# BATS ASSOCIATED WITH INACTIVE MINE FEATURES IN SOUTHEASTERN ARIZONA[1]

Angela M.D. Barclay[2]

**Abstract.** The purpose of this study was to determine whether inactive mine features on privately owned lands and lands administered by the Bureau of Land Management (BLM) in Pima County, in southeastern Arizona (the study area), were being used by bats. External pre-screening surveys of 60 inactive mine features were completed in March 2012, and it was determined that 23 of these sites had the potential to provide roosts for bats. Passive external portal acoustic and visual surveys of these 23 features were completed using AnaBat acoustic detectors and infrared trail cameras from May through mid-October 2012. Acoustic survey data were analyzed, and 10 species of bats were identified. Bat species were acoustically detected at all 23 sites but were only visually detected at two sites.

Acoustically, bat activity and species richness were highest in the spring and lowest in the fall. The two most common species, canyon bat (*Parastrellus hesperus*) and Mexican free-tailed bat (*Tadarida brasiliensis*), accounted for more than 50% of all the survey data. Ten sites accounted for more than 75% of all bat activity. Species richness was highest at two sites, with seven species detected at each site, and was lowest at two sites, where only one or two species were detected. Two species identified as species of concern under the Endangered Species Act (ESA) – western small-footed myotis (*Myotis ciliolabrum*) and Yuma myotis (*M. yumanensis*) – were acoustically detected at 15 and three sites, respectively. Two BLM-sensitive species (also identified as species of concern under the ESA) – Townsend's big-eared bat (*Corynorhinus townsendii*) and cave myotis (*M. velifer*) – were acoustically detected at 10 sites (seven of which are on BLM lands) and seven sites (three of which are on BLM lands), respectively.

Although no bats were detected in any photos or videos, when biologists visually monitored each site, bats occasionally were seen flying in the study area around sunset, but only one bat was seen exiting from an inactive mine site. Townsend's big-eared bats were observed roosting in two adits on BLM-administered lands during the fall. No major bat roosts or no threatened or endangered bat species (e.g., lesser long-nosed bats [*Leptonycteris curasoae yerbabuenae*]) were detected through these surveys.

**Additional Key Words:** activity, adit, shaft, species richness.

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[2] Angela M.D. Barclay is the Wildlife, Fish, and Rare Plants Program Manager for the Coronado National Forest, 300 West Congress Street, Tucson, AZ 85701.

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## Introduction

Bat populations, including populations of species that were once thought of as common, are declining in many areas of North America and worldwide (Hinman and Snow, 2003). Roost disturbance and destruction from recreational caving and mine exploration, deliberate vandalism, and closure of inactive mines for hazard abatement or renewed mining can be particularly devastating to mine-roosting bats and has led to the loss of nursery (also termed maternity) colonies and to population declines (Chung-MacCoubrey, 1996; Schmidt and Dalton, 1994). Loss of foraging areas and adequate water resources may also have adverse impacts on bats.

The largest challenge to bat conservation is the lack of knowledge about natural history, including migration patterns, and the scarcity of population estimates and data on population trends for most species. Bats are frequently overlooked or ignored in vertebrate studies and ecological evaluations, and there are few publications on mammal species, especially bats, in Arizona (Chung-MacCoubrey, 1996; Koprowski et al., 2004; Schmidt and Dalton, 1994). Essential components of suitable habitat for bats of the Southwest include appropriate roosts for various seasonal and reproductive activities, suitable foraging areas and resources, and adequate, available surface water (Chung-MacCoubrey, 1996; Schmidt and Dalton, 1994).

Nineteen of the 28 bat species occurring in Arizona are known to roost in mines (Hinman and Snow, 2003). Bats in Arizona, and in 26 other states (Lera, 2002), are protected by state and federal laws and regulations. Additionally, because the study area includes some Bureau of Land Management (BLM)-administered lands, BLM sensitive species were considered (BLM, 2008). The endangered lesser long-nosed bat (*Leptonycteris curasoae yerbabuenae*) species in Pima County, Arizona receives protection under the Endangered Species Act (ESA). Other bats have been given the conservation status “species is of concern” by the U.S. Fish and Wildlife Service (USFWS), but the term does not have official status. Finally, 12 bat species in Arizona are included in the state’s list of Species of Greatest Conservation Need (Arizona Game and Fish Department [AGFD], 2012).

Bats may use a mine site at different times of the year because of the biological requirements of different bat species (Navo, 1994). Bats use mines for hibernation (in the winter), as maternity roosts, day roosts, and night roosts in the summer, and intermediate roosts during migration and interim periods between hibernation and summer season in the spring or fall. Also, there are several factors that can affect bat activity: temperature may affect both bats and their prey items; some bat species are thought to be less likely to exit a roost during a full moon; bats may take advantage of currents on a windy night or they may be less active; the season affects bat activity and the presence of some species that migrate; and ephemeral food sources may cause bats to forage in different areas or switch roosts (Tyburec, 2012).

