Males	Adult Females					Juveniles		Unk	Total
				Pr	Lc	Pl	Nl	Unk	M	F		
Antrozous pallidus												
	1-Apr-11	Bitter Spring	2	2								4
	4-May-11	Bitter Spring	2	5	1							8
	31-May-11	Bitter Spring			1		1					2
	22-Jul-11	Bitter Spring	1			2			2	1	1	7
	5-Sep-11	Bitter Spring	1									1
	28-Jun-12	Bitter Spring					1					1
	23-Jul-11	Panther Spring	2		1	1						4
		Subtotal	**8**	**7**	**3**	**3**	**2**	**0**	**2**	**1**	**1**	**27**
Corynorhinus townsendii												
	3-Jun-11	Panther Spring	1									1
	21-Jul-11	Cave Spring	1									1
	6-Sep-11	No Name Spring	1									1
		Subtotal	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**
Lasiurus cinereus												
	1-Apr-11	Bitter Spring					3	1				4
		Subtotal	**0**	**0**	**0**	**0**	**3**	**1**	**0**	**0**	**0**	**4**
Myotis californicus												
	4-May-11	Bitter Spring	2		3							5
	31-May-11	Bitter Spring	1									1
	22-Jul-11	Bitter Spring	1		1							2
	5-Sep-11	Bitter Spring	1									1
	2-Apr-12	Bitter Spring	2					4				6
	28-Jun-12	Bitter Spring	4		4	1	1				2	12
	27-Aug-12	Bitter Spring	3			2						5
	21-Jul-11	Cave Spring	6		10				1		2	19
	24-Jul-11	Cave Spring	1		3						2	6
	3-Sep-11	Cave Spring	6									6
	7-Sep-11	Cave Spring	3			2						5
	3-Oct-11	Cave Spring	2			2						4
	25-Jun-12	Cave Spring	27		6		3					36
	28-Aug-12	Cave Spring	5			2		1				8
	27-Jun-12	Desert King Spring	1		1		1					3
	6-Sep-11	No Name Spring	1			4	1				1	7
	29-Jun-12	No Name Spring	1			1					1	3
	3-Jun-11	Panther Spring		2	7							9
	19-Jul-11	Panther Spring	2		1							3
	20-Jul-11	Panther Spring	1		2							3
	23-Jul-11	Panther Spring	2		4				1	1		8
	30-Mar-12	Panther Spring						1				1
	24-Jun-12	Panther Spring	1		8		3					12
		Subtotal	**73**	**2**	**50**	**14**	**9**	**6**	**2**	**1**	**8**	**165**
Parastrellus hesperus												
	3-May-07	Bitter Spring	3		1							4
	30-May-07	Bitter Spring	6			1					1	8
	21-Jul-07	Bitter Spring	13		3				1		3	20
	4-Sep-07	Bitter Spring	7			3					1	11
	27-Jun-08	Bitter Spring	2		3							5
	26-Aug-08	Bitter Spring	8			1						9
	20-Jul-07	Cave Spring	4		32							36
	23-Jul-07	Cave Spring			1						1	2
	2-Sep-07	Cave Spring						1				1
	24-Jun-08	Cave Spring	1									1
	27-Aug-08	Cave Spring	1			2			1			4
	26-Jun-08	Desert King Spring	4		1							5
	5-Sep-07	No Name Spring	3			1				1		5
	28-Jun-08	No Name Spring	2			1					2	5
	2-Jun-07	Panther Spring	1									1
	18-Jul-07	Panther Spring			4						1	5
	19-Jul-07	Panther Spring	3		3				1			7
	22-Jul-07	Panther Spring	1		2				1	2		6
	1-Sep-07	Panther Spring						1		1		2
	29-Mar-08	Panther Spring	1					2				3
	23-Jun-08	Panther Spring	2		4							6
		Subtotal	**62**	**0**	**54**	**9**	**0**	**4**	**4**	**4**	**9**	**146**
Tadarida brasiliensis												
	3-May-07	Bitter Spring	3				1					4
		Subtotal	**3**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**4**
	TOTALS		**149**	**9**	**107**	**26**	**15**	**11**	**8**	**6**	**18**	**349**

During the current survey, some of the locations that were available during the previous survey were now not included in the geographic scope or were off-limits (Goldstone, Leach Spring, Two Springs and Hellwind Canyon). However, mist-netting data and acoustic identifications from 1993-94 were available for Desert King, Garlic, Cave and Bitter Springs (Table 8). New locations for mist-netting and acoustic data were No Name and Panther Springs.

Table 8. Numbers of individuals of each species captured by mist-netting in earlier studies (1993-2005),

Locality	Date	Net Hours	*Anpa*	*Coto*	*Laci*	*Myca*	*Pahe*	*Tabr*	TOTAL
Bitter Spring	18-Apr-93	3.0							0
	17-May-05	7.5	1				1		2
Cave Spring	19-Jun-93	2.25				2	56		58
	27-Mar-94	3.0				15	15		30
Desert King Spring	1-Aug-93	1.8							0
Garlic Spring	19-Apr-93	3.0							0
	2-Aug-93	1.0							0
	TOTALS		**1**	**0**	**0**	**17**	**72**	**0**	**90**

Mine Roosts:

Three general mine areas in Ft. Irwin were surveyed for bats (Tables 9,10,11). All of these mines had been previously inventoried for bats during either the 1993-94 surveys of the NTC (Brown 1994), or for the Eastern or Western Expansions in 2005-06. Four bat species (*M. californicus*, *P. hesperus*, *A. pallidus* and *C. townsendii*) were using these mines as day or night roosts, although no large colonies were discovered.

The nineteen Avawatz and Granite Mountain mine features (Table 9) resurveyed in the main NTC area were selected because they had evidence of bats in 1993-94 and/or they were accessible to the current training areas. None of the mines had received bat compatible closures, although this had been a recommendation in the 1993-94 report to prevent troops from entering hazardous mines and disturbing the bats and other wildlife, such as owls, living in them. There appeared to have been no overt disturbance to the mines, and the amount of bat activity was similar to that noted during the prior inventory.

The Desert King Mine, located about 2.5 km NW of Desert King Springs, would seem an ideal location for roosting bats (Figure 9). The upper and lower adits are connected and allow for airflow and a variety of temperatures. Because no road goes to the mine, the amount of human disturbance is minimal. However, very few bats appear to use the mine as determined by internal surveys and warm season exit surveys, and this has not changed between1993-94 and the present survey. During the current surveys, the Desert King Mine was entered on three occasions, and an evening exit survey was conducted also on June 2011. In January 1994 and December 2010 and 2011, only one hibernating *M. californicus* was observed during each visit in the lower adit, although more could have been hidden in crevices and inaccessible areas of the mine (up raises and down winzes). In August 1993, a male *C. townsendii* was captured in the mine during the day, and in June 2011 a *M. californicus* exited the mine after dark. No *C. townsendii* were observed during the current survey.

The mines visited in the Avawatz Mountains (Table 9) in the vicinity of Goat Mountain are more human accessible due to their close proximity to roads. Troops are currently ordered not to enter mines, and the amount of human trash in the mines has declined since 1993. Bats were observed diurnally roosting in Avawatz 15, 16, 18, and 21 (Crackerjack) in the warm season and/or cold season. The number of bats appears to have increased slightly since 1993-94, with the exception of Avawatz 18, which had 3 hibernating *C. townsendii* in January 1994, and none in December 2011. The adit entrance to this mine is now almost eroded closed, and this could have affected the airflow that is important for winter hibernation. Avawatz 7 was not visited at night during this survey, but large piles of fresh pallid bat guano during a daytime visit attest to its continued use as a night roost (Figure 10a&b). No vertical shafts were entered during the current survey, but diurnal observations revealed barn owls roosting in at least six shafts. A bobcat and two kittens were flushed from Avawatz 4, and fresh desert tortoise scat was observed outside Avawatz 16.

Mines in the Western Expansion were originally surveyed from June 2005 through January 2006. Some of the more complex mines in which bats or guano were discovered had been recommended for bat compatible closures. The most important of these mines that had received some closure treatment were resurveyed in December 2011, June 2012 or August 2012 (Table 10). Guano and no bats had been observed in the Victor Mine in 2005 and 2006, and after gate installation there is very little fresh guano. The Uncle Sam Mine has about the same amount of bat activity both pre and post gating. The Montana Mine had been one of the more important complexes in 2005-2006, and was used by *C. townsendii* in winter and summer and a family of burrowing owls. PUF closures of the stopes (Figure 11) have removed the burrowing owl habitat and bisected the shaft and adit, so that there is no airflow in the system. The mine is no longer a *C. townsendii* hibernaculum, and only one *Myotis* exited during the warm season from the adit and none from the shaft. Burrowing owls are not present now. The Belmont Mine had 3 cupolas installed, and one of these has hazardous erosion around the footing (Figure 12). None of the "owl or bat compatible" aluminum grates that were placed over several shafts (Figure 13) west of the Goldstone Mine, (including Goldstone 32 where a family of burrowing owls was observed in August 2005) are currently being used by bats or owls. The main Goldstone Mine 43 had cupolas installed on the main shaft and a shallow adjacent feature (Figures 14a), but missed installing a bat-compatible closure on a dangerous stope (Figure 14b) on the edge of the waste rock dump. No exit flights were done at this location due to high winds on the night of the survey. Contrary to Dr. Brown's 2006 recommendations, Goldstone 42 had a massive cupola installed on two shallow features (with currently one resident *C. townsendii*), while the main declined adit 42A previously used by bats (Figure 14c) received a vertical metal culvert with bars laid across it that is not compatible with bat use (and no bats were observed entering or exiting in an evening survey).

The Eastern Expansion Mines (Table 11) were originally surveyed between May 2006 and May 2006. The more complex adits were visited in December 2011. Red Pass adits 7 and 9a had been gated and contain pallid bat guano indicative of night roosting behavior. Crackerjack 14 has also been gated (Figure 15) and no hibernating bats were found during the diurnal survey. The vertical shafts with cupolas (Red Pass 12 and Crackerjack 15 and 16) were not entered.

Table 9. Bat surveys, conducted 1993-2012, for mines located in the Granite and Avawatz Mountains on Fort Irwin, including survey notes and recommendations.

Name	Number	Easting	Northing	Type	Opening (WxH, Ft)	Depth (meters)	Bat Survey Dates	Bat Survey Notes	Recommendation
GRANITE MTNS									
Desert King	lower	524201	3931037	adit	4x4 ft	>430m	8/1/93 1/29/94 12/8/10 6/2/11 12/18/11	1 male COTO during day 1 MYCA hibernating 1 MYCA hibernating 1 MYCA exited 1 MYCA hibernating	Gate
Desert King	upper	524152	3931061	adit	5x4	190m	8/1/93 1/29/94 12/8/10 6/2/11 12/18/11	1 male MYCA during day no bats seen during day 1 MYCA hibernating 1 MYCA entered after dark I MYCA flying during day	Gate
AVAWATZ MTNS.									
Avawatz	3	549154	3930342	adit	6x7	17 m plus winze	6/19/93 7/24/11	no bat sign (didn't enter winze) need vertical survey of winze	Gate
Avawatz	4	549078	3930332	decline	3x1	17 m	6/19/93 7/24/11	dead woodrat bobcat adult and 2 kittens	no action
Avawatz	7	548908	3930126	adit	5x6	100m	6/19/93 7/24/11	ANPA and MYCA night roost; striped skunk ANPA and COTO guano	Gate
Avawatz	12	549931	3929333	shaft	8x8	10m	6/20/93 9/7/11	dangerous since next to road barn owl	now fenced, could exclude and close
Avawatz	13	549985	3929328	shaft	5x6	30 m	6/20/93 9/7/11	3 barn owls and nest w 7 eggs (entered) not entered	Needs fence or cupola, near road
Avawatz	15	5499736	3929396	adit	4x5	35m	6/20/93 9/3/11 12/15/11 6/25/12	no bats seen male MYCA cluster 3 MYCA torpid no bats seen	Gate
Avawatz	16	549659	3929360	adit/shaft	4x5	78m	6/20/93 1/29/94 9/3/11 12/15/11 6/25/12	*Myotis* guano MYCA hibernating *Myotis* and COTO guano, fresh tortoise scat outside hibernating COTO and MYCA no bats seen	gate
Avawatz	17	549653	3929406	shaft	12x10	20m	6/20/93 9/3/11	not entered not entered	now fenced, could exclude and close
Avawatz	18	549428 549413	3929600 3929621	shaft adit	12x12 1x1	27m 145m	6/20/93 1/29/94 9/3/11 12/15/11 6/25/12	adit and shaft connected 1 each male MYCA and COTO 1 torpid MYCA and 3 COTO 1 COTO 1 torpid MYCA , barn owl no bats seen	cupola
Avawatz	19	549257	3929709	adit	2x1	33m	6/20/93 9/3/11	no bats seen no bats seen	
Avawatz	20	549819	3930023	adit	6x5	15m	6/20/93 9/7/11	no bats seen,woodrat no bats seen	
Crackerjack	21	549407 549431	3930627 3930611	shaft adit	 6x7	>20m 35m	6/20/93 connected 1/29/94 9/7/11 12/15/11 6/25/12	owl nest beyond winze torpid MYCA 2 owls exited shaft 2 torpid COTO 1 active PAHE	shaft:cupola adit:gate
Crackerjack	22	549420	3930596	shaft	5x6	10m	6/20/93 9/7/11	 barn owl	fence or exclude and close
Crackerjack	23	549486	3930512	adit	3x3	33m	6/20/93 9/7/11	woodrat, no bat sign woodrat, no bat sign	no action
Crackerjack	24	549721	3930860	shaft	6x6	20m	6/20/93 9/7/11	family barn owls owl flew out during day	fence or exclude and close
Crackerjack	50	549085	3930227	shaft	8x12	~33m	7/24/11	at least 2 barn owls during day	Fence, need exit survey
Cave Springs		551499	3933044	adit	3x4	10m	6/20/93 6/1/11	water pool, night roosting male Myca 1 male COTO and 2 male MYCA in mine after dark MYCA and PAHE enter mine every night to roost and drink	

Table 10. Bat surveys, conducted 2005-2011, for mines located in Western Expansion of Fort Irwin, including survey notes and recommendations.

Name	Number	Easting	Northing	Orientation	Opening Size (Ft)	Depth/ length (m)	Bat Survey	Bat Survey notes	Recommendations	Closure Actions
Montana Gold Min	09	513553	3899012	Adit	3.5 x 3.3	6m	6/25/05 6/26/12	No bat sign, burrowing owl at portal No burrowing owl	no action	metal culvert gate
Montana Gold Min	10	513551	3899356	Adit/5shafts	6.5 x 4.5	~ 50m to collapse	6/25/05; 8/19/05 1/28/06 6/26/12	Evening exit survey on windy night=3 Coto exit. Myotis and Coto guano. Burrowing owl family in stope. Entered and found torpid Coto just before collapsed area in first adit. 1 Myotis exited from adit, none from shaft. Foaming had closed features that created airflow. No burrowing owls	bat protection (gate and fence	Adit gated, shaft #5 cupola, all other openings foamed.
Belmont Mine	16	508821	3904593	Hor/Vert	4 x 5	>70	8/16/05 8/30/12	Coto and Myotis exited, shaft connects to decline; pair of burrowing owls in mine No exit count conducted	Bat gate on decline; close small shaft	erosion outside decline foundation has created dangerous hole outside.
Uncle Sam Mine	19	509748	3904896	Adit	3 x 5	95m	8/16/2005; 1/27/06	#19 & 20 connect. Portals unstable. Exit survey Coto and Myotis entered and exited; no bats seen 1/27/06	would be difficult to gate, may need exclusion and backfill	
Uncle Sam Mine	20	509737	3904909	Adit	5 x 6		8/16/2005; 1/27/06 8/30/12	Coto exited #20 and another seen in # 19 after that. Myotis in and out of both portals.	would be difficult to gate, may need exclusion and backfill	19 and 20 gated 2007-2008
Unnamed	32	507196	3906633	Shaft	12 x 20	17	8/18/05 6/30/12	burrowing owls present No owls	exclude any animals, then fill.	Aluminum grate over mine that is NOT owl or bat compatible
Unnamed	33	507108	3906757	Shaft			6/21/05 6/30/12	Coto exited No surveys done	? Bat protection	Cupola installed
Unnamed	34a	507071	3906817	Shaft	10x15	20	8/18/05 6/30/12	Exit Survey, no bats	exclude any animals, then fill.	Has been hard closed
Unnamed	34b	507071	3906817	Shaft	30 x 20	>35	8/18/05 6/30/12	At least 3 barn owls, possible nest	?fence for owls or exlude and then close	Has been hard closed
Unnamed	42	508876	3906017	Hor/Vert	15 x 5	various	6/22/05 6/30/12	5 portals, 2 are connected. No bat sign on entry 1 Coto exited	exclude any animals, then fill.	Massive cupola over two shallow features
Unnamed	42A			adit	2x5	55	6/22/2005;1/27/06 6/30/12	Myotis guano; 1/27 Myotis flying in mine after dark and rock wren perching. No bats exited; cupola on closure is NOT bat friendly, bars not removable for entry	?Bat Gate	Non bat friendly culvert with angle iron laid across
Goldstone Mine	43	508006	3906271	Shaft	4 x 6	>200	6/22; 8/18/05 6/30/12	Main shaft, no bats exited	possible bat-compatibleclosure	cupola intalled on main shaft 2007-2008
Goldstone Mine	43a			Shaft	10x10	90	6/22/05; 8/18/05; 1/27/06 6/30/12	8/18 Coto exited out of stope on south side of dump; 1/27 no bats. Too windy for exit survey. Stope is still open, and needs bat cumpatible closure		cupola was put on shafllow feature to west of main shaft
Victor Gold Mine	47	511545	3906390	Decline	3 x 4	70	6/22/2005; 1/27/06 12/19/11	Coto and Myotis guano; no bats on 1/27. No bats or fresh guano	?Bat compatible closure	Gated 2007-2008

Table 11. Bat surveys, conducted 2005-2011, for mines located in Eastern Expansion of Fort Irwin, including survey notes and recommendations.

