


White River National Forest Bat Survey and Monitoring 2016-2018

2018

CNHP's mission is to preserve the natural diversity of life by contributing the essential scientific foundation that leads to lasting conservation of Colorado's biological wealth.

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INTRODUCTION

Caves are a critical resource for many bats in Colorado. At least 12 of Colorado's 19 bat species have been documented using caves during some phase of their annual cycle (Armstrong *et al*. 2011). The environmental stability and protection provided by caves can make them highly suitable for roosting throughout the year. During summer, caves are used as day roosts, night roosts, and maternity roosts. Caves are used as hibernacula during winter and as migratory resting areas (transient roosts) in the spring and fall. The availability of suitable cave roosts has been shown to be a limiting resource in the distribution and abundance of some cave-dwelling bats in the eastern U.S. (Humphrey 1975).

With the emergence of White-nose Syndrome (WNS) in eastern North America (Blehert *et al.* 2009) and progression into western states (Lorch *et al.* 2016), the need for baseline data on bat populations, especially in caves, has become more urgent. Some information on bat use of caves in Colorado is known (e.g., Navo *et al.* 2002; Siemers 2002; Siemers *et al.* 2012; Siemers and Neubaum 2013, 2014 & 2015), however data are still lacking. Colony sizes similar to the large aggregations of bats impacted by WNS in eastern North America are not known to occur in Colorado, so detection of WNS, if it should appear in the state, may not be as obvious. Additional information suggests that rock crevices in cliff faces and talus slopes may offer other winter roosting opportunities (Neubaum *et al.* 2006; Neubaum 2018). Consequently, investigating the extent to which Colorado bats rely on caves can help inform future management decisions.

This report details data collected by both the Colorado Natural Heritage Program (CNHP) and Colorado Parks and Wildlife (CPW) from cave surveys conducted on the White River National Forest (WRNF) from 2016-2018, and partially fulfills the reporting requirement for the Challenge Cost Share Agreement (16-CS-11021500-060) between the USFS and CNHP. The objectives of this project for 2016-2018 were to verify bat use at select caves during the maternity season, to evaluate suspected maternity roosts and hibernacula, and to monitor a maternity colony of individually marked *Corynorhinus townsendii* at Elephant Mountain Mine. Another priority of this project was to survey caves for any evidence of WNS. Such evidence might include dead bats within or near features, bats with abnormal scarring on their wings, or any external indication of fungal growth on observed bats. **During the surveys conducted in 2016-2018, no evidence or suspicion of the presence of White-nose Syndrome was encountered.**

In 2016-2018, CNHP and CPW conducted surveys at five caves and one mine. The surveys took place during the maternity and hibernation seasons. In addition, we led the population monitoring project at Elephant Mountain Mine. Results from these efforts are presented along with recommendations for future work and measures for protecting these resources.

Cave Survey Methods

Evidence of bat activity was documented using multiple survey methods, including internal underground surveys, external trapping surveys, acoustic surveys using ultrasonic detectors, and external surveys with infrared video equipment. Entry into caves was permitted by Exemption Authorizations to Emergency Closure Order #R2-11-02 and White River National Forest Order #2013-14 (Prohibitions and Restrictions on Cave Access).

We conducted internal surveys to determine the presence or apparent absence of bats, as well as the degree and seasonality of use. Sites were surveyed during seasons that corresponded with specific suspected usage (*e.g*., maternity roost, swarming) or to confirm use as a hibernaculum, which relates directly to WNS concerns. Survey activities consisted of entering the cave or mine to gather bat presence information, to estimate the number and identify the species of bats, to collect temperature and humidity data, and to gather soil samples if appropriate. Species and microclimate data collected during internal surveys were recorded on cave maps when available or hand sketched to capture the spatial distribution of use by bats. Time spent in each cave or mine was kept to a minimum whenever possible, and internal survey data were collected in a manner that attempted to minimize the disturbance to roosting bats.