The purpose of this study was to determine whether inactive mine features on privately owned lands and lands administered by the BLM in Pima County, in southeastern Arizona (the study area), were being used by bats and is part of a larger goal of conducting baseline studies for long-range planning for the study area.

## Methods

### Study Area

The study area was located on privately owned lands and lands administered by the BLM southwest of Tucson in Pima County in the Santa Cruz River valley in southeastern Arizona. The study area occurred at an elevation of approximately 3,400 to 3,800 ft above mean sea level (amsl) within the Semi-desert Grassland and Arizona Upland subdivision of the Sonoran Desert-scrub biotic communities (Brown, 1994). Topography in the area varied, and there were ephemeral drainages in the study area. Dominant vegetation included velvet mesquite (*Prosopis velutina*), yellow palo verde (*Parkinsonia microphylla*), ocotillo (*Fouquieria splendens*), and an occasional saguaro (*Carnegiea gigantea*) in the overstory. Creosote bush (*Larrea tridentata* var. *tridentata*), catclaw acacia (*Acacia greggii*), whitethorn acacia (*A. constricta*), wolfberry (*Lycium* sp.), spiny hackberry (*Celtis ehrenbergiana*), oreganillo (*Aloysia wrightii*), sangre de cristo (*Jatropha cardiophylla*), cholla (*Cylindropuntia* spp.), and prickly pear (*Opuntia* sp.) formed the midstory. Soaptree yucca (*Yucca elata*), sotol (*Dasylirion wheeleri*), brittlebush (*Encelia farinosa*), and various grasses (e.g., *Bouteloua* spp.) and forbs formed the understory. Stock tanks and settling ponds were located in the study area, but no other aquatic habitats (e.g., wetlands, springs, etc.) or broadleaf deciduous riparian vegetation was observed.

There are several historical mine workings that may provide roosts for bats within the study area. Arizona bat species whose range encompasses the study area and that rely heavily on inactive mine features include the lesser long-nosed bat, cave myotis (*Myotis velifer*), Yuma myotis (*Myotis* *yumanensis*), big brown bat (*Eptesicus fuscus*), pallid bat (*Antrozous pallidus*), Townsend's big-eared bat (*Corynorhinus townsendii*), Allen's big-eared bat (*Idionycteris phyllotis*), Mexican long-tongued bat (*Choeronycteris mexicana*), Mexican free-tailed bat (*Tadarida brasiliensis*), and California leaf-nosed bat (*Macrotus californicus*) (Hinman and Snow, 2003). In addition, California myotis (*Myotis californicus*), western small-footed myotis (*Myotis ciliolabrum*), fringed myotis (*Myotis thysanodes*), long-legged myotis (*Myotis volans*), canyon bat (*Parastrellus hesperus*), and ghost-faced bat (*Mormoops megalophylla*) may also roost in mines (Hinman and Snow, 2003).

<u>Survey Techniques</u>

Bats usually emerge nightly to feed (except during hibernation), so surveys during most of the year in this region do not typically require mine entry to detect bat occupancy (Navo, 1994; Sherwin et al., 2009). Such is the case at the time of year at which the present surveys were completed. In contrast, past and current use (e.g., roosting bats, guano, insect parts, staining, dead bats, and odors) and habitat potential are typically determined through the use of internal surveys (Sherwin et al., 2009).

This assessment was completed using passive external portal survey techniques that incorporated a combination of pre-survey screening, acoustic surveys, and visual surveys to provide a snapshot of bat use in the study area in 2012. External surveys were conducted for two reasons:

1. <u>Human safety</u> Prior to the development of high-tech visual and acoustic detection equipment, internal surveys were standard practice for surveying for bats in mine adits and shafts. Entering inactive mines, however, can be dangerous and can pose serious threats to human safety because of cave-ins and falling rocks, rattlesnakes, bees, deadly gases, oxygen deficiency, hidden shafts, and old explosives.

2. <u>Bat health</u> External surveys avoid the risk of disturbing nursery colonies, which can result in mortality of young. Additionally, white-nose syndrome is a fungal disease that has killed more than 5.7 million bats since its discovery in 2006; seven bat species in 25 states and in five Canadian provinces have been documented with white-nose syndrome (USFWS, 2014). Although it is unknown whether it will spread to Arizona, the AGFD is

recommending that people avoid entering mines to prevent or slow the spread of this disease.

According to the Bat Conservation International manual *Managing Abandoned Mines for Bats* (Sherwin et al., 2009:70), external surveys are based on the following underlying assumptions:

- All openings to a mine have been identified.
- Bats will use the sampled openings.
- Any use of the mine by bats will be exhibited during the survey.
- The survey method is sufficient to detect use.
- If bats are present in or use a mine, they will be active and observable at the time of the survey.

External pre-screening surveys. Before conducting acoustic surveys, an initial assessment of 60 inactive mine features was completed to determine the potential for bat use. The initial pre-survey screening collected a variety of data, including:

- Description of the portal, including dimensions and obstruction, along with a photograph;
- Evidence of water or flooding and water temperature, if flowing;
- Visual signs of bats (e.g., staining, guano, culled insect parts, live or dead bats);
- Presence of airflow, including direction and temperature relative to ambient air;
- Notes about safety hazards; and
- Universal Transverse Mercator (UTM) coordinates and site identification (ID).