Name	Number	Easting	Northing	Type	Opening (WxH, Ft)	Depth (m)	Bat Survey Dates	Bat Survey Notes	Recommendation 2005	Action Taken
Silver Lakes	2	562933	3917732	Adit	3x3	10	5/19/05 12/16/11	ANPA Night Roost ANPA guano	No action or Bat Gate	none
Red Pass	7	564707	3909625	Adit	4x5	10	5/16; 5/19/2005 12/17/11	ANPA Night Roost ANPA guano	Bat Gate	Gated
Red Pass	9a	564571	3908898	Adit	5x5	15	5/16/05 12/17/11	*Myotis* sp. and ANPA guano *Myotis* sp. and ANPA guano	No Action or Gate	Gated
Red Pass	12	564707	3908412	Shaft	15x6	>25'	5/16/05 5/16/06 12/17/11	Possible Habitat No bats emerged at night	Another warm season survey, then exclusion before closure, not in winter	Cupola installed
Crackerjack	13	564079	3907729	Adit	5x2	UNK	5/17; 5/19/2005 5/16/06 12/17/11	Possible Habitat No bats emerged at night	Another warm season survey, then exclusion before closure, not in winter	closed
Crackerjack	14	564112	3907675	Adit	6x6	230	5/17; 5/19/05; 1/26/06 5/16/06 12/17/11	COTO, ANPA and *Myotis* sp. guano COTO in mine during day No bats observed during day	Bat Gate	Gated
Crackerjack	15	564202	3907611	Shaft	7x4	>30	5/17; 5/19/05; 1/26/06 12/17/11	Connects to 14; *Myotis* guano	Cupola	Cupola installed
Crackerjack	16	564248	3907707	Shaft	8x8	>30	5/17; 5/19/2005 5/16/06 12/17/11	Possible Habitat 1 COTO; I barn owl emerged	Another warm season survey, then exclusion before closure, not in winter	Cupola installed

DISCUSSION

From a combination of mist netting, roost surveys, and long-term acoustic monitoring, the bat assemblage observed on the NTC Range includes seven species. Two (*L. blossevillii* and *L. cinereus*) are regional or long distance migrant species netted or detected acoustically on a few nights largely consistent with spring or fall migration passage. While the timing and continental scale dimension of lasiurine (*Lasiurus* sp.) migrations have been described (Cryan 2003), little is known at the regional level of movement corridors and numbers. This is a particular concern in the context of wind power development siting, since these are among species most frequently killed by turbines (Arnett et al. 2008, Baerwald and Barclay 2009)

There is both capture and acoustic evidence of substantial aggregated movements of lasiurines (*e.g.* Vaughan 1953, Johnson et al. 2011), but whether most of these bats move in large or small groups or individually is unknown. A benefit of the long-term, continuous acoustic monitoring in this study is to recognize season-to-season recurrence of some migrants, indicating that these isolated observations can accumulate to form an interpretable pattern.

Acoustic activity data from NTC for a third, far more common species, *T. brasiliensis*, shows substantial seasonal variation, while at some spring sites activity continues throughout the year. Both movements and limited banding returns show this species is a migrant in areas of California (Leitner 2005) consistent with extensive migration in the mid-continent (Glass 1982). It seasonally occupies and vacates very large aggregated roosts in the Central Valley and is significant among mortalities in Sacramento Delta wind turbine monitoring (Johnston et al. 2010). Molossids do not hibernate, so winter habitats for California *T. brasiliensis* are known or presumed to be in climatically moderate sites along the coast or at lower elevations and latitudes inland where there is some winter insect availability. Some California *T. brasiliensis* populations have been described as non-migratory, but with limited mark and recapture studies in a highly mobile species, it is an assumption that the same animals are present in winter and summer.

The other NTC bat species (Table 3) are viewed as resident, though nightly foraging movement scale could be 10 km or more, based on radio-tracking studies elsewhere for some of the species. Mist netting and, in more detail, NTC acoustic activity plots (Appendix II) show that activity falls to low levels for most species from October through February or March. Prior winter netting surveys at other southwestern U.S arid lands spring or riparian sites have obtained similar results with some bat activity persisting, at least at dusk, on nights with even subfreezing temperatures (O'Farrell and Bradley 1970, Geluso 2007). While flying insect activity is generally positively correlated with air temperature, observations in those studies indicated bats were continuing to forage as well as to drink.

The bats at NTC display a range of foraging styles that are adaptively linked to their echolocation call structure, wing and ear shape, and other aspects of morphology, including overall body size and dentition. A key factor in habitat use and prey selection is a bat species' ability to detect and maneuver to capture prey on or close to habitat structure (rocks, plant branches, water surface). Bats are receiving echoes from their calls from both prey and objects around them while one or often both are moving. Schnitzler and Kalko (2001) offered a widely used bat foraging style classification based on clutter tolerance, *i.e.,* how close bats will hunt to complex surfaces. Among NTC species, the two long-eared bats, *C. townsendii* and *A. pallidus* are gleaners that can take prey off surfaces, and may recognize and take prey even when it is not moving. They can also take and detect insects in flight. The remaining species are all pursuit predators of flying insects, though the smaller species (*M. californicus*, *P. hesperus*) and the somewhat larger *L. blossevillii,* often hunt in close proximity to vegetation that is moving in the wind. The remaining detected species (*L. cinereus* and *T. brasiliensis*) have long narrow wings and are encountered flying rapidly in more open settings. *L. cinereus* is often observed flying regular routes along drainage channels or rows of trees where present. The foraging space of *T. brasiliensis* extends upward from a few meters above ground to at least 1 km. Detectors on kites, radar and other techniques have demonstrated in Texas that they hunt migrant moths seasonally transported nightly in low level wind jets at approximately 500 m above ground (McCracken et al. 2008). *E. perotis*, detected in prior NTC studies, is an even larger, less maneuverable, open space forager that generally feeds on large insects. Much less is known about this species.

Foraging habitat, foraging range, prey type, roost requirements, and use of surface water resources all relate to patterns of species activity observed at the NTC sites sampled. The natural history of the species observed and, more briefly, others that may be encountered in future studies, is included in the following descriptions.

Category 1: Common bats

California myotis (*Myotis californicus*)

Natural History: This small myotis is ubiquitous in most habitats in the Southwest below about 2,000 m elevation (Barbour and Davis 1969; Krutzsch1954; Simpson 1993). *M. californicus* are recorded in the driest habitats where they forage in the open for small moths and mosquitoes. They roost singly or in small groups in crevices in rocks, mines, trees and manmade structures. *M. californicus* sometimes are visible during internal mine surveys, but usually they are hidden in crevices, emerging at dusk.

Morphological and Acoustic Characteristics: Only slightly larger than *P. hesperus,* this tiny bat is more uniform in color without a distinct dark face and ears and has very small feet (Figure 16).

M. californicus echolocation calls are steep FM sweeps with characteristic frequencies of 43 to 52 kHz, most commonly above 45 kHz (Appendix I [Figure I-F]). In low clutter the calls sometimes display a range of different features (slight curvature, an obvious flat toe on the bottom, etc.), but for typical bats foraging near vegetation calls appear as dense strings of simple linear down sweeps The M50 filter recognizes linear down-sweeps with characteristic frequencies that include calls of two nominal 50 kHz *Myotis* (*M. californicus*, and *Myotis yumanensis*), but *M. yumanensis* has not been detected on the NTC (see account below). As discussed earlier in Results (and below under *P. hesperus*) the filter may recognize also some similarly linear high clutter *P. hesperus* calls. With bats at high density at small spring pools (e.g., the access portal to Cave Spring), *P. hesperus* calls converge on characteristics of *Myotis*, so a small fraction of the M50 activity assigned to *M. californicus* could be from *P. Hesperus*.

Capture and Acoustic Results from this Study: Solitary bats were found roosting in the Desert King Mine in winter and summer, as well as Avawatz 15, 16, 18 and 21. The greatest number of bats found at one time were three individuals clustered near the portal in Avawatz 15 on December 15, 2011. During the current survey at NTC, *M. californicus* was the most frequently captured species in mist nets in all locations (Table 6). At Cave Spring on June 19,1993, only one *M. californicus* was captured with 56 *P. hesperus* (Table 8), while on June 25, 2012 only one *P. hesperus* was captured with 36 *M. californicus* (most were males).

In acoustic surveys, *M. californicus* (M50 or Myca) showed the highest activity in total minutes among species at all sites (Figure 7). Though observed activity was strongly seasonal (lowest October-February) this species was recorded every night at most sites, even in mid winter (Appendix II), except for the two rocky slope short-term sites near Granite Pass (Table 5). These were some distance from surface water and had no bat detections on several cool season nights (Oct, Dec, Mar, Apr).

Canyon Bat (*Parastrellus hesperus*):

Natural History: This common species is the smallest of all North American bats, and is often associated with rocky canyons and outcrops (usually at elevations below 2,000 m), where roosts are in small crevices (Stager 1943, Cross 1965), sometimes within mines and caves. Females give birth to single young or twins in late May through June, and mothers with their young may roost alone or in groups of fewer than 10 individuals. The juveniles are volant within a month. These small bats can be observed at dusk flying over creosote bush scrub several miles from rocky areas, and they may roost under rocks or in rodent burrows. *P. hesperus* emerge early in the evening, often before sunset, and may be active after sunrise. Near rocky canyons, their small fluttery forms can fill the sky in the fading desert light. They are often the first bats captured in the evening in mist nets set over isolated desert water holes (O'Farrell and Bradley 1970) or across mine entrances as they enter to roost at night. Stomach content analysis suggests that they feed on mosquitoes and small swarming insects such as flying ants (Hayward and Cross 1979). During cooler winter months, *P. hesperus* hibernate in rock crevices (sometimes in mines), although on warm winter days, they may emerge to forage during the day.

Morphological and Acoustic Characteristics: *P. hesperus* is the smallest bat in North America and can be distinguished from the almost equally small *M. californicus* by the club-shaped tragus, compared to the pointed tragus of *Myotis* (Barbour and Davis, 1969) (Figure 17). It also has a conspicuous black mask and black ears.

Low clutter *P. hesperus* calls have low minimum slopes and relatively high characteristic frequency (42-49 kHz). When multiple *P, hesperus* are calling, this range can widen further. Sequences are often long and have a uniform baseline (see Appendix I [Figure I-J]). Some low clutter sequences are almost flat while others have a hooked or reverse J form similar to those produced by *L. blossevillii*, but more uniform in pulse-to-pulse shape and characteristic frequency. As discussed below in the *L.blossevillii* account, *P. hesperus* social call groups can be very similar to that species. As discussed in Results, in structural clutter or when multiple bats are interacting acoustically, *P. hesperus* calls decrease in duration, increase in frequency range and slope and may become steep almost linear FM sweeps, similar to *M. californicus* calls. Under these high activity conditions, using filter screening, a small proportion of *P. hesperus* activity may be assigned to *M. californicus*.

Capture and Acoustic Results from this Study: In the current survey, *P. hesperus* were captured in mist nets at all of the netting locations, and were second to *M. californicus* in terms of number of bats captured (Table 6). They were usually the first bat species captured in the evening. As noted previously, reversal of capture ratios between the two species at Cave Springs occurred between June 1993 and 2012.

The typical distinctive open air echolocation signals were recorded in all acoustic sampling locations. In total minutes of activity and nights with activity at long-term spring sites (Figures 7&8), *P. hesperus* was only exceeded by *M. californicus*. At the North Sewage Pond, the number of nights with activity by *T. brasiliensis* slightly exceeded those values for the two smaller more ubiquitous species. Patterns of seasonality for *P. hesperus* acoustic activity are similar to *M. californicus.* At the Granite Pass sites (away from water) no activity was detected on several cool to cold season nights. (Table 5).

Mexican free-tailed bat (*Tadarida brasiliensis*)

Natural History: *T. brasiliensis* forms maternity colonies of up to several million in some caves in Texas, but in California, with the exception of one population of about 250,000 (in a lava cave in northern California), most colonies in California range in size from a few hundred to a few thousand. Although some populations migrate large distances (*e.g.*, Texas populations over-winter in Mexico), seasonal movement patterns and population structure within California are poorly understood. Free-tailed bats can enter torpor during cold weather, but do not hibernate.

T. brasiliensis are crevice or cavity dwellers, and can fit in cracks smaller than one inch wide. While this species roosts in a number of natural features (rock crevices, caves, and abandoned swallow nests), it is also the species most often found in man-made structures, including buildings, bridges, and mines (Barbour and Davis 1969, Wilkins 1989). Colonies also appear to be more mobile than many bat species, apparently displaying less loyalty to particular roost sites, with the exception of major maternity sites which are occupied year to year.

Mexican free-tailed bats can forage over large areas each night, ranging as far as 25 miles from their roosts. *T. brasiliensis* are aerial foragers, and feed on a wide variety of flying insects (Whitaker et. al. 1996).,including a variety of agricultural pests, such as the corn earworm moth (*Heliothis zea*) (McCracken 1996), and the codling moth (*Cydia pomonella* L.) (Hogan 2000). Year-round diet studies conducted at Lemoore Naval Air Station showed that this species foraged primarily over cotton fields and other agricultural areas, and included flies, moths, true bugs (mostly plant hoppers) and beetles in their diet (Johnston 1998).

Morphological and Acoustic Characteristics: As their common name implies, the tail of *T. brasiliensis* extends beyond the interfemoral membrane that joins the hind legs. Their ears are rounded, and are not joined at the middle of the head (Figure 18). They have long narrow wings that enable them to fly rapidly over relatively great distances, and are less maneuverable than most other bat species.

Acoustically, *T. brasiliensis* often appears to be one of the most ubiquitous bat species, in part due to their loud, low frequency echolocation signals that are detectable over large distances. Calls of this species cover a wide frequency range and are highly varied in shape. In open air flight, *T. brasiliensis* often emits long, almost constant frequency (CF) signals with characteristic frequencies between 20 and 28 kHz,sometimes rising to near 30 kHz. Between 20-24 kHz these can be diagnostic (Appendix I [Figure I-H]). Below 20 kHz *L. cinereus* may produce similar calls, while *Lasionycteris noctivagans* (silver haired bat) can produce similar flat calls at 25 kHz. In physical clutter or interaction, *T. brasiliensis* also produces a diverse array of steeper frequency modulated (FM) calls extending to higher frequencies that can be difficult to distinguish from *Eptesicus fuscus* (big brown bat), *L.noctivagans*, *A. pallidus* and *L. cinereus* sequences. In this analysis a filter identifying flat low frequency *T.brasiliensis* signals yielded moderate numbers of candidate files that were visually screened, particularly for sequences with characteristics suggesting that they were *L. cinereus*. No sequence files were detected by filter or observed that could be identified as *E. fuscus* or *L.noctivagans.* After identifying *A. pallidus* sequences by filter and visual screening, the larger set of files that were selected by the generalized Q25 filter (FM sweeps with characteristic frequencies from 24 to 35 kHz) were examined to find any remaining visually identifiable sequences of other species. The remaining calls were then labeled as Q25. These presumptive *T.brasiliensis* were combined with the flat low frequency filter data set to obtain the activity index data used in the summaries.

Capture and Acoustic Results from this Study: On December 9, 2010, we accompanied Liana Aker of the NTC Environmental Branch to Building # 855 in the Cantonment area, where roosting *T. brasiliensis* and their guano were an issue. We observed one bat roosting under a sign on the outside of the building, but no bats emerged from the main structure. We provided suggestions for excluding bats from the building. No other roosts of this species were identified.