Based on the findings of the pre-survey screening, the mine entrances were determined to have

- low potential (e.g., flooded or substantial blockage),
- moderate potential, or
- presence of bats (e.g., sign observed).

Twenty-three sites either were confirmed to have bats present or were determined to have at least a moderate potential for bats. The remaining 37 sites were determined to have low to no potential to serve as bat roosts and were therefore removed from further analysis.

Acoustic surveys. As stated previously, the use of passive external portal surveys was recommended to promote human safety and to protect bat health. Because the purpose of the study was to determine species' presence, external portal surveys offered an easy and typically effective solution by which most species could be detected and identified using acoustic and visual surveys without jeopardizing human safety and bat health. Survey guidelines described by Navo (1994) were followed, and acoustic surveys were completed using AnaBat acoustic detectors at 23 inactive mine features.

Because it is critical that surveys or evaluations take place at different times of the year to adequately evaluate the potential for a mine to provide roosting habitat for various species of bats, it is recommended that four sets of surveys be conducted during three survey periods in order to assess bat use at different seasons: spring (once in March through mid-May for spring roosts or intermediate roosts); summer (once in mid-June through July for summer or maternity roosts); and fall (twice in mid-August through mid-October for fall swarming or pre-hibernation evaluations).

For this analysis, spring surveys were conducted May 2 through 10, summer surveys were conducted June 25 through July 12, and the two fall surveys were conducted September 19 through 27 and October 1 through 9. The only roosts that are nearly impossible to identify using external portal surveys are hibernation roosts, which are typically occupied in January and February (Navo, 1994). The purpose of the fall surveys, however, was to look for swarming or pre-hibernation activities of bats because internal winter surveys would not be conducted as part of this study.

An AnaBat acoustic detector was deployed at each site before sunset, and each detector was programmed to operate from 0.5 hour before sunset to 2 hours after sunset. This period was chosen because most bats exit the roost to feed and are active at this time (Hinman and Snow, 2003; Navo, 1994). Two biologists were present for most surveys, and up to four AnaBats operated simultaneously at four different sites on any given night. At each inactive mine site, an AnaBat was mounted on an approximately 5-foot-tall T-post (used to fence the portal for safety) or on a 5-foot-tall tripod (when T-posts were not present). The acoustic detection equipment consisted of an Anabat II or AnaBat SD2 bat detector and a Compact Flash Zero Crossings Analysis Interface Module (CF ZCAIM). The detector and CF ZCAIM were purchased from Titley Electronics in Ballina, New South Wales, Australia.

The AnaBat detectors recorded data files (.dat files) of high-frequency bat echolocation and social calls. These files were downloaded using cfcread software (developed by Chris Corben) and identified to species by Dr. Michael J. O'Farrell of O'Farrell Biological Consulting using Analook software (developed by Chris Corben). Species-level analysis was accomplished by Dr. O'Farrell using methods described by O'Farrell and Gannon (1999). Because all sites were surveyed for the same amount of time (one night per season per site), with equal sampling effort, the sum of 1-minute time increments for which a species was detected (= minutes of bat activity) was used to describe the relative abundance of bats among sites.

Visual surveys. Visual surveys were conducted using infrared (IR) cameras. An IR camera was deployed at each site at least twice during the year. In addition, each site was visually monitored by a biologist until dark at least once during the year.

## Results

### External Pre-screening Surveys

Acoustic and visual surveys were conducted at the 23 sites where the presence of bats was confirmed or that were determined during pre-screening to have at least a moderate potential for containing bats.

### Acoustic Surveys

During the four survey periods, 610 minutes of bat activity was recorded (Table 1). Throughout the study period, 10 bat species from two families were detected, including three (possibly four [see Table 1]) ESA species of concern[3] (AGFD, 2010) and one BLM sensitive species[4] (BLM, 2010) (Table 2). Technical issues during the summer and fall survey periods resulted in a loss of 4 days of potential data at four sites (two in the summer [HC 2 and SM 15] and one in each of the fall surveys [TB 5 and SM 14, respectively]). The technical issues that resulted in a loss of data were associated with an error in formatting one data card and the failure of AnaBat units.

Using minutes of bat activity as the response variable, and using site, season, species, and all the two-way interactions as predictors, generalized linear models were used to fit a Poisson regression. Based on this analysis, it was determined that all main effects and all interactions discussed below were statistically significant ($P < 0.005$).

[3] The conservation status of this species is of concern to the USFWS, but the term does not have official status.
[4] These species occur on BLM lands in Arizona and are considered sensitive.

Table 1. Summary of Acoustic Survey Results

| Season | Minutes of Bat Activity | Species Richness* |
|---|---|---|
| Spring 2012 | 355 | 9 |
| Summer 2012 | 111 | 8 |
| Fall 1 (September) 2012 | 66 | 8 |
| Fall 2 (October) 2012 | 78 | 7 |
| **Total** | **610** | **10** |

* Total does not sum to 10; rather, 10 represents the total number of species identified during the surveys.

Table 2**.** Bat Species Identified through Acoustic Surveys

| Scientific Name | Common Name | Species Code | Listing Status | |
|---|---|---|---|---|
| **Family Vespertilionidae** | | | **ESA** | **BLM** |
| *Antrozous pallidus* | Pallid bat | ANTPAL | | |
| *Corynorhinus townsendii* | Townsend's big-eared bat | CORTOW | SC* | S |
| *Eptesicus fuscus* | Big brown bat | EPTFUS | | |
| *Myotis californicus* | California myotis | MYOCAL | | |
| *Myotis ciliolabrum* | Western small-footed myotis | MYOCIL | SC | |
| *Myotis velifer* | Cave myotis | MYOVEL | SC | S |
| *Myotis yumanensis* | Yuma myotis | MYOYUM | SC | |
| *Parastrellus hesperus* | Canyon bat | PARHES | | |
| **Family Molossidae** | | | | |
| *Nyctinomops femorosaccus* | Pocketed free-tailed bat | NYCFEM | | |
| *Tadarida brasiliensis* | Brazilian free-tailed bat | TADBRA | | |

Source: AGFD (2010).

Note: SC = ESA Species of Concern; S = BLM Sensitive Species.

* Pale Townsend's big-eared bat (*Corynorhinus townsendii pallescens*) is SC; however, this subspecies cannot be acoustically differentiated from Townsend's big-eared bat (*C. townsendii townsendii*).

Bat activity differed between species and seasons (Table 3). Approximately 58% of all bat activity was recorded in the spring, followed by 18% in the summer, 13% in the second fall session, and 11% in the first fall session (Fig. 1). Species richness was highest in the spring, when nine species were recorded. Eight species were detected in summer and in the first fall session, and seven species were detected in the second fall session. Two species, canyon bat and Mexican free-tailed bat, accounted for 59% of all the survey data. Western small-footed myotis constituted approximately 17% of the survey data, and big brown bat constituted approximately 10% of the survey data. The remaining six bat species each constituted less than 5% of the overall activity. Canyon bats accounted for the most bat activity in the summer and both fall survey sessions, whereas the Mexican free-tailed bat accounted for the greatest amount of bat activity in the spring.

Table 3. Percent Activity of Bat Species for all Sites by Season

| **Scientific Name** | **Common Name** | **Spring** | **Summer** | **Fall (Sept.)** | **Fall (Oct.)** | **Total*** |
|---|---|---|---|---|---|---|
| *Parastrellus hesperus* | Canyon bat | 22 | 61 | 41 | 50 | **35** |
| *Tadarida brasiliensis* | Mexican free-tailed bat | 31 | 26 | 6 | 6 | **24** |
| *Myotis ciliolabrum* | Western small-footed myotis | 24 | 0 | 23 | 0 | **17** |
| *Eptesicus fuscus* | Big brown bat | 15 | 2 | 5 | 0 | **10** |
| *Nyctinomops femorosaccus* | Pocketed free-tailed bat | 2 | 3 | 3 | 24 | **5** |
| *Myotis californicus* | California myotis | 1 | 5 | 12 | 3 | **3** |
| *Corynorhinus townsendii* | Townsend’s big-eared bat | 2 | 1 | 8 | 4 | **2** |
| *Myotis velifer* | Cave myotis | 2 | 2 | 0 | 5 | **2** |
| *Myotis yumanensis* | Yuma myotis | 0 | 0 | 0 | 8 | **1** |
| *Antrozous pallidus* | Pallid bat | <1 | 1 | 3 | 0 | **1** |

* This column is not the sum of the percent of bat activity per season for each species; rather, it represents the total percent of bat activity during all surveys per species.

Bat activity also differed between sites and seasons (Table 4, Fig. 2). Four sites (BLM 482, BLM 483, BLM 492, and HC 1) accounted for 42% of all the bat activity, and six other sites (BLM 494, HC 2, HC 3, SM 14, SM 23, and State 3[5]) accounted for an additional 34% of all the bat activity, whereas the remaining 13 sites each constituted less than 5% of the overall bat activity (see Table 4). Most of the bat activity occurred at BLM 482 during the spring session, at State 3 in the summer and second fall sessions, and at SM 14 in the first fall survey session. Species richness was highest at sites BLM 492 and SM 23, with seven species detected at each site. Species

[5] This site was owned by the Arizona State Land Department when surveys began in the study area but became privately owned in September 2012.

richness was lowest at sites SM 28 and TB 6, with one and two species detected, respectively. It is possible that the bats detected in the study area may be using other natural (e.g., rock crevices, vegetation, etc.) and manmade (e.g., buildings) features in the study area as roosts instead of, or in addition to, the inactive mine features that were surveyed as part of this study.