With their long narrow wings, they are less maneuverable than *M. californicus* and *P. hesperus* and require a larger water surface area to dip for drinking (such as the sewage ponds). Therefore, it was surprising when four *T. brasiliensis* (3 males and a non-reproductive female) were captured in succession in the mist nets at Bitter Springs on May 4, 2011 (Table 7).

T. brasiliensis was recorded at all long-term sites, but not at either Devouge or No Name Spring among the four short-term sites. This difference is seemingly not just low sampling effort at all these sites since *T. brasiliensis* was detected on multiple nights throughout the project at the short-term Granite Pass sites. Among long-term sites, the highest total minutes of activity for *T. brasiliensis* was at the North Sewage Pond (Figure 7), consistent with the expectation that the large water source would be an attractant. Total active times at all other sites are considerably lower (*e.g.*, Garlic Spring, the next highest is 7x less). Other than the Sewage Pond, activity is temporally dispersed at the sites with lower total minutes as a few detections/night across the study interval. Consequently, despite the large difference in total minutes of activity, Garlic Spring had 253 nights with some activity while the Sewage had 292(Figure 8). *T. brasiliensis* activity data for NTC spring sites show localized activity peaks of varied duration, (*e.g*,ca 8/10/1and 7/4/12 at Garlic Spring, 3/25/12 at North Sewage Pond), but while these might be migration events another cause can be *T. brasiliensis* foraging on brief concentrated aquatic or terrestrial insect emergences (Rainey, pers. obs.).

Category 2: Relatively common near appropriate habitat, but not ubiquitous.

Pallid bat (*Antrozous pallidus*):

Natural History: In California, Orr (1954) described the species as occurring in a variety of habitats, including coniferous forests, oak woodlands, brushy terrain, rocky canyons, open farmland, and desert. Roosts are apparently selected on the basis of temperature and proximity to foraging habitat. Radio-tracking studies in the Mojave Desert at Camp Cady near Barstow have demonstrated that the bats roost in crevices in granite boulders, between rocks in loosely-cemented conglomerate and in mud solution tubes in badlands formations (Brown and Berry 1998). In another telemetry study near Coso Hot Springs on NAWS China Lake, the *A. pallidus* roosted in historic buildings, mines and rock crevices in granite boulders (Brown, pers. obs). Boulder and crevices throughout the NTC provide excellent day-roosting habitat, while night-roosting in the mines is a common occurrence as bats congregate for socialization (Lewis 1994).

The relatively powerful jaws of *A. pallidus* are essential to disable their prey, which include scorpions, solpugids, beetles, grasshoppers, cicadas, katydids and sphinx moths (Barbour and Davis1969, Hermanson and O'Shea 1983) captured on or near the ground. Radio-telemetry (Brown and Grinnell 1980, P. Brown pers. obs.) and the known behavior of favored prey items suggest *A. pallidus* fly close to the ground, and land on the ground to capture prey. This species apparently locates prey primarily by listening (Bell 1982), although they use echolocation to navigate and assess habitat. Between foraging bouts, *A. pallidus* congregate in night roosts in mines, buildings and under bridges where they leave guano and the remains of scorpions, katydids, sphinx moths, Jerusalem crickets, and/or beetles.

With sufficient moonlight, pallid bats can navigate visually, use prey-produced sounds to hunt (Bell 1982), and may not emit echolocation signals. Therefore, it is potentially difficult to estimate the relative abundance of this species only by acoustic methods.

Morphological and Acoustic Characteristics:

A. pallidus is one of the larger California species, and is distinguished from all others in that size range by the combination of several characteristics: long ears, blonde fur, a pig-like snout, and a skunky odor (Figure 19).

The communication sounds (Brown 1976, Orr 1954) of *A. pallidus* are convenient signals for acoustic identification because they are distinctive, loud and of low (audible) frequencies that propagate farther. These calls, however, are typically not numerous in extended acoustic records unless the detector is located close to a roost. Echolocation calls are nearly linear down-sweeps with characteristic frequencies between 23 and 33 kHz. These can resemble calls from several other species, particularly *E. fuscus*, and *L. noctivagans* in clutter.

Two filters, one for communication calls, the other for echolocation pulses (Appendix I [Figure I-A]) were applied to the data sets to identify candidate calls for review. On the NTC, *T.brasiliensis* is the only other species that sometimes produces similar calls recognized by the filter. Though these features are not incorporated by current filter criteria, many *A.pallidus* sequences are visually recognizable by several small regular changes in slope replicated in each call. Combined outputs from the qualitatively screened file selections of the two filters were used to calculate activity indices.

Capture and Acoustic Results from this Study: Although no *A. pallidus* were found using mines as day roosts in this survey, large amounts of their distinctive guano and associated insect remains were discovered in Avawatz #7 (Figure 10b), and in the Eastern Expansion mines (Silver Lake 2, Red Pass 7 and 9A and Crackerjack 14). *A. pallidus*, including reproductive females and juveniles, were captured regularly in netting at Bitter Spring (Table 7). Rocky habitat is several km away, and the bats here could be roosting in cavities in the soil. A telemetry study conducted here could yield valuable data on roosting habitat. This species was also captured at Panther Spring on July 23, 2011, in an area with abundant crevices in granite boulders.

A. pallidus was detected at all long and short term acoustic sites. The highest counts of nights with this species present were Cave (260), Bitter (237), and Panther (177) Spring (Figure 8). The maximum count of total minutes was 1305 at Bitter Spring, and inspection of the temporal plot for this site shows considerably more activity during the same months in 2011 than 2012 (Appendix II). This is not a general pattern and other sites vary distinctively, *e.g.*, Cave Spring is markedly seasonal with minimal activity through the cooler months. Panther Spring in contrast has relatively constant activity through the entire study interval.

Townsend's big-eared bat (*Corynorhinus townsendii*):

Natural History: The determining factor in the distribution of this species in the Western United States tends to be the availability of cave-like roosting habitat (Pierson 1998). Population concentrations occur in areas with substantial surface exposures of cavity forming rock (e.g., limestone, sandstone, gypsum or volcanic) and in old mining districts (Genter 1986, Graham 1966, Perkins et al. 1994, Perkins and Levesque 1987). From the perspective of many bat species, old mines are cave habitat and are now sheltering many large colonies (Tuttle and Taylor 1994, Altenbach and Pierson 1995; Brown *et al*. 1992 &1993).

The proximity of good foraging habitat appears to be a determining factor in roost selection. In recent surveys in the Panamint Mountains, mines with suitable temperatures were occupied by large maternity colonies (>100 bats) only if they were within 2 miles (3.2 km.) of a canyon with water (P. Brown, pers. obs.). Brown et al. (1994) determined by radio-telemetry that this species on Santa Cruz Island bypassed lush introduced vegetation near their day roost, and traveled up to 3 miles (4.8 km.) to feed in native oak and ironwood forest. Although the diet of California populations of *C. townsendii* has not been analyzed, elsewhere this species is a lepidopteran specialist, feeding primarily (>90% of the diet) on medium sized moths (Dalton et al. 1986, Ross 1967, Sample and Whitmore 1993, Whitaker et al. 1981 &1997, Shoemaker and Lacki 1993).

This sensitive species has declined in numbers across the western United States, as documented in the Conservation Assessment and Strategy (Pierson et al. 1999) prepared by scientists and land managers for the Idaho Conservation Effort. The Western Bat Working Group rates *Corynorhinus* at high risk of imperilment across its range, and the species has been recently proposed for listing in California by the Center for Biological Diversity. Studies conducted by Pierson and Rainey (1996b) for the California Department of Fish and Game showed marked population declines for this subspecies in many areas of California, and they proposed that Townsend's big-eared bats be recommended for threatened status in the state. Although several causative factors are identified, roost disturbance or destruction appears to be the most important reason for the decline. In another report, Pierson (1998) suggested that a combination of restrictive roost requirements and intolerance to roost disturbance or destruction has been primarily responsible for population declines of Townsend's big-eared bats in most areas.

The tendency for this species to roost in highly visible clusters on open surfaces near roost entrances makes them particularly vulnerable to disturbance. Additionally, low reproductive potential and high roost fidelity increase the risks for the species. In all but two of 38 documented cases, roost loss in California was directly linked to human activity (e.g., demolition, renewed mining, entrance closure, human-induced fire, renovation, or roost disturbance; Pierson and Rainey 1996b). Human entry into caves and mines in California provides one explanation for why most otherwise suitable and/or historically significant roosts are currently unoccupied. Townsend's big-eared bats are so sensitive to human disturbance that a single entry into a maternity roost can cause a colony to abandon or move to an alternate roost (Graham 1966, Stihler and Hall 1993). The installation of bat-compatible gates on mines can protect the bats and exclude humans from hazardous mines. This is especially important in areas where there is the potential for troops to visit mines adjacent to training areas.

Morphological and Acoustic Characteristics: *C.townsendii* can be distinguished from all other California species by the combination of several characteristics: very long ears and horse-shoe shaped lumps surrounding the nostrils, hence the alternate common name of "lump-nosed bat"(Figure 20). When torpid or hibernating, they roll their ears like ram's horns.

During foraging *C. townsendii* typically uses low intensity echolocation calls. There is general recognition that cavity roost surveys are preferable to acoustic monitoring for determining the presence of this species. However, both typical and social *C. townsendii* echolocation calls have two harmonics (often of similar intensity) and are relatively distinctive when recorded (Appendix I [Figure I-B]). The first harmonic is a steep down-sweep with a characteristic frequency of about 30 kHz and may extend down to 20 kHz. Presumptive social calls have a short upward hook or other variation at around 40 kHz in the beginning of the first harmonic down-sweep. The lower frequency of the first harmonic contributes to a larger detection radius and is the call portion more often retained in the NTC data.

Capture and Acoustic Results from this Study: On the NTC, solitary and presumably male *C. townsendii* and/or the distinctive guano have been found in a number of mine features (Tables 9,10,11), although no maternity colonies have been located. In mist net surveys during this project three single adult males were caught at Bitter, Cave and No Name Springs (Table 7).

Among the long-term sites, *C. townsendii* was detected acoustically at Cave, Garlic, Panther and Bitter Springs (in declining rank order of nights with activity; Figure 8). Cave Spring offers an underground refuge with reliable access to water in which we captured a single night-roosting male. At Garlic Spring, multiple nights with detections throughout the survey interval also suggest a roost in the vicinity (Appendix II, Garlic Spring). Adjacent slopes to that site appear, like Bitter Spring, to be largely soil mantled, so a rocky site refuge may be some distance (perhaps km) away. Among the four short-term acoustic sites, this species was only detected at No Name Spring. Detections there on three nights across the intermittent surveys, plus a mist-net capture, suggest another roost in the vicinity.

Category 3: Occurrence sporadic with restrictive roosting requirements.

Hoary bat (*Lasiurus cinereus*):

Natural History: This solitary tree-roosting species is easily identified in flight visually and is relatively distinctive acoustically depending on other species at the study location. The lasiurine bats are unique among North American species in giving birth to litters of more than two young (Barbour and Davis 1969; Shump and Shump 1982b). Hoary and red bats migrate seasonally over large distances latitudinally but also altitudinally, (Grinnell 1918, Krutzsch 1948, Cryan 2003) and are often the species most frequently killed at wind farms. For southern California most records are from the fall, winter and spring (Grinnell 1918, Vaughan and Krutzsch 1954). While rare in the summer in southern California, males and non-reproductive females are relatively common in the Sierra Nevada and parts of northern California (Rainey and Pierson 1996a; Pierson and Rainey 2009). Long-term acoustic monitoring and, rarely, visual observation show spring and fall aggregated migration pulses (Vaughan 1953, Rainey et al. 2006, Johnson et al. 2011). In April 2012, birdwatchers near Bishop, California observed multiple hoary bats in different locations, flying during the day (James Wilson, pers. comm.).

Morphological and Acoustic Characteristics:

L. cinereus is a large bat with long narrow wings, and very distinctive coloration: frosted fur over most of its body, with golden fur around the face (Figure 21). The interfemoral membrane and the underside of the wing are furred.

L. cinereus echolocation calls include a very wide range of frequencies and shapes (see repertoire plot in O'Farrell et al. 2000). They resemble other members of the genus *Lasiurus*, but extend lower in frequency than other North American species. As noted earlier in discussion of *T. brasiliensis*, the most distinctive *L. cinereus* calls at the NTC are low clutter, often nearly flat calls with characteristic frequencies at 16-18.5 kHz (Appendix I [Figure I-D]). Some of these were detected by filter and their occurrence matches expectations of passage of scattered spring and fall migrants. These calls are audible to people who retain high frequency hearing sensitivity.

Like other bats *L. cinereus* calls increase in frequency and slope and decrease in duration near physical clutter, in prey pursuit, or interactions with other bats..In moderate clutter, their calls retain the typical lasiurine features of changing the characteristic frequency in an irregular manner from pulse to pulse and having a hook at the bottom of each call. *L. cinereus* sequences may extend to characteristic frequencies above 30 kHz but become nearly linear down-sweeps. *L. blossevillii* calls are above this range.

Capture and Acoustic Results from this Study: On April 1, 2011, four hoary bats (3 females and one escaped) were captured in mist nets at Bitter Spring within a short time span, suggesting a migratory flock (Table 7). Similar nettiing efforts there on April 2, 2012 failed to capture this species. Hoary bats have been mist netted in the spring and fall at Salt Creek just northeast of the NTC boundaries (P. Brown, pers. obs). At NTC, all acoustic detections were in the warmer months (April through November). Some activity occurred at all long-term sites, but was highest at Garlic and Bitter Springs and the Sewage Pond (Figure 7,8). Among the short term sites, there was only a single detection at Granite Pass West in Sept 2012.

Unexpectedly, some higher frequency NTC lasiurine sequences match yellow bat (*Lasiurus xanthinus*) known calls. These include calls that show low slope at characteristic frequencies of 25 kHz, with other pulses in the sequence rising to characteristic frequencies above 35 kHz. An example sequence is included in Appendix I (Figure I-E). This species was not expected based on area distribution records and current range maps, although recent records indicate it has been expanding its range in southern California (Constantine 1998). It is usually associated with palms, where it will roost in the untrimmed skirts. Palm trees have been planted in the Cantonment area, but do not occur on the ranges. Limited samples of known calls and frequency overlap with high *L. cinereus* calls makes species discrimination more difficult. We did not confirm the presence of *L. xanthinus* by capture. We considered capture or extensive further call comparison to be preferred before positing a substantial range extension, Thus most lasiurine sequences in the 25-35 kHz range are for now labeled and plotted as *L. cinereus*, although some of this small total could be *L. xanthinus*.

Red bat (*Lasiurus blossevillii*):

Natural History: This is a foliage roosting species that has been historically associated with sycamore and cottonwood riparian ecosystems (Shump and Shump 1982a). It has become rare in California in the remnant Central Valley riparian and forest regions, which historically had the highest concentration of reproductive females (Pierson et al. 2000). It is currently a CDFG Species of Concern. Under the Lower Colorado River Multi-Species Conservation Plan (LCR MSCP, 2004) of the Bureau of Land Management, cottonwood and willow revegetation plots in former agricultural fields are now attracting red bats and hoary bats (Calvert 2010). This species is an open air forager that feeds primarily on moths. Radio-tracking studies conducted in northern California documented distances of 10 km between roosting and foraging areas. In that study, roost areas were in sheltered, tree-filled settings (native vegetation and mature walnut orchard), and foraging took place over agricultural fields and wetlands (Pierson et al. 2011). Museum and capture records suggest that there is a seasonal segregation of the sexes throughout much of California, with females confined to lower, warmer elevations, and males in the lower to mid-elevations of the mountainous areas. Like *L. cinereus*, this is a migratory species. Records for the desert regions of California are rare. The closest physical record to NTC is for an animal found on October 21, 1991 at Furnace Creek in Death Valley National Park to the north (Constantine 1998).

Morphological and Acoustic Characteristics: Similar in natural history and habits to the hoary bat, this species is visually and often acoustically distinctive (Corben pers. comm.).

L. blossevillii is morphologically similar to the other lasiurine confirmed on the NTC (*L. cinereus*) in having long wings and fur on the interfemoral membrane and the underside of the wing. It is smaller than *L. cinereus* and can be easily distinguished from all other California species by its red fur (Figure 22).

L. blossevillii echolocation sequences, like those of *L. cinereus*, have the distinctive features of the genus. Calls in moderate clutter usually each have a distinct hook at the bottom, and their characteristic frequency jumps irregularly up and down rather than following a smooth trend. Characteristic frequency ranges from 35-50 kHz, but is sometimes higher. Extended sequences of *L. blossevillii* echolocation signals are distinctive (Appendix I [figure I-C]), but brief sequences of a few pulses are far more common. In locations without *P. hesperus*, these too are distinctive.

In *P. hesperus* sequences there are occasionally clusters of a hooked or reverse J-shaped social pulses with an irregular frequency baseline below their normal echolocation calls. These may fall in the *L. blossevillii* characteristic frequency range and resemble short sequences from that species. When canyon bats are common, more abundant social calls resulting from interaction. This can make *L. blossevilli* recognition more difficult, since current filters cannot separate these call types.

Capture and Acoustic Results from this Study:

No red bats were captured or visually observed during the current survey. Counts of days and of minutes with *L. blossevillii* activity are the lowest of any of the species compared acoustically among sites (Figures 7 and 8). This species was detected at Bitter, Garlic and Panther Springs as well as the North Sewage Pond. The spring sites with activity all have substantial arborescent vegetation and both Garlic and Panther have cottonwoods, a normal roost tree for this species. The North Sewage Pond has a perimeter row of woody shrubs or small trees with other more developed tree plantings not far away in the Cantonment area. The tree windbreak at the golf area resembles the planted (tamarisk) windbreaks between San Joaquin agricultural fields that were once favored red bat collecting localities (Pierson et al. 2000). The seasonal pattern of these limited detections is largely consistent with spring and fall migration (Appendix II).

Western mastiff bat (*Eumops perotis*):

Natural History: Unlike most other North American bat species that mate in the fall, free-tailed bats breed in the spring and give birth to a single young in early to mid-summer, usually by early July (Krutzsch1955), with colonies generally containing fewer than 100 animals (Barbour and Davis 1969, Howell 1920). Adult males and females may roost together at all times of year (Krutzsch 1955) in contrast to most other North American bat species.

This crevice-dwelling species predominantly selects cliff faces (granite, sandstone, or columnar basalt) or exfoliating granite boulders (Dalquest 1946, Krutzsch 1955, Vaughan 1959), but also utilizes cracks in buildings (Howell 1920, Barbour and Davis 1969). All roosts located in California by Pierson and Rainey (1996a) are in crevices at least 3 m above the ground. The species appears to forage over open areas (Vaughan 1959, Pierson and Rainey 1996a), and many individuals have been heard feeding over agricultural fields in the Imperial Valley (P. Brown, pers. obs.).

These strong, fast fliers cover an extensive foraging area in an evening. The species has been heard in open desert, at least 15 miles from the nearest possible roosting site (Vaughan 1959). Often multiple animals are detected together, and this species may travel or forage in groups (E. Pierson, pers. comm, P. Brown pers. obs.). Unlike *T. brasiliensis* that undertake long seasonal migrations, *E. perotis* move relatively short distances seasonally. Although capable of lowering their body temperatures for short periods of time, they do not undergo prolonged hibernation, and may be periodically active throughout the winter. In Southern California, *E. perotis* have been detected at all seasons, although they may change roost sites (Howell 1920, Krutzsch 1948 &1955; Leitner 1966, Barbour and Davis 1969).

Morphological and Acoustic Characteristics: Western mastiff bats belong to the free-tail family Molossidae, and are the largest bat species found in North America (Figure 23). They have a two foot wingspan and large bonnet-like ears, which extend forward over the eyes and are connected at the midline (Barbour and Davis 1969, Best et al. 1996).

E. perotis emit a loud audible echolocation call readily detected by people with uncompromised hearing. *E. perotis* echolocation and social calls overlap in frequency and structure with some birds and rodents, but are distinctive among California bats. The characteristic frequency of low slope “cruising” calls is often around 7-8 khz though this value rises to 12 kHz with higher slope calls, Call duration is often around 20-30 milliseconds, but can increase to 50 ms.

Capture and Acoustic Results from This Study: During the previous surveys by P. Brown (1994) at Ft. Irwin, *E. perotis* were detected flying over Bitter Spring (4/18/93), Leach Spring (5/23/93) and Hellwind Canyon (3/28/94). The latter two localities were off-limits to visitation during the current surveys. However, no bats were heard during the longer periods of time spent mist-netting at Bitter Spring during the current survey. No acoustic records were obtained during the project, including in areas of suitable roosting habitat such as the boulder areas of Cave Spring, Panther and Desert King Springs and Granite Pass or at the North Sewage Pond, an accessible drinking site for such a large bat.

Category 4: May Occur but not Confirmed in this Study

Western yellow bat (*Lasiurus xanthinus*): This species was recently split from the southern yellow bat (*Lasiurus ega*) based on genetic characteristics (Kurta and Lehr, 1995; Baker *et al.*, 1988; Morales and Bickham, 1995). Both species roost in trees, with preference given to palm trees with intact skirts, although other reports describe use of hackberry and sycamore (Mumford and Zimmerman 1963) and yucca (Higginbotham et al., 2000). During a bat survey of the Bill Williams River (BWR) in western Arizona, Brown (1996) captured one juvenile and two adult male yellow bats near Planet Ranch in October. They were fitted with transmitters and tracked for the next week. One bat roosted for several days in cottonwood trees along the BWR as he headed towards the LCR. The last fix on this bat was from a palm grove at Gene Pumping Station. The other bat left the BWR, and was detected by airplane roosting in a palm tree in a residential area one mile NE of London Bridge (exact location confirmed from the ground). The third bat disappeared.

There is some evidence to support the hypothesis that this species has expanded its range northward in response to the planting of palms along the LCR, using the river as a corridor. Constantine (1966) collected the first yellow bat along the LCR at Yuma, with a subsequent specimen turned in for rabies testing in 1980 from Blythe (Constantine 1998). Recently, O'Farrell et al. (2004) studied a resident population in the palm groves of the upper Moapa Valley, where it was the second most abundant bat captured and acoustically detected. During the current Bureau of Reclamation surveys of bats in revegetation plots along the LCR, yellow bats have been captured regularly, however radio-telemetered bats captured while foraging in cottonwood riparian are tracked to roosts in palm trees (Calvert 2010 and pers.comm.).

Yellow bats may be present on the NTR either as a small resident population or as vagrants (see discussion in *L. cinereus* species account above). This puts them outside of their current known range in California. They may, however, be expanding their range northward in California as in Arizona (Constantine 1998). The signals recorded at Garlic Spring (Appendix I [FigureI-E]) may represent bats that are roosting in trees there or in nearby Cantonment area where palms and other trees have been extensively planted.

Since acoustic surveys were not conducted in the developed areas of the base, the presence of this species needs further confirmation.

Big brown bat (*Eptesicus fuscus*): This species occurs in most habitat types in all 48 contiguous United States (Barbour and Davis 1969, Kurta and Baker 1990). They roost in a diverse range of sites including mines, caves, rock outcrops, tree cavities, buildings, bridges and other manmade structures. Many of the moths and beetles they consume are agricultural and forest pests (Whitaker et al. 1997), making *E. fuscus* one of the most beneficial insectivorous bat species. They are found in mines close to the Lower Colorado River (Brown and Berry 2003), However, they have not been captured or detected acoustically on the NTC, and may require more extensive riparian or mesic vegetation habitat for foraging. *E. fuscus* echolocation calls are similar to some produced by both *T. brasiliensis* and *L. noctivagans.* As with other groups of similar species, higher slope calls produced in physical clutter or interaction with other bats converge in characteristics and can be indistinguishable. Distinctive low clutter *E. fuscus* search phase sequences include a series of quite similar calls with an abrupt change of slope between the steep higher frequency down-sweep and lower frequency segment with constant slope and a characteristic frequency at or above 25 kHz. No calls of this pattern were detected by filter or visual scan.

Yuma myotis (*Myotis yumanensis*): In desert areas, Yuma myotis are usually found near open fresh water. Yuma myotis are now one of the most common bats along most stretches of the LCR (both visually and acoustically), especially in the vicinity of water impoundments (Brown and Berry 2003). Foraging habitat is often near open water (Brigham et al. 1992). The bats usually fly low over the water feeding on emerging aquatic insects, often trawling them from the water surface. They can be viewed in this activity everywhere along the LCR (Brown and Berry 2003). The sewage ponds adjacent to NTC Cantonment provide suitable foraging habitat, but *M. yumanensis* were not observed foraging in a spotlight survey of the North Sewage Pond or observed with night vision or headlamp over seasonally extensive channel pools at Bitter Spring.

Echolocation calls of *M. yumanensis* and *M. californicus* are grouped as M50 --- steep frequency modulated calls with characteristic frequencies near 50 kHz. In clutter, which is typical over water or when multiple *Myotis* are foraging, these calls are nearly linear down-sweeps and the two species calls are usually not separable. Less common low clutter *M. yumanensis* search phase calls also vary considerably in form, but some have features distinct from *M. californicus* (e.g., lowered slope mid frequency segments) that allow acoustic identification. No calls attributable to *M. yumanensis* were observed during this survey.

Small-footed myotis (*Myotis ciliolabrum*): The small-footed myotis is a crevice and tree-dwelling species that forages early in the evening on a variety of small insects

(Bogan et al. 1998). An USFWS Species of Concern and BLM sensitive species, in California it is considered stable, but rare in the South Coast Ecoregion in the riparian and wooded habitats of the inland valleys, foothills, and mountains, although it may be losing habitat at the lower elevations of its range (Miner and Stokes 2003). *M. ciliolabrum* is commonly found in the Great Basin Desert of Nevada and Eastern California. It also occurs in the higher elevation mountains of the Mojave Desert (P. Brown pers. obs.), usually in pinyon juniper habitat associations above 2000 m. Reproductive females were mist-netted in a recent survey in Red Rock Canyon State Park in a riparian stretch of Last Chance Canyon (Brown 2009). The species has also been discovered roosting in mines on the Naval Weapons Station (NAWS), China Lake in an ecotone between Mojave and Great Basin Desert (Brown, pers obs.). Although not detected yet on NTC, there is a possibility that *M. ciliolabrum* could occur in areas of the base not surveyed, such as at higher elevations in the Avawatz Mountains or in the Granite Mountains in the northwest corner of NTC where it borders NAWS China Lake.

M. ciliolabrum is very similar to *M. californicus* in size and general appearance, but distinguishable in hand via subtle morphological differences (Bogan 1974), including an apparently longer nose and darker facial mask and ears. Their echolocation calls are similar steep down-sweeps. .*M. californicus* calls have a characteristic frequency of 43-52 kHz while this value for *M. ciliolabrum* is typically slightly above 40KHz, but ranges from 38-45 kHz (C. Corben, pers.comm.) Thus there is marginal overlap in acoustic characteristics as well. No calls attributable to this species were recorded during this survey.

Category 5: Rodents

White footed mice (*Peromyscus* sp.)

Studies of laboratory rodents (*Mus musculus* and *Rattus rattus*) showed long ago that audible vocalizations were evident in a variety of social contexts, but the development of ultrasound detection tools later demonstrated these animals also produced largely or entirely ultrasonic sounds, especially as isolation responses of young.

The audible vocalizations of some wild New World rodents, notably North American grasshopper mice (*Onychomys*) and Neotropical singing mice (*Scotinomys*) have been studied in the past, but the recent wide availability of handheld bat detectors and other ultrasound recording equipment has lead to recognition that at least some of the speciose array of *Peromyscus* produce loud upper audible or ultrasonic calls in both lab and unconfined natural settings.

The long-term passive monitors used in this project were configured to detect signals that primarily came from above the microphone, but analysis revealed relatively frequent long duration calls closely resembling those in literature descriptions of *Peromyscus* calls (Miller and Engstrom 2012). They report laboratory samples showing species specific call characteristics for both some *Peromyscus* and *Onychomys* species. Recht (1995) sampled small mammals on the NTC and trapped five species of *Peromyscus* (*P. boylii*, *P. crinitus*, *P. eremicus*, *P. maniculatus* and *P. truei*) and *Onychomys torridus*.

Miller and Engstom (2012) do not include all these *Peromyscus* species, so the call characteristics of some NTC species are currently unknown. The approach taken in this analysis was to treat all detections (both complete and long fragments) resembling *Peromyscus* calls as a single acoustic category. This aggregate class is plotted by long term site in Appendix II and summarized in counts in Figures 7 and 8 with an example call in Appendix I (Figure I-I).Temporal plots of *Peromyscus* vocalization activity are in general less seasonal than the more common bats across sites. Review and filter manipulation to detect long duration signals like the *Peromyscus* calls also found other less common vocalizations. One of these, a narrow band tone near 12 kHz with a duration of approximately one second (Appendix I [FigureI-J]), matches the description of calls of *O. torridus* (Hafner and Hafner 1979). The current acoustic monitoring hardware operation also allows, without labor-intensive, continuous trapping, some insight into the seasonal pattern of rodent activity.

ROOST SURVEYS

The most important goal of the current research was the installation and maintenance of long-term acoustic detection stations is areas of Ft. Irwin NTC as selected by the Environmental Branch biologist, and the analysis of the large data set collected. Mist-netting at the appropriate sites where the Anabat stations were installed was done in concert with maintenance checks and data download trips. A tertiary goal was to re-survey mine roosts that Dr. Brown had first visited on NTC in 1993-94 and on the Western and Eastern Expansion areas in 2005-2006. As noted in the results section, the current level of bat use was similar at the Desert King Mine and the Avawatz mines near Goat Mountain as was observed in 1993-94. However the road access to several of these mines has been improved in the past 20 years. Both for the protection of wildlife and the safety of the troops, bat compatible closures should be installed on these mines (Table 9). For Avawatz 18, a cupola should be installed on the shaft and a gated culvert installed on the connecting adit. The culvert is necessary to keep both entrances open to preserve airflow necessary for hibernation use. A removable locking bar in the bat closures will permit entry by biologists for periodic surveys.

Only winter surveys were conducted of the Eastern Expansion Mines (Table 11), and no bats were observed roosting in the horizontal features. However, these mines are lower in elevation and warmer than those in the Avawatz Mountains, and possibly too warm for hibernation. Bats could easily move to higher elevation mines in the Avawatz Mountains for the winter months. The closures that had been installed on the features visited were all bat compatible, and there is no evidence that military training is conducted in the vicinity of the mines with the possible exception of Red Pass 7 which is close to a main MSR.

Some closure types installed in the Western Expansion did not follow Dr. Brown's recommendations for wildlife closures (Table 10). During the 2005-2006 surveys, the airflow and open stopes (large mined areas extending to the surface) of the Montana Mine provided good habitat for a family of burrowing owls and bats. The foaming rather than fencing of the intermediate open stopes (Figure 11) severed the connections necessary for airflow and destroyed the owl access. The small vertical metal culvert installed in 42A inhibits bat and owl use (Figure 14c), as do the aluminum grates placed over the shafts west of the Goldstone Mine (Figure 13). Although the cupola installed at the Belmont Mine is wildlife compatible, the declined shaft has eroded open beyond the cupola concrete footing creating a human safety hazard (Figure 12). At this time, no military maneuvers occur in this area, but the general public could access the site from the south.

CONCLUSIONS

1. Seven bat species were documented occurring on the NTC during the current research. Six of these were captured in mist nets as well as acoustically detected, while western red bats were identified only through echolocation analysis.

2. In contrast to the 1993-94 surveys, no western mastiff bats were detected.

3. Four species were verified as using mines as roosts at some seasons, although no colonies were identified. No maternity colonies for Townsend's big-eared bats were observed.

4. Local reproduction was confirmed in three species (Canyon bats, California myotis and pallid bats) by the capture of reproductive females or juveniles.

5. The long term acoustic monitoring station with the most bat activity was Cave Spring, although all seven species were recorded at Bitter, Garlic and Panther Springs. Sites with more arborescent vegetation volume and structural development generally have higher activity for the less frequently detected species.

6. Canyon bats, California myotis and Mexican free-tailed bats are the most frequently recorded species based on the combined results for all stations, though activity for Mexican free-tailed bats varied widely among sites. Female hoary bat spring captures and low, recurring spring and fall detections in both study years of western red and hoary bats at most sites suggest low, but consistent migratory passage.

7. Rodent vocalizations (largely Peromyscus spp.) were detected at all sites and revealed substantial seasonal activity at most of the long term sites.

MANAGEMENT RECOMMENDATIONS AND FUTURE RESEARCH

1. Continue the maintenance and analysis of the data from the long-term acoustic stations on the NTC, along with documentation of any environmental change at the springs and in surrounding areas. In light of DOD agreements on collaborative development of renewable energy that now extend to extensive solar installations on Ft. Irwin, but may eventually include wind, baseline data on bat activity will have a role in environmental assessment. Tree roosting migrant western red and hoary bats probably are more abundant seasonally in the extensive established tree plantings in the Cantonment than in the generally small spring vegetation sites on the Range. This could be evaluated with fixed, long-term, solar powered detectors. The presence of western yellow bats may be confirmed by detectors placed in the Cantonment area.

2. Install wildlife- compatible closures on mines in the Avawatz Mountains near Goat Mountain, especially those close to roads. Monitor the effectiveness of the closures on bat populations.

3. Repair or replace the non-wildlife compatible closures on the Western Expansion, and monitor the effectiveness of these installations.