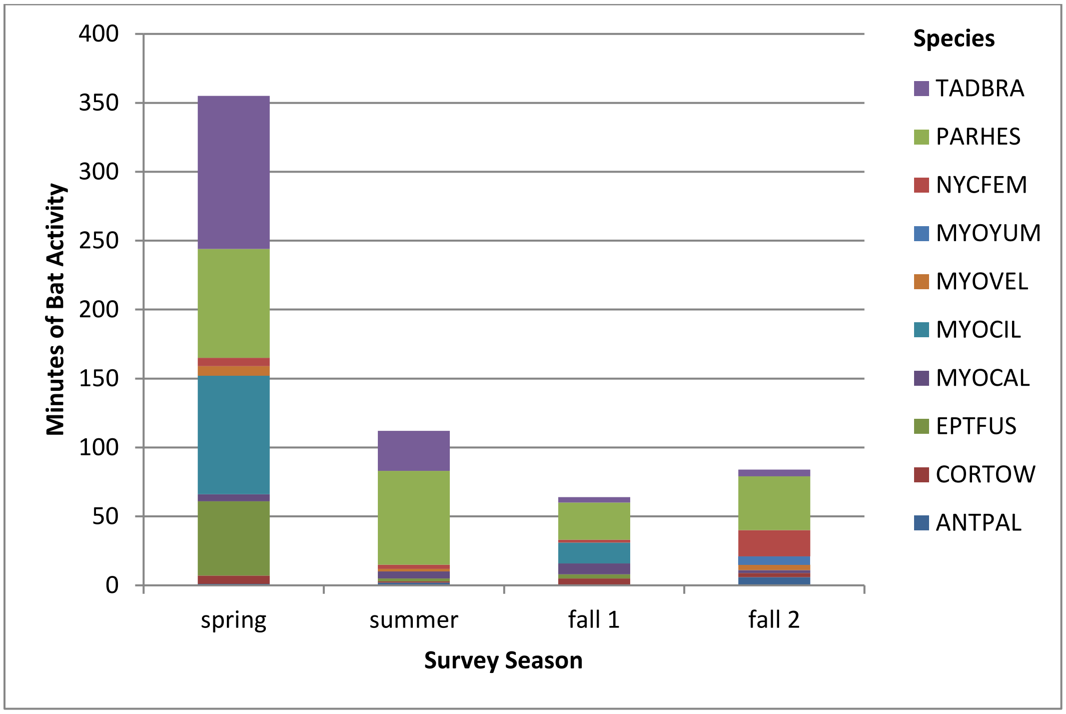


Figure 1. Minutes of bat activity by species in each survey season.

There were no threatened or endangered bat species observed during these surveys. Two species identified as species of concern under the ESA, western small-footed myotis and Yuma myotis, were acoustically detected at 15 and 3 sites, respectively. Western small-footed myotis accounted for 17% of the bat activity but this species was only detected during the spring and first fall session. Yuma myotis only accounted for 1% of the bat activity, and this species was only detected during the second fall session. The two BLM sensitive species (also identified as species of concern under the ESA) – Townsend's big-eared bat and cave myotis – were acoustically detected at 10 sites (seven of which are on BLM lands) and seven sites (three of which are on BLM lands), respectively. Townsend's big-eared bat was detected in every season, and cave myotis was detected in spring, summer, and the second fall session, but each of these species only accounted for 2% of total bat activity.

Table 4. Percent Bat Activity by Site and Season for All Sites

| Inactive Mine Site | Type of Feature | Current Land Ownership | Spring | Summer | Fall (Sept.) | Fall (Oct.) | Total* |
|---|---|---|---|---|---|---|---|
| BLM 482 | adit | BLM | 19 | 14 | 3 | 15 | **16** |
| BLM 492 | adit | BLM | 8 | 12 | 8 | 13 | **9** |
| HC 1 | shaft | private | 13 | 8 | 0 | 0 | **9** |
| BLM 483 | shaft | BLM | 10 | 1 | 6 | 5 | **8** |
| SM 14 | adit | private | 7 | 1 | 17 | 0 | **6** |
| HC 2 | shaft | BLM | 9 | 0 | 5 | 0 | **6** |
| State 3† | shaft | private | 1 | 13 | 0 | 23 | **6** |
| BLM 494 | shaft | BLM | 5 | 3 | 15 | 3 | **6** |
| SM 23 | shaft | private | 5 | 5 | 11 | 4 | **5** |
| HC 3 | shaft | BLM | 6 | 3 | 6 | 3 | **5** |
| HC 6 | shaft | private | 2 | 10 | 2 | 1 | **3** |
| SM 15 | shaft | private | 4 | 0 | 2 | 6 | **3** |
| SM 33 | shaft | private | 3 | 4 | 0 | 6 | **3** |
| BLM 486 | adit | BLM | 2 | 8 | 0 | 3 | **3** |
| TB 4 | shaft | private | 1 | 5 | 9 | 4 | **3** |
| BLM 496 | shaft | BLM | 2 | 3 | 2 | 1 | **2** |
| TB 1‡ | shaft | private | 0 | 5 | 6 | 1 | **2** |
| BLM 485 | shaft | BLM | 1 | 3 | 5 | 1 | **2** |
| SM 18 | shaft | private | 1 | 1 | 3 | 3 | **2** |
| TB 5 | shaft | private | <1 | 3 | 0 | 4 | **1** |
| SM 24 | shaft | private | <1 | 0 | 3 | 0 | **<1** |
| SM 28 | shaft | private | 0 | 0 | 0 | 3 | **<1** |
| TB 6 | shaft | private | 0 | 1 | 0 | 1 | **<1** |

* This column is not the sum of the percent of bat activity per season for each site; rather, it represents the total percentage of bat activity during all surveys per site.