4. If water retention structures to increase wildlife water access are planned, they should incorporate escape ramps for bats and other small vertebrates accidentally immersed. This should be considered in renovation or new construction of open impoundments on or off the Range that have steep walls or slippery liners

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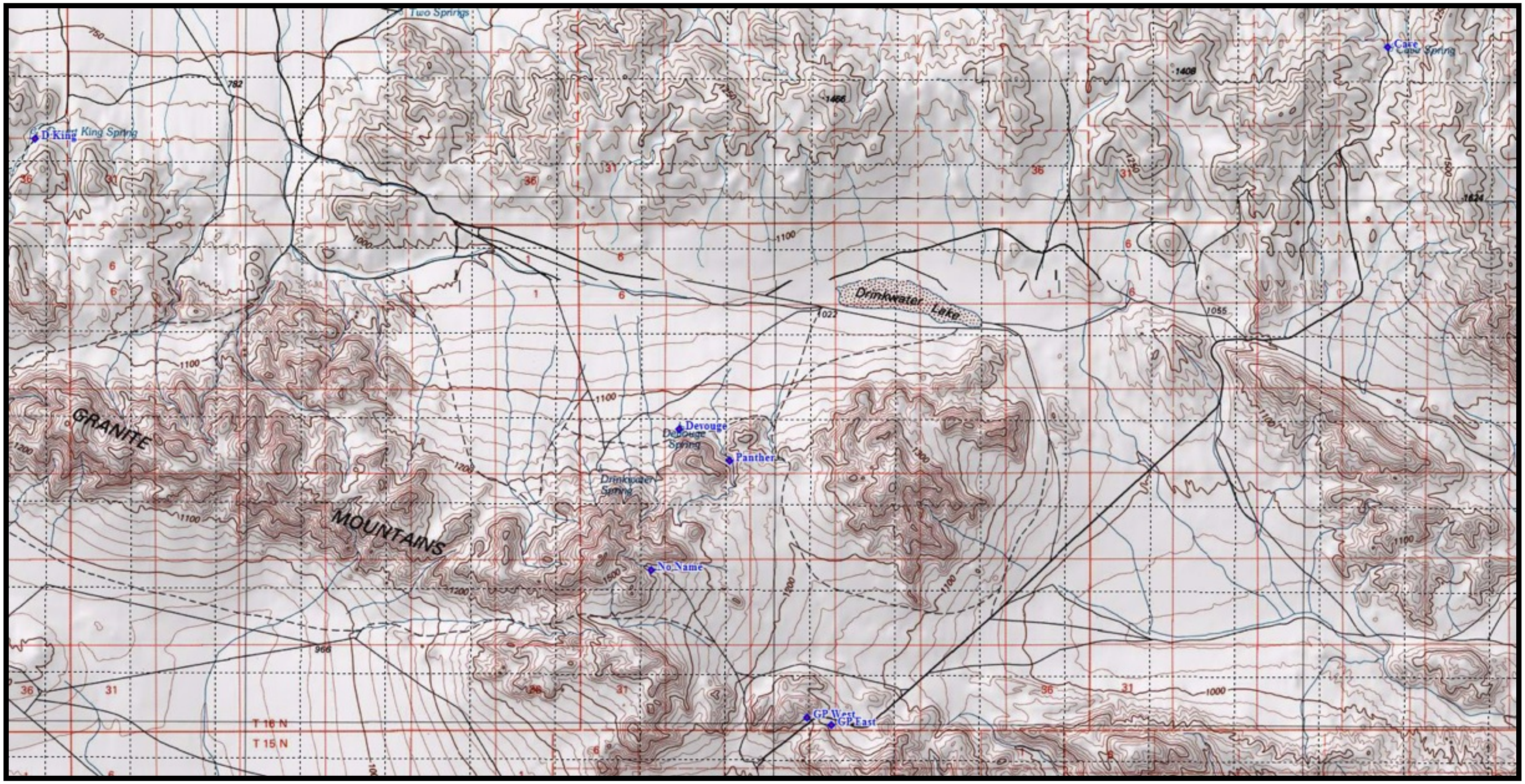


Figure 1a. Northern acoustic monitoring stations. Long term stations are Cave Spring, Panther Spring, and Desert King Spring. Additional locations with acoustic monitors deployed during site visits were Granite Pass West, Granite Pass East, No Name Spring and Devouge Spring.

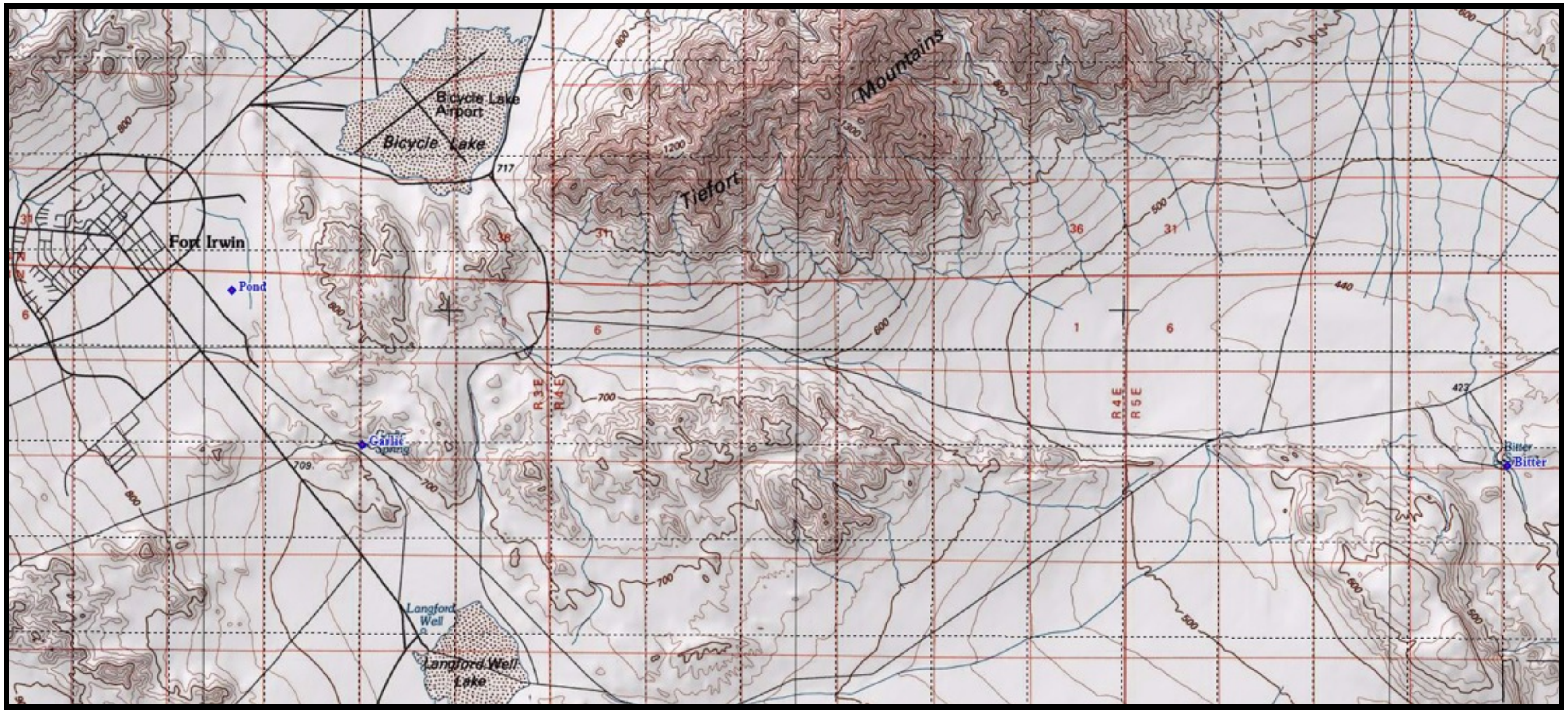


Figure 1b. Southern long term acoustic monitoring stations are North Sewage Pond, Garlic Spring, and Bitter Spring.

a.

b.

Figure 2a & b. Panther Spring, showing *M. californicus* drinking at pool.

c.

d.

Figure 2c & d. Figure 2c is of Cave Spring and Figure 2d is of Desert King Spring.

e.

f.

Figure 2e & f. Figure 2e shows Bitter Spring, and Figure 2F shows the Garlic Spring site.

g.

Figure 2g. Sewage Pond site.

a.

b.

Figure 3a & b. Figure 3a depicts the Granite Pass East site, and Figure 3b the Granite Pass West site.

c.

d.

Figure 3c & D. Figure 3c depicts the Devouge Spring site, and Figure 3d the site at No Name Spring.

a.

b.

Figure 4a&b. Photos of the long-term acoustic deployment systems.

Figure 5. A photo of a short-term acoustic deployment.

Figure 6. Mist-netting at Cave Spring, with *C. townsendii* (large ears) and *M. californicus* (smaller bats) flying near the net. There also is one *M. californicus* in the net.

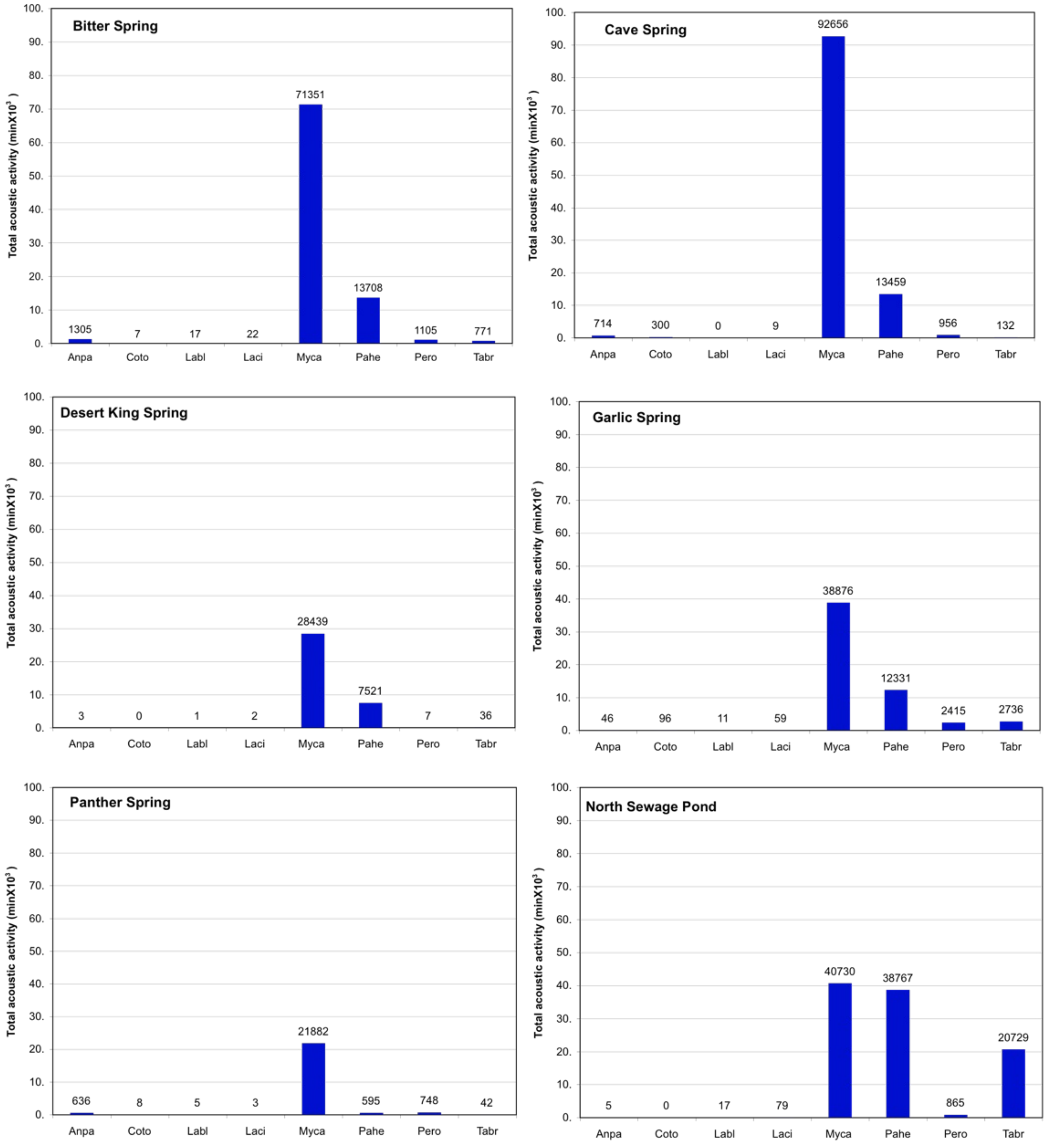


Figure 7. Counts for entire survey interval of minutes with acoustic activity by species.

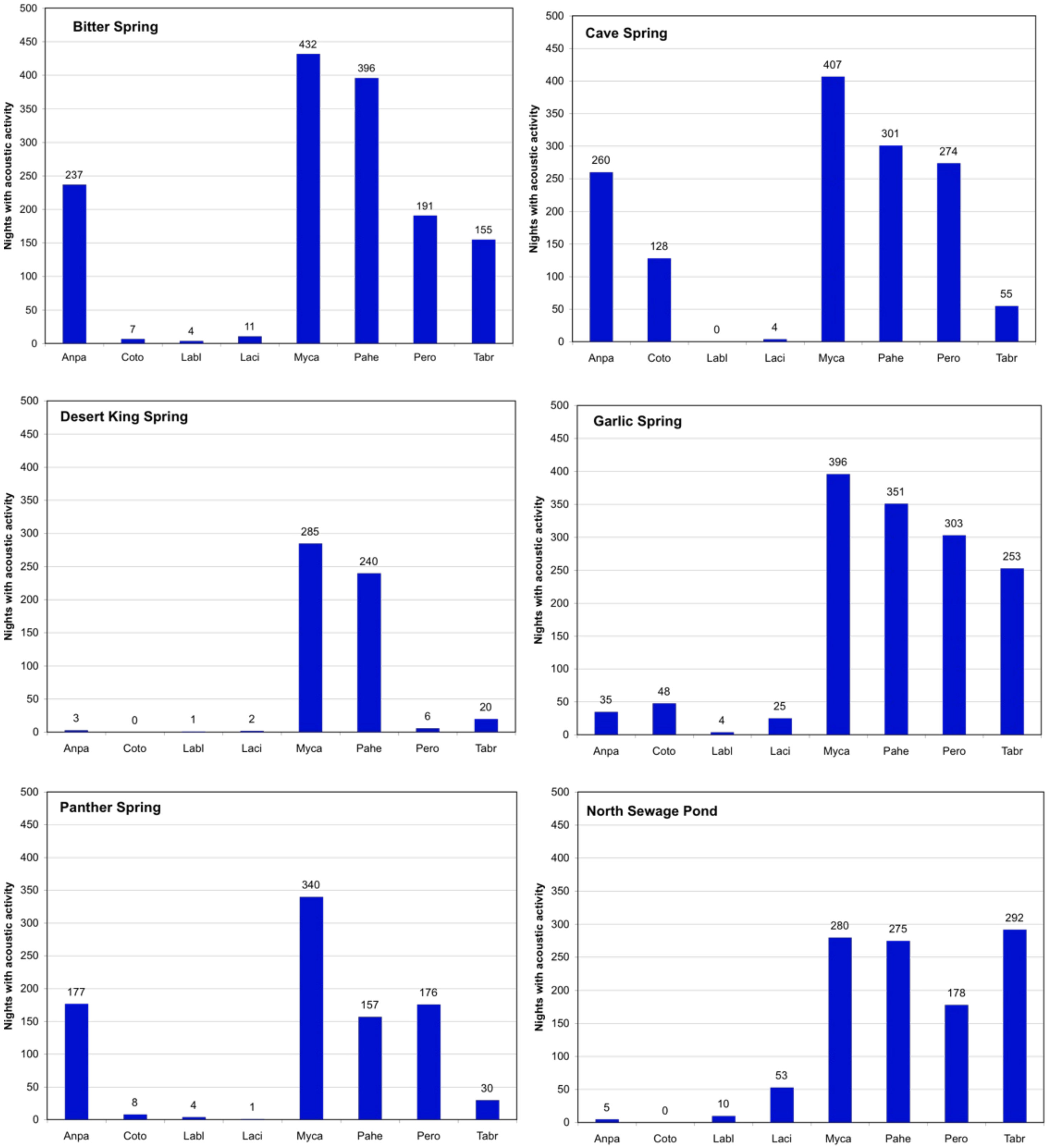


Figure 8. Counts for entire survey interval of nights with acoustic activity by species.

Figure 9. Desert King Mine showing the upper and lower adits which connect underground.

a. b.

Figure 10a&b. Figure 10a depicts the Avawatz 16 portal, and Figure 10b a deposit of pallid bat guano in Avawatz 7.

Figure 11. PUF closure of the Montana Mine.

Figure 12. Hazardous erosion at the Belmont Mine.

Figure 13. Aluminum grate on shaft west of the Goldstone Mine that is neither bat nor owl compatible.

a.

b.

c.

Figure 14a,b &c. Goldstone Mine. A cupola (a) and a dangerous stope (b) at main mine #43, and a vertical metal culvert (c) at Goldstone #42a that is not a bat compatible closure.

Figure 15. Bat compatible gate at Crackerjack 14 Mine.

Figure 16. *M. californicus* captured during this study at Panther Spring. Photo credit: W. Rainey.

Figure 17. *P. hesperus* captured during this study at Cave Spring. Photo credit: W. Rainey.

Figure 18. *T. brasiliensis* captured at Salt Creek, just northeast of Fort Irwin. Photo credit: Pat Brown.

Figure 19. A cluster of *A. pallidus* taken in a mine in the California desert. Photo credit: W. Rainey.

Figure 20. *C. townsendii* captured during this study at Cave Spring. Photo credit: W. Rainey.

Figure 21. *L. cinereus* captured during this study at Bitter Spring. Photo credit: W. Rainey.

Figure 22. *L. blossevillii*, captured by P. Brown on the Lower Colorado River. Photo credit: P. Brown.

Figure 23. Photo of *E. perotis* taken in Yosemite Valley, Yosemite National Park. Photo credit: W. Rainey

APPENDIX I. Examples of bat and rodent calls from study sites at Fort Irwin.