† This site was owned by the Arizona State Land Department when surveys began in the study area but became privately owned in September 2012.

‡ During the last fall survey at this location, water was noted at the bottom of the shaft, so this site likely did not provide roosting habitat for bats at this time.

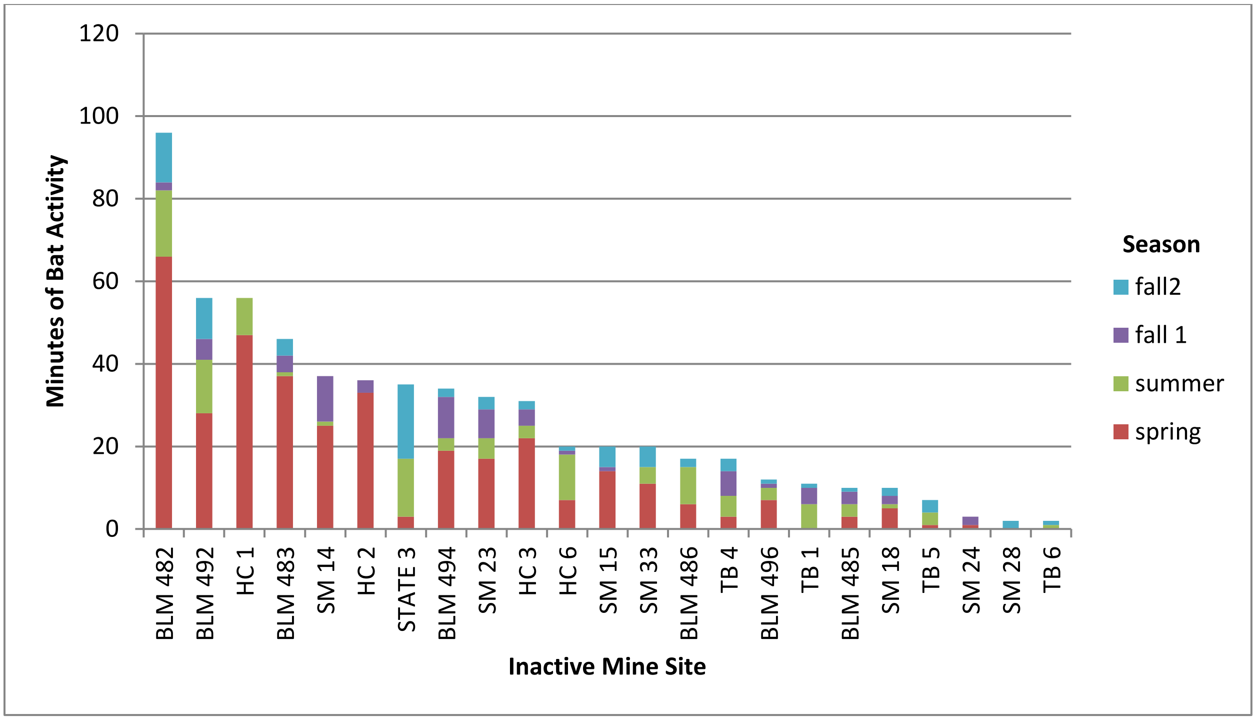

Figure 2. Minutes of bat activity in each survey season, by site.

The remaining six species – canyon bat, Mexican free-tailed bat, big brown bat, pocketed free-tailed bat (*Nyctinomops femorosaccus*), California myotis, and pallid bat – are not afforded any protection by the ESA or the BLM; however, all bat species in Arizona are protected by Arizona State law. The canyon bat accounted for the greatest amount of bat activity (35% of the total) and for most of the survey data in summer and in both fall survey sessions. The Mexican free-tailed bat accounted for 24% of the survey data, and most of the survey data for this species occurred in the spring and summer survey sessions. The big brown bat was documented in three of the four survey sessions (spring, summer, and the first fall session) but only at seven sites, and it accounted for 10% of the total bat activity. The pocketed free-tailed bat was documented in all four survey sessions at 10 sites, which accounted for 5% of total bat activity. Most of the activity was in the second fall session at one site (State 3), which accounted for 24% of the bat activity during this survey session. The California myotis was documented in all four survey sessions, but it was only documented at seven sites and only accounted for 3% of the total bat activity; however, one site accounted for 45% of the total activity for this species (BLM 492) during the summer and both fall survey sessions. The pallid bat – although it was documented in three of the four survey sessions (spring, summer, and first fall session), it was only documented at three sites (HC 1, HC 3, and SM 15), and it constituted the least amount of bat activity (1%) in the analysis area.

Visual Surveys

Photos and videos from IR cameras were examined for visual evidence of bat activity; no bats were detected in any photos or videos. When the biologists visually monitored each site, bats occasionally were seen flying in the study area around sunset. However, only one bat was seen exiting an inactive mine site (BLM 492 during the second fall session), and bats were seen roosting in BLM 482 during both fall sessions and in BLM 492 in the second fall session. The bats in both adits appeared to be Townsend's big-eared bats, and this species was acoustically detected at both sites during the second fall session.

In addition to documenting the presence of bats, the presence of other vertebrates and invertebrates (e.g., bees) was noted. Bees were observed nesting in seven shafts (BLM 493, HC 2, HC 3, SM 15, SM 18, SM 24, and TB 5).

## Discussion

The study area is located on the fringe of, or within the known range of, and partially or completely within mapped habitat for all 10 species that were detected during surveys in the study area (Hinman and Snow, 2003). Acoustically, bat activity and species richness were highest in the spring, which indicates that most of the bat species detected use the study area as a spring roost during migration or in the interim period between hibernation and summer. In contrast, bat activity and species richness were lowest in the fall, so most species are likely not using the study area this time of year.

Ten sites accounted for more than 75% of all the bat activity, and four of these sites accounted for 42% of all bat activity. Two of the sites that accounted for 42% of the bat activity are adits (these two sites actually accounted for 25% of all bat activity) at which bats were observed. It is possible that the proximity to good foraging habitat (e.g., ephemeral washes) for the insectivorous bat species detected in the study area influenced bat activity at several sites. The four sites that accounted for 42% of all bat activity are located within 650 feet (an average of 250 feet) of the nearest wash (or water source), whereas the remaining 19 sites are located between 35 and 1,120 feet (an average of 595 feet) from the nearest wash (or water source). Species richness was highest at two sites, with seven species detected at each site, and was lowest at two sites, with only one or two species detected. The two sites with the highest species richness were located 650 and 1,000 feet from the nearest wash. It is unclear whether the proximity to these washes influenced bat species diversity at each site.

The two most common species, canyon bat and Mexican free-tailed bat, accounted for more than 50% of all the survey data. The canyon bat was documented in all four survey sessions at all but one site; the species accounted for the greatest amount of bat activity (35% of the total) and for most of the survey data in summer and both fall survey sessions. The fairly consistent activity across survey seasons indicates that the canyon bat is common in the study area and likely uses the study area all year, including the maternity season. The Mexican free-tailed bat was documented in all four survey sessions at 19 sites. It accounted for 24% of all the survey data, and most of the survey data for this species occurred in the spring and summer survey sessions. This suggests that the Mexican free-tailed bat is common in the study area, or was just easily detected, that it primarily uses the study area in the spring and summer (i.e., maternity season), and that some individuals may migrate away from the study area in the fall.

Two species identified as species of concern under the ESA – western small-footed myotis and Yuma myotis – were acoustically detected in the study area. The western small-footed myotis was documented at 15 sites in the study area and accounted for 17% of the total bat activity, but was only documented in the spring and first fall session. This suggests that the western small-footed myotis is common in the study area during some seasons, likely uses the study area during migration, and possibly winters in the study area. The Yuma myotis was only documented at three sites in the spring and second fall session and accounted for only 1% of the total bat activity. This indicates that the Yuma myotis likely uses the study area during migration or winters here, although likely in small numbers.

Two BLM sensitive species (also identified as species of concern under the ESA) – Townsend's big-eared bat and cave myotis – were acoustically detected at 10 sites (seven of which are on BLM lands) and seven sites (three of which are on BLM lands), respectively. No bats were detected in any photos or videos, but when biologists visually monitored each site, bats occasionally were seen flying in the study area around sunset; only one bat was seen exiting an inactive, mine site. Townsend's big-eared bats were seen roosting in two adits on BLM lands during the fall. Although the Townsend's big-eared bat was documented in the study area in all four survey sessions, this species was only documented at 10 sites and constituted only 2% of the total bat activity. This suggests that the Townsend's big-eared bat likely uses the study area all year, although probably just in small numbers. This is plausible because this species roosts in small groups compared to the other bat species. However, this species is difficult to detect acoustically, so it may be present at more locations and in larger numbers than indicated by the acoustic data. The external portal surveys confirmed that Townsend's big-eared bats, and possibly other species, are using two adits on BLM lands (BLM 482 and BLM 492). The cave myotis was documented at seven sites during three of the four survey sessions (spring, summer, and the second fall session) but only accounted for 2% of the total bat activity. This indicates that the cave myotis likely uses the study area all or most of the year, although likely in small numbers.