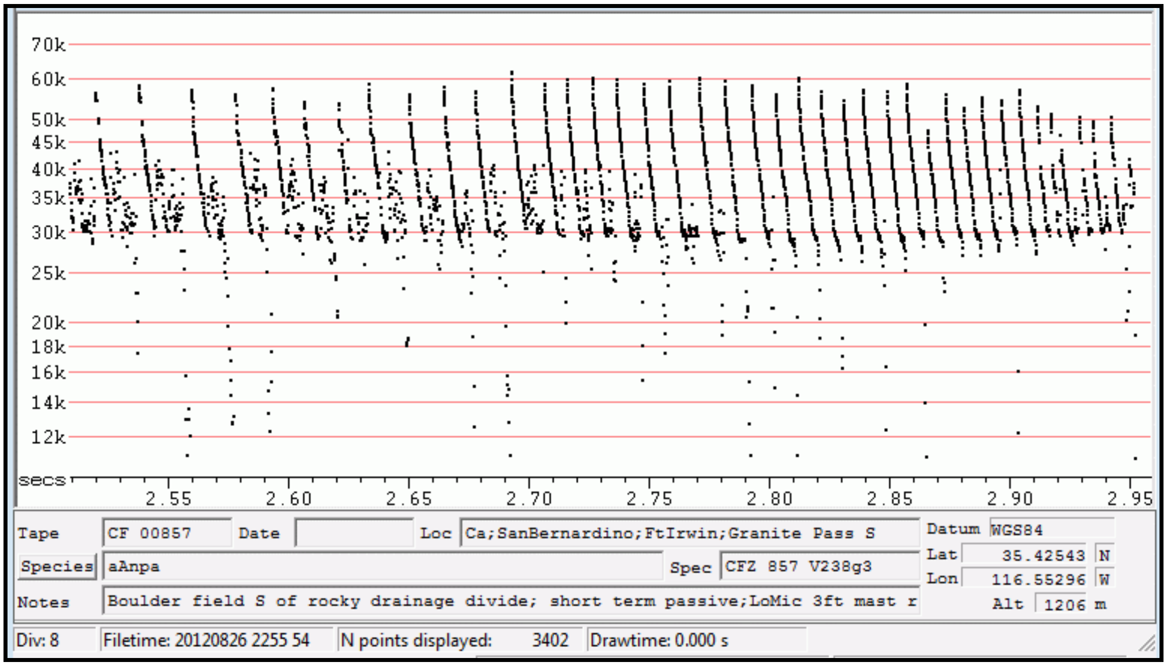


Figure I-A. *Antrozous pallidus* Pallid bat

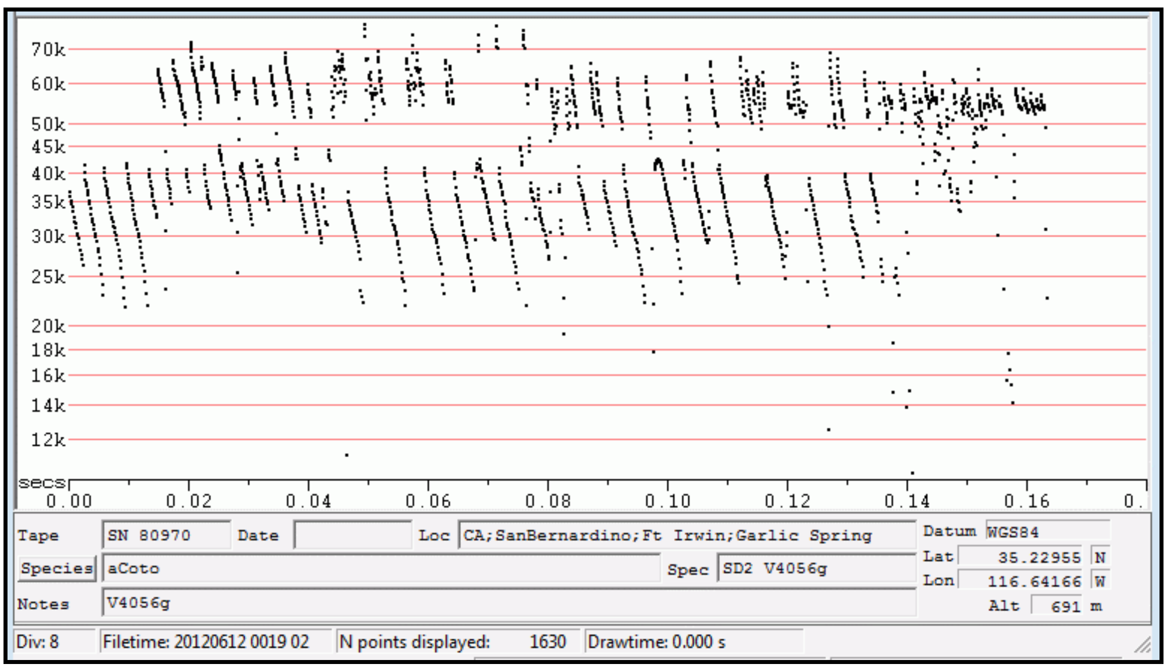


Figure I-B. *Corynorhinus townsendii* Townsend’s big eared bat

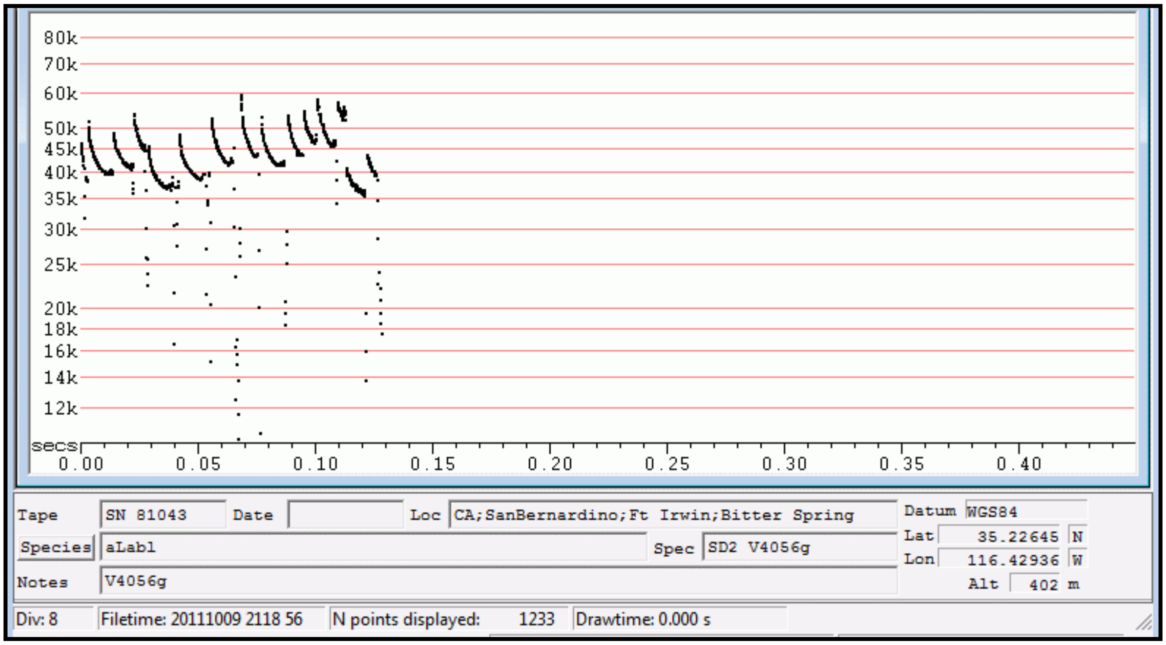


Figure I-C. *Lasiurus blossevillii* Western red bat

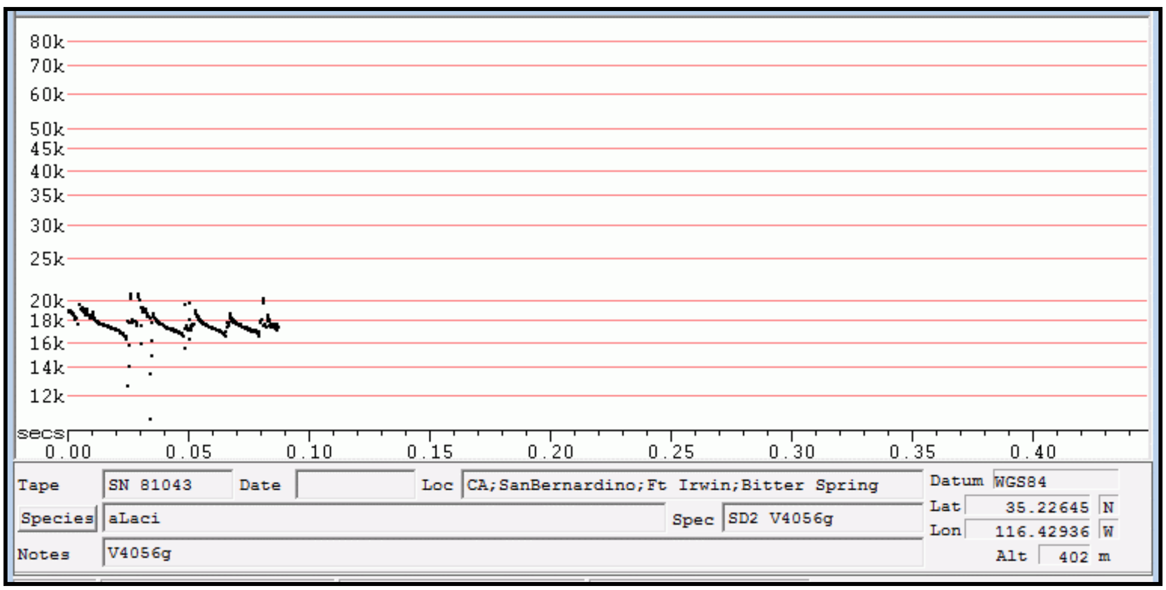


Figure I-D. *Lasiurus cinereus* Hoary bat

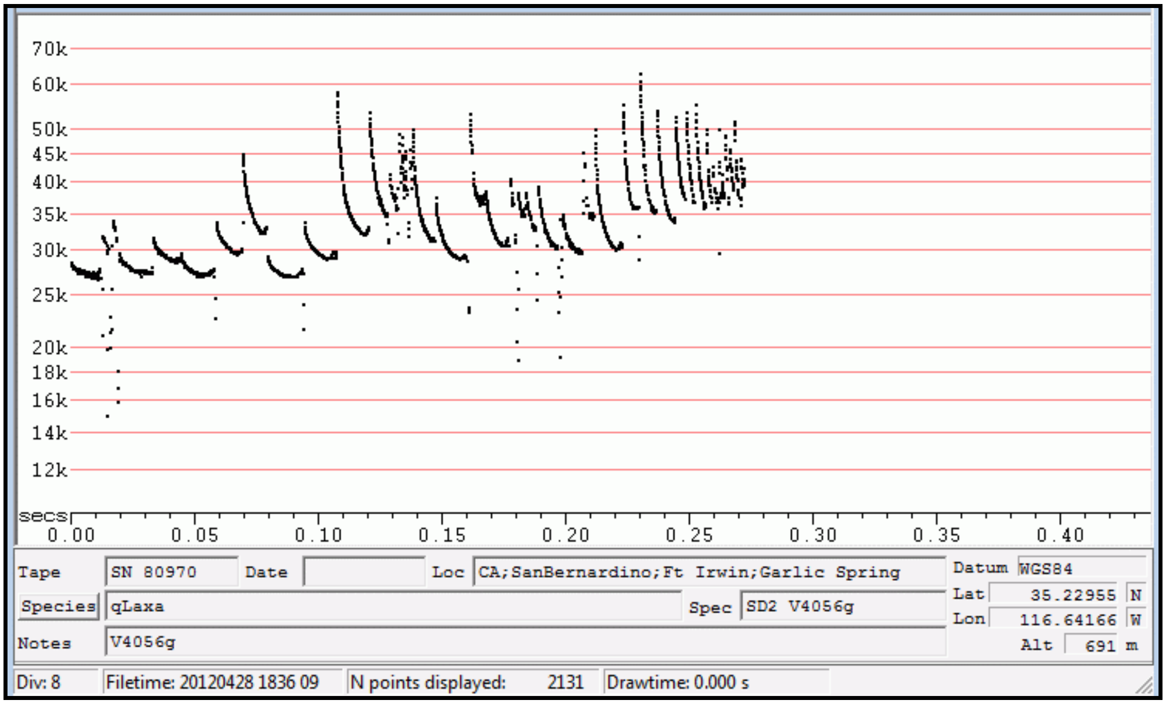


Figure I-E. probable *Lasiurus xanthinus* Yellow bat

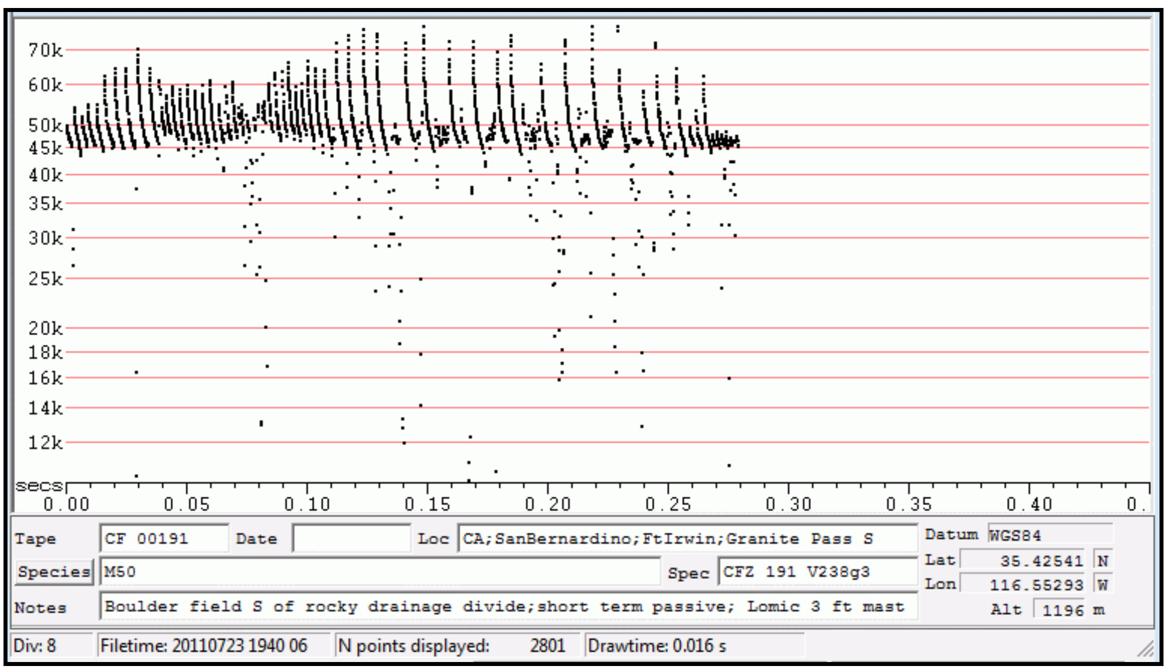


Figure I-F. *Myotis californicus* California myotis

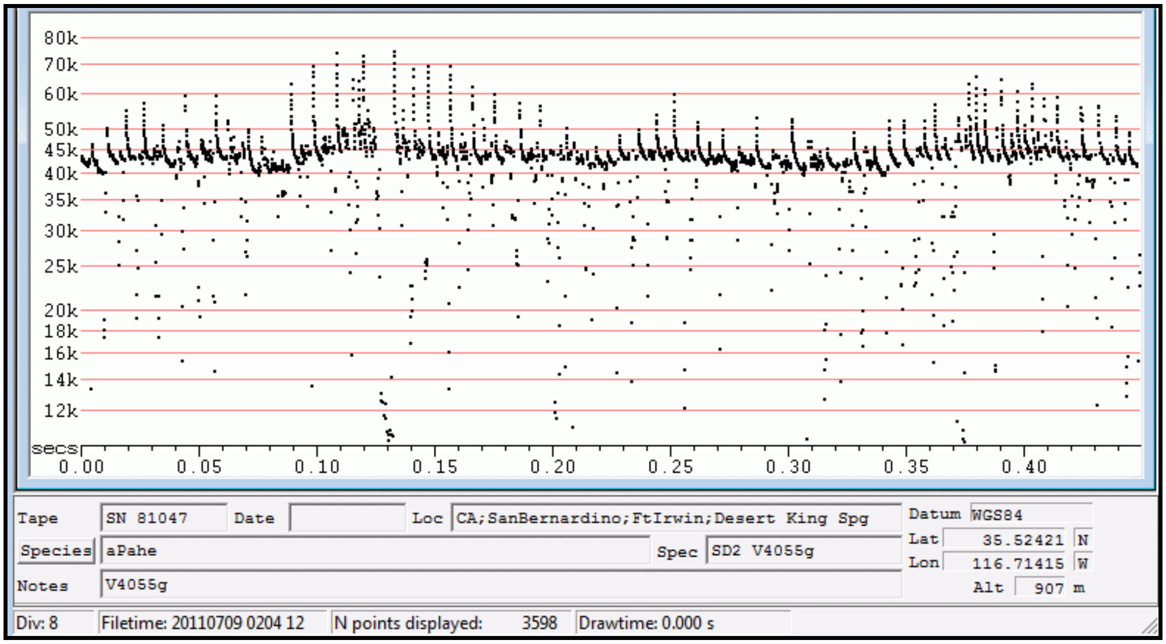


Figure I-G. *Parastrellus hesperus* Canyon bat

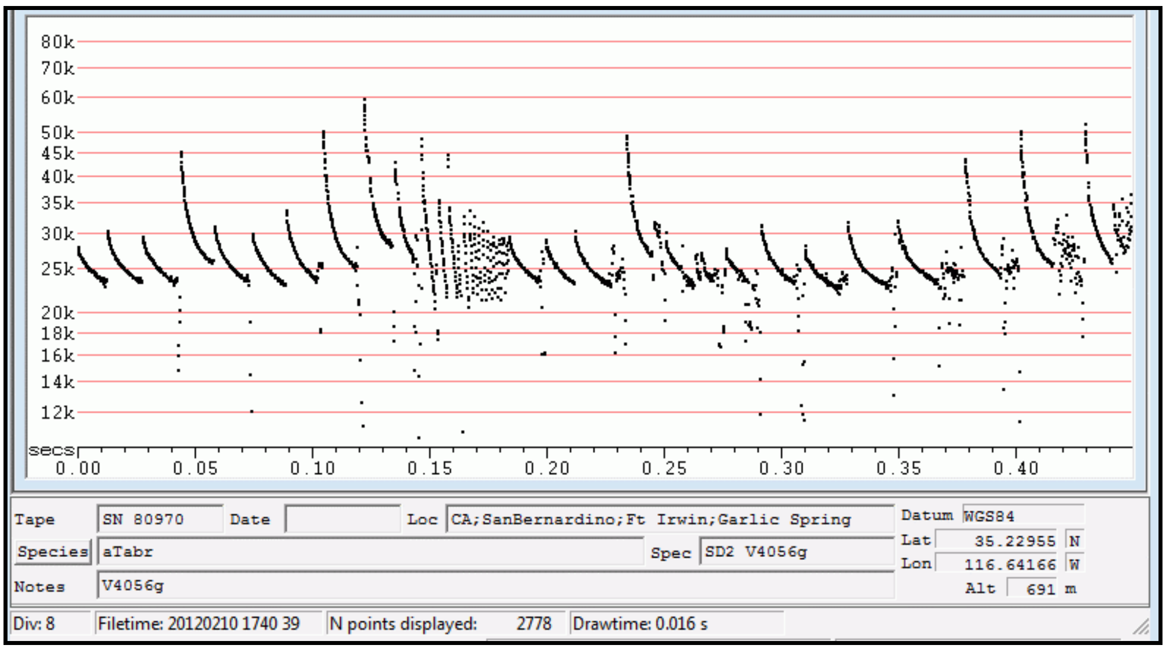


Figure I-H. *Tadarida brasiliensis* Mexican freetail

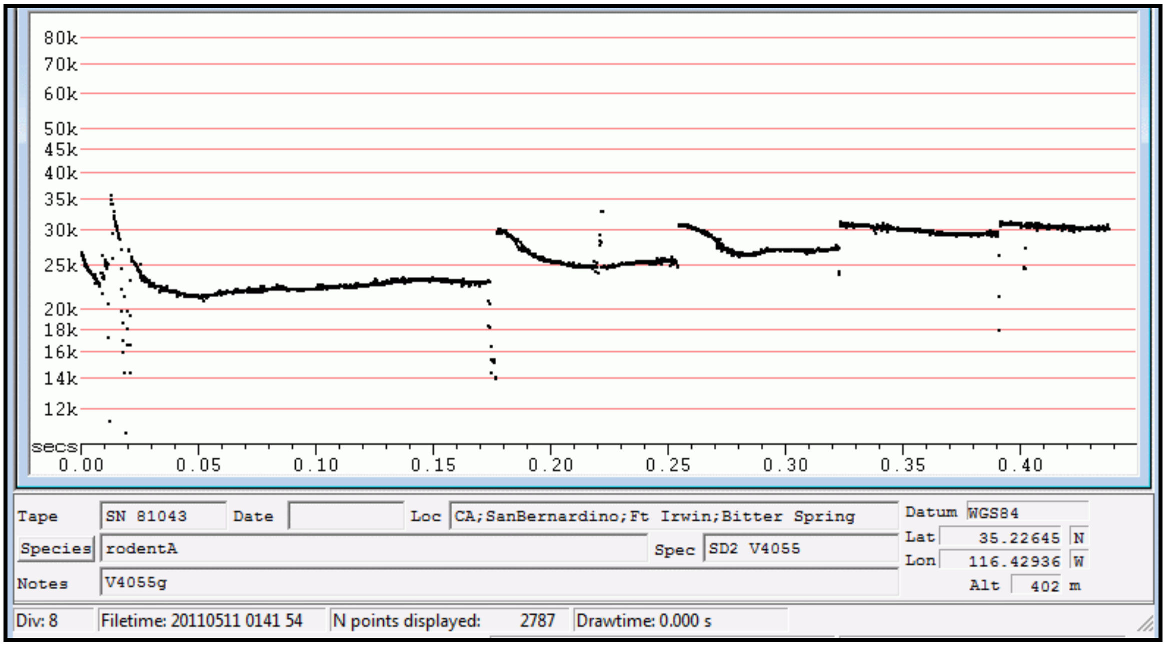


Figure I-I. *Peromyscus* sp. White Footed Mouse

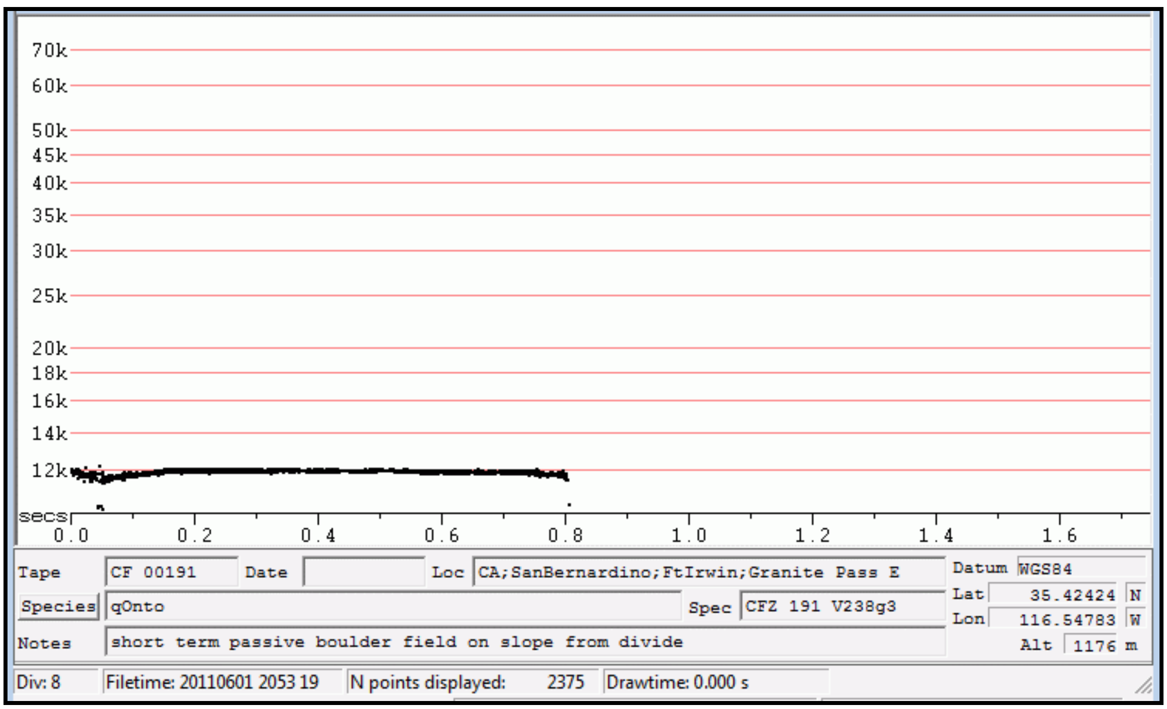
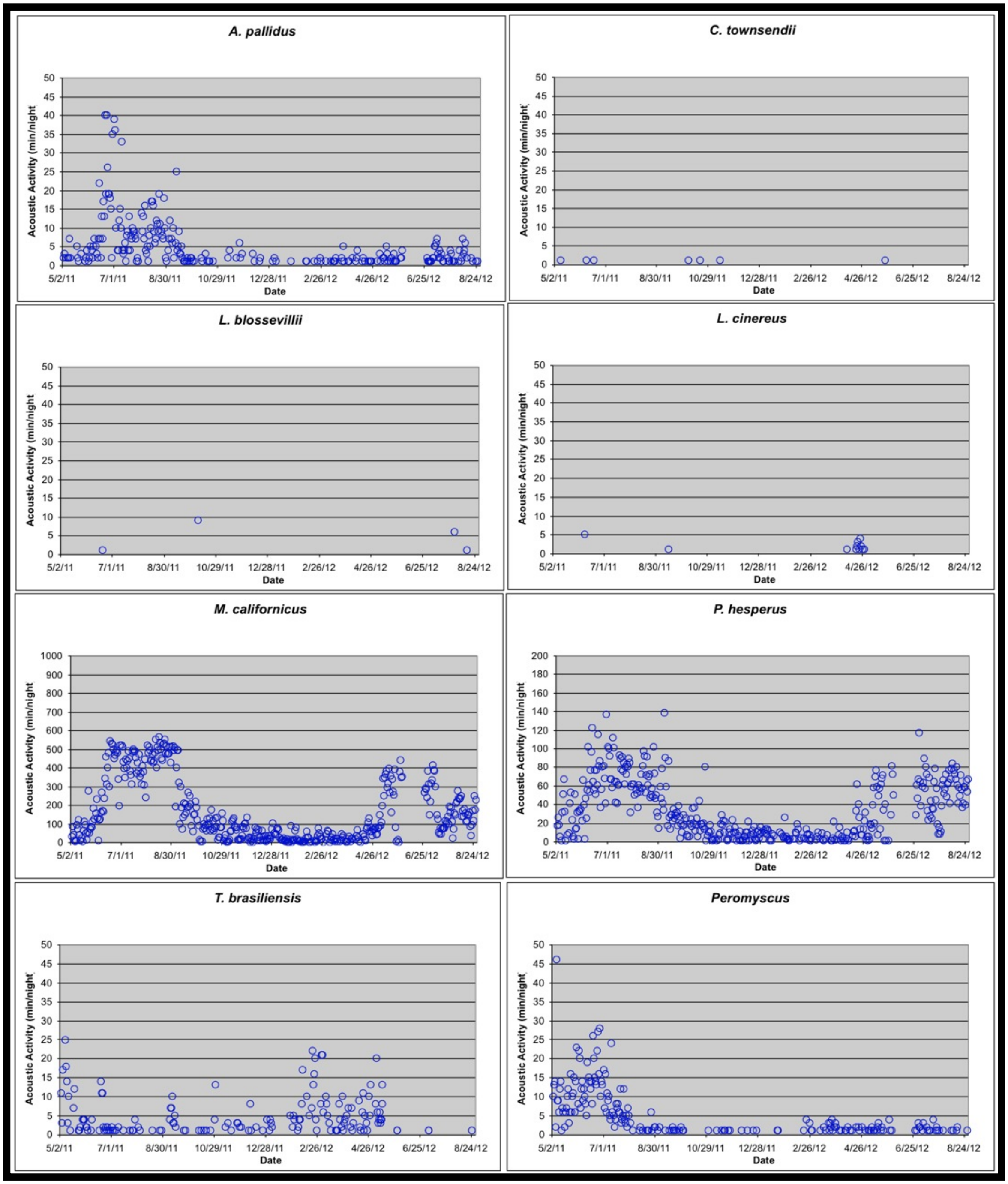
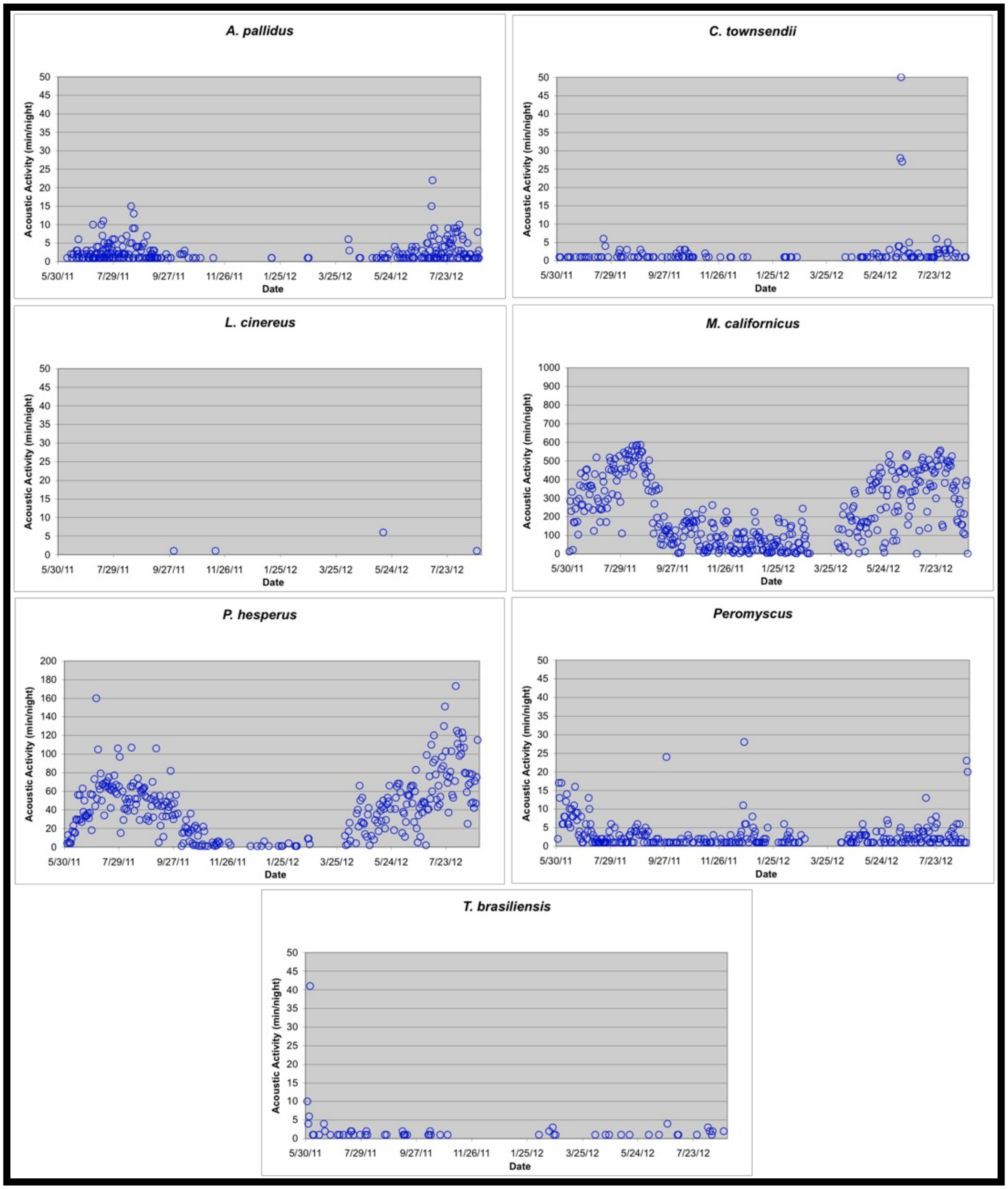


Figure I-J. Probable *Onychomys torridus* Grasshopper Mouse

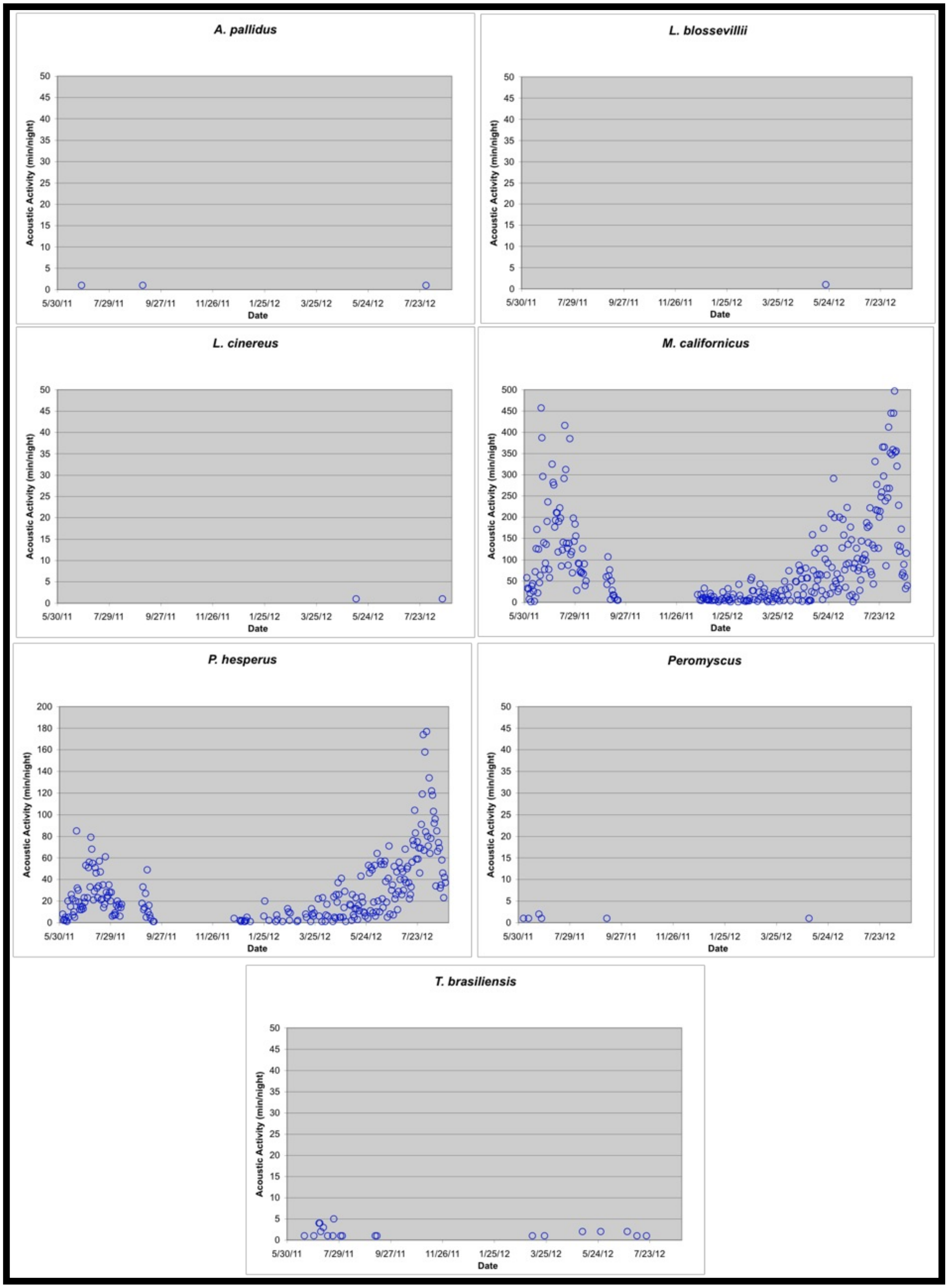
APPENDIX II. Graphs of bat acoustic activity by species and locality for the study interval.



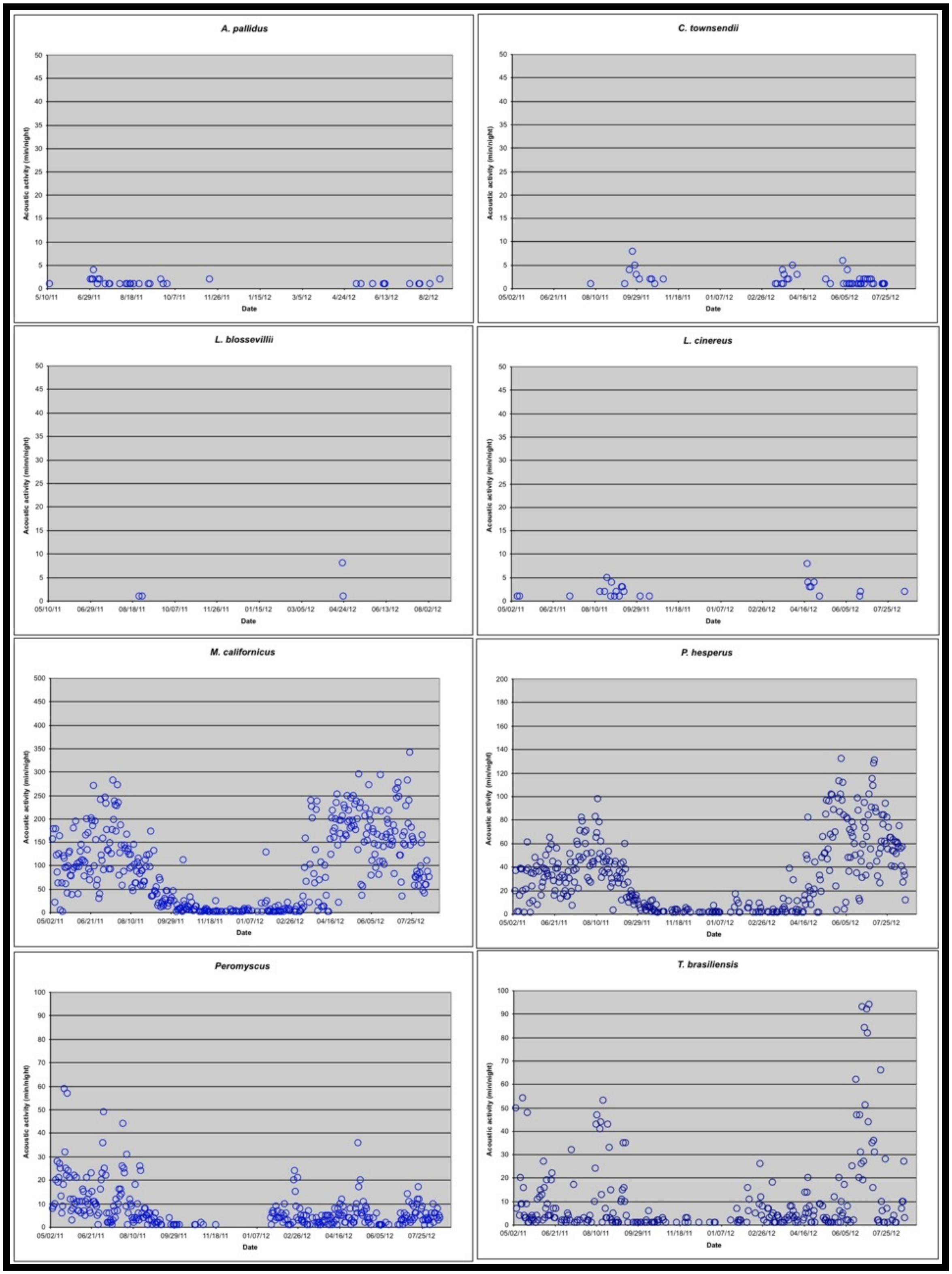
Bitter Spring. Minutes of activity per night, by species, for the duration of the study. All seven bat species, plus *Peromyscus* were detected at this site.



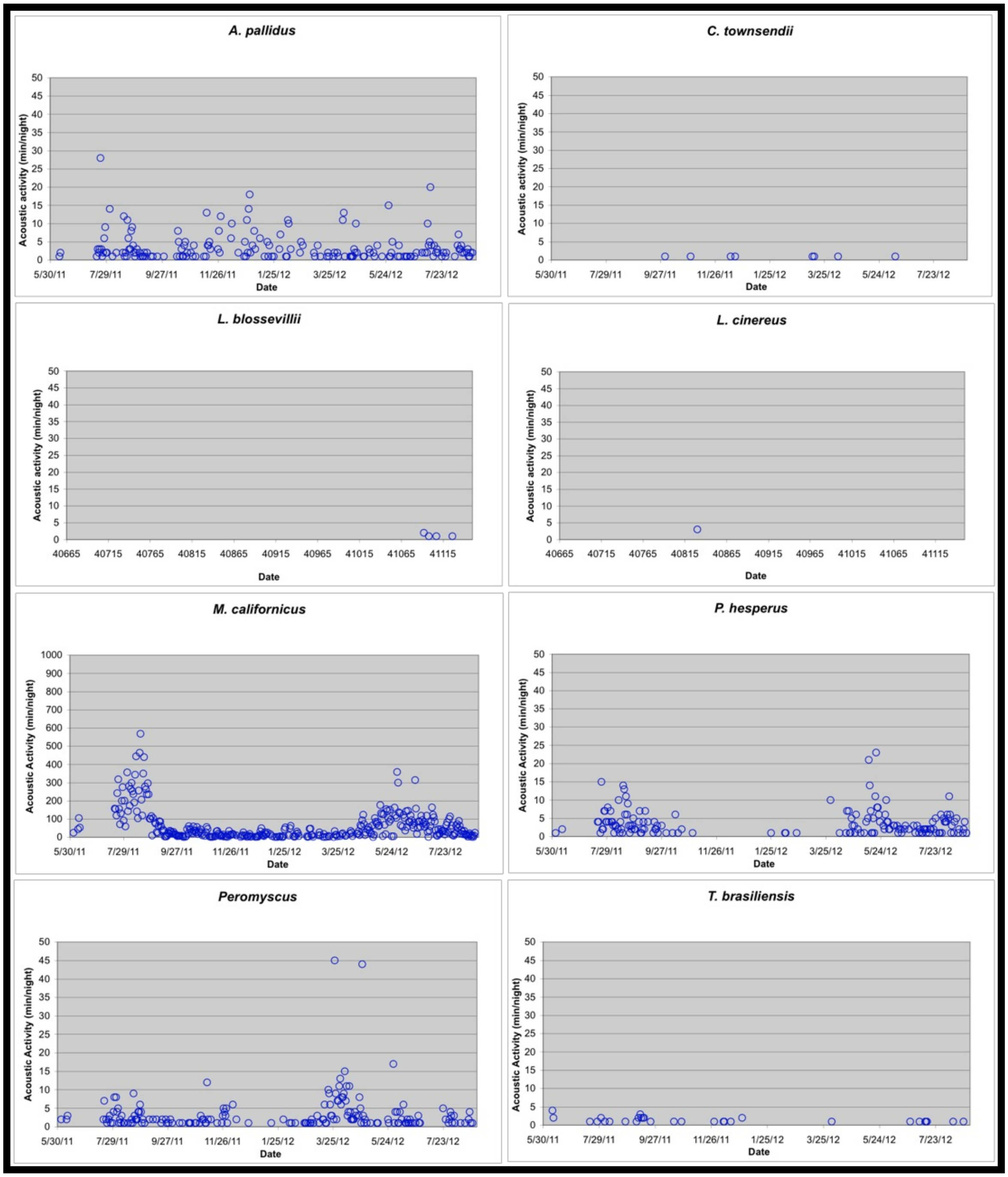
Cave Spring. Minutes of activity per night, by species, for the duration of the study. No *L. blossevillii* were detected at this site



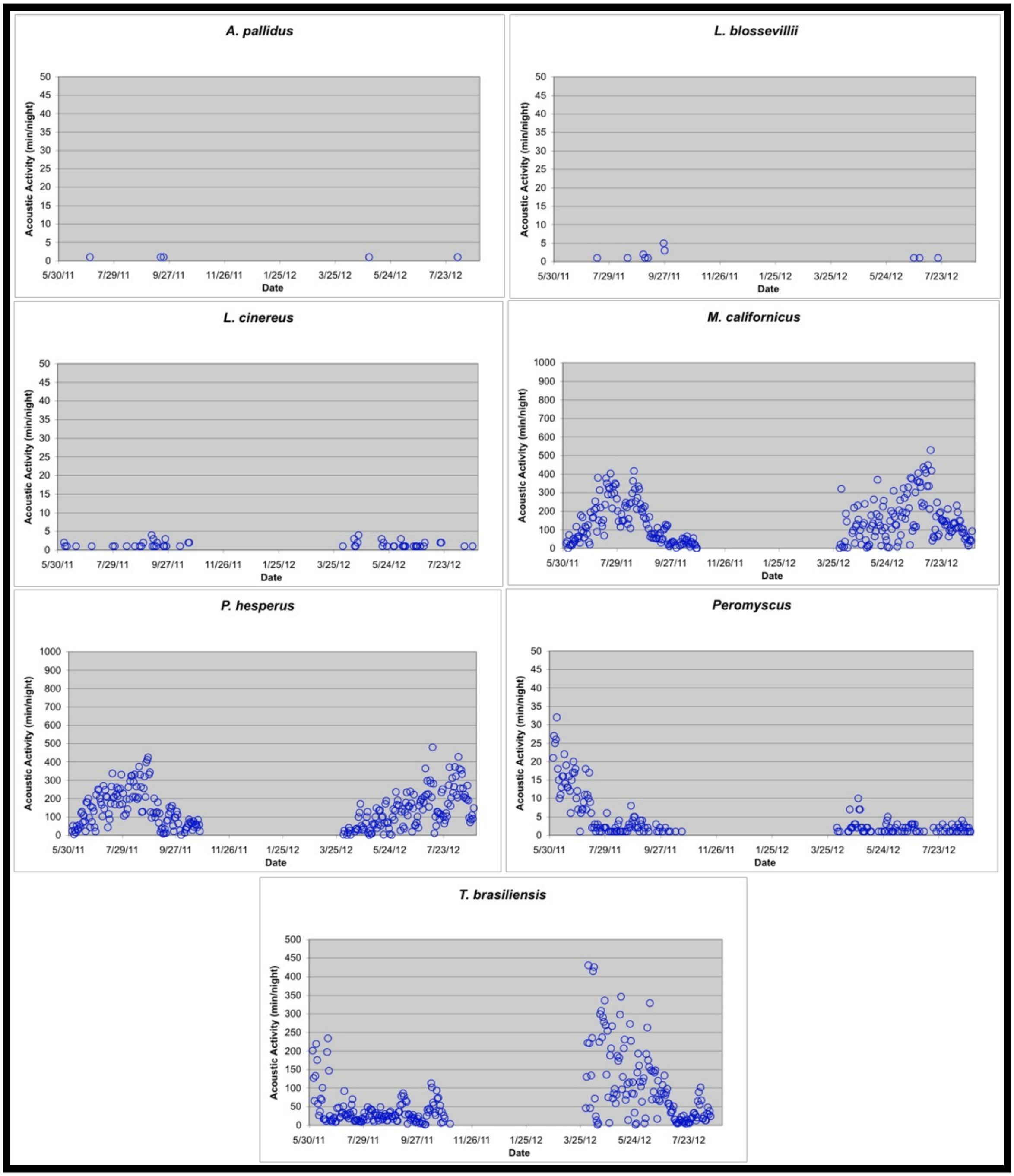
Desert King Spring. Minutes of activity per night, by species, for the duration of the study. No *C. townsendii* were detected at this site.



Garlic Spring. Minutes of activity per night, by species, for the duration of the study. All seven bat species, plus *Peromyscus* were detected at this site.



Panther Spring. Minutes of activity per night, by species, for the duration of the study. All seven bat species, plus *Peromyscus* were detected at this site.



Sewage Pond. Minutes of activity per night, by species, for the duration of the study. No *C. townsendii* were detected at this site.