The big brown bat was documented in three of the four survey sessions (spring, summer, and the first fall session) but only at seven sites, and it accounted for 10% of the total bat activity. This suggests that the big brown bat likely uses some sites in the study area all or most of the year but not in large numbers, especially since this species is easy to detect acoustically. The pocketed free-tailed bat was documented in all four survey sessions at 10 sites and accounted for 5% of total bat activity. Most activity for this species was in the second fall session and at just one site, where it accounted for 24% of the bat activity during this survey session. This suggests that small numbers of the pocketed free-tailed bat use the study area all year but that one site may be particularly important for this species in the fall, a conclusion supported by the fact that this species is also easy to detect acoustically.

Although the California myotis was documented in all four survey sessions, it was only documented at seven sites and only accounted for 3% of the total bat activity. One site, however, accounted for 45% of the total activity for this species during the summer and both fall survey sessions. This suggests that the California myotis likely uses the study area all year, although likely in small numbers. Although the pallid bat was documented in three of the four survey sessions (spring, summer, and first fall session), it was only documented at three sites and constituted the least amount of bat activity (1%) in the study area. This suggests that pallid bats use some sites in the study area all or most of the year, but only in small numbers. This is plausible because this species roosts in small groups, relative to other bat species. However, this species is acoustically difficult to detect, so it could be present at more locations and in larger numbers than the acoustic data indicate.

No lesser long-nosed bats, an endangered bat species, were observed through these surveys. Although lesser long-nosed bats were not detected, nectar-feeding bats such as this species are more difficult to detect than other bats (Tyburec, 2012), so the lack of acoustic identification should not be interpreted as absence. The columnar cacti occur in lower-elevation areas of the Sonoran Desert region, whereas the paniculate agaves occur primarily in higher-elevation areas, such as desert grasslands, shrub-lands, and montane habitats (USFWS, 1995). As a result, concentrations of food resources for this species are patchily distributed and are only available seasonally. Cactus flowers and fruits are available during the spring and early summer, whereas blooming agaves are primarily available during mid- to late summer (typically from July through early October). Agave were not documented in the study area, and although there were saguaros in the study area, there were no large stands of saguaros that could serve as forage plants for a large colony of nectar-feeding bats. The nearest known post-maternity roost was located approximately 20 miles to the east in the Santa Rita Mountains, and the nearest known maternity roost was located approximately 70 miles to the northwest (USFWS, 1995). The lesser long-nosed bat is known to fly long distances from occupied roost sites to foraging sites; night flights from maternity colonies to flowering columnar cacti have been documented in Arizona at distances of up to 15 miles and in Mexico at distances of up to 38 miles (USFWS, 2007). Lesser long-nosed bats, therefore, may use the study area, although probably not in large numbers because the study area does not contain agaves, only saguaros.

Bats were acoustically detected at all 23 sites. Some studies have indicated that although bats sometimes cannot be visually confirmed entering or exiting inactive mine features through the use of external surveys, because the acoustic recording equipment was very close to the mine entrance, it is likely that many of the bats detected were using the mines (Morrison and Fox, 2009). However, without entering each inactive mine feature, surveys cannot confirm the past and current use or habitat potential of each site (Sherwin et al., 2009). Further, these results cannot provide any information regarding the presence or absence of hibernation roosts because there would be no external bat activity to detect during this season. However, no pre-hibernation swarming was observed in the study area, which could signify that bats use the study area during hibernation. Although the results of the external portal surveys are not 100% conclusive, if bats were using these inactive mine features in 2012, they were using them in small numbers. Further, it is unlikely that any of the sites surveyed provided roosts for large numbers of bats because no bats were detected exiting or entering the sites visually by biologists or with IR cameras. Also, these results are a snapshot of bat use in the study area in 2012, and although some suggest that the results of this type of study are good for up to 1 year, bat use of the study area can change from season to season and from year to year.

## Recommendations

Because the timing of reclamation activities or closures can be critical for minimizing impacts on bats, such activities should be avoided when bats are using a mine, especially during maternity and hibernation periods (Sherwin et al., 2009). The timing of these types of activities should take into account the needs of the bat species documented in the study area. The best time to construct closures is during late summer or early fall, after maternity activities have ceased and before hibernation. Based on the bat activity detected during these surveys, this likely applies to the study area and the species detected using the study area. If bats are using any inactive mine features in the study area, early fall closures will allow hibernating bats to find alternate hibernacula and will allow females to locate alternate maternity roost sites.

A final assessment of bat presence/absence should be performed prior to any reclamation activities or closures. Immediately prior to such activities, an additional survey at each site to determine presence/absence of bats at that time is recommended. An effective pre-closure survey method, without jeopardizing human safety or bat health, involves the use of a down-the-hole video camera system that is hard-wired to a surface viewing system. If a maternity roost or bat hibernaculum is detected at that time, activities should be postponed to a later date, and the inactive mine feature should be resurveyed prior to scheduling closure. In the event of destructive closures only, if no bats or small numbers of bats are documented as present at the subject sites (outside of maternity or hibernation season), methods should be employed, if feasible, to exclude bats (e.g., tarping or netting opening or using smoke bombs) after they exit the mine for the evening before constructing closures. The development of a closure and mitigation plan that would outline more detailed exclosure methods using AGFD, Bat Conservation International, and BLM current guidelines is recommended.

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