At Spring Cave, ultrasonic acoustic detectors (Model SM2, Wildlife Acoustics, Inc., Concord, MA) were deployed to record bat vocalizations. Recordings were analyzed using SonoBat 3.1.5 (SonoBat, Arcata, CA) and vocalizations were compared to reference bat calls from the Northern Arizona bat call library (SonoBat, Arcata, CA). Call analysis parameters were set to use a discriminant probability threshold of 0.9 and an acceptable call quality of 0.8 with a maximum of 8 calls. The discriminant probability refers to the probability of a call sequence falling within the centroid of the multi-dimensional data space for reference calls for a species. Two outputs result from the analysis for assessing the likelihood of a call sequence matching reference calls from a particular species. The "sequence classification by vote" identifies the species by requiring that the species with the greatest number of calls classified be at least twice as prevalent as the sum of the second and third most abundant species classifications. The second output, the "mean sequence classification", is based on the mean parameter values of the most prevalent classification group then uses these mean values (minimum of 2 calls) through a decision tree engine. If the values fall below the minimum threshold for a classification group, the call is not attributed to that group, but instead is displayed with the species groups that sum to the thresholds for the last decision tree step attained. A consensus value is also generated, which indicates the species designation if determined by both methods. We report species determinations based on this consensus value when possible. If a consensus value is not attained, we report the call as a general classification of high frequency or low frequency species.

At Hubbards Cave, acoustic detectors designed for use within caves or near cave entrances (Roost Logger, Titley Scientific, Columbia, MO) were deployed inside the cave. We placed detectors at locations thought to be of high potential for internal bat activity (*e.g.*, passage junctions, pinch points, *etc.*). Detectors were set in February 2018 and retrieved in August 2018. Acoustic recordings were scrubbed and viewed using Kaleidoscope (Wildlife Acoustics, Inc., Concord, MA) and general measures of bat activity were made.

Video data were collected using cameras equipped with infrared (IR) capabilities (Model HDR-CX560V, Sony Electronics, San Diego, CA) supplemented with external IR lights (IRLamp6, Bat Conservation and Management, Inc., Carlisle, PA) and video surveillance cameras that image in the 'thermal' spectrum of infrared light (approximately 9,000–14,000 nm; Model Q1921-E w/ 19-mm lens, Axis Communications, Lund, Sweden) and which require no supplemental illumination. The effective sensor array size of the cameras was 384 x 288 pixels, and we recorded digital video to digital storage cards in the camera at a rate of 30 frames per second (H.264 advanced video compression codec). Cameras were placed at entrances to document flights in and out of a cave or mine. Data were analyzed by visually inspecting video segments and counting the number of bats emerging from the feature each night. We did not attempt to identify bats to species during video analysis.

RESULTS

A total of five caves and one mine on the White River National Forest were surveyed during 19 visits in 2016-2018. Several sites that were visited during past efforts were revisited during different seasons to further elucidate bat use throughout the year at these locations. Bat species names and abbreviations are found in Table 1 and data from each visit are briefly summarized in Table 2. The following section provides specific information regarding the 2016-2018 survey effort as well as recommendations for each cave and mine visited. At the end of this section (Table 15), we provide a summary of bat use for all caves and mines we visited from 2012-2018.

Table 1. Scientific names, species abbreviations, and common names of bat species noted in this report.

Species Name	Abbreviation	Common Name
*Corynorhinus townsendii**	COTO	Townsend's big-eared bat
Eptesicus fuscus	EPFU	Big brown bat
*Lasiurus cinereus**	LACI	Hoary bat
Lasionycteris noctivagans	LANO	Silver-haired bat
Myotis ciliolabrum	MYCI	Western small-footed myotis
Myotis evotis	MYEV	Long-eared myotis
Myotis lucifugus	MYLU	Little brown myotis
Myotis sp.	MYSP	Unidentified myotis species
*Myotis thysanodes**	MYTH	Fringed myotis
Myotis volans	MYVO	Long-legged myotis
Myotis yumanensis	MYYU	Yuma myotis

*USFS Region 2 Sensitive Species (FSM 2670 R2 Supplement, December 18, 2018)

Table 2. Summary of surveys conducted at caves and mines on the White River National Forest in 2016-2018.

Cave Name	Date	Survey Type	Bat Activity Summary
Buffalo Cave	3/11/2017	internal	41 COTO hibernating.
Devil's Den Cave	1/24/2018	internal	2 MYSP hibernating.
Elephant Mountain Mine	2/19/2016	internal PIT retrieval	83 PIT tags scanned in mine.
	7/20/2016	PIT tag work	PIT tagged 148 COTO.
	7/21/2016	PIT tag work	PIT tagged 31 COTO.
	7/28/2016	video	1,034 COTO counted at emergence.
	8/30/2016	PIT tag work	PIT tagged 61 COTO.
	1/31/2017	internal PIT retrieval	71 PIT tags scanned in mine.
	7/11/2017	video	839 COTO counted at emergence.
	8/22/2017	video	1289 COTO counted at emergence.
	2/12/2018	internal PIT tag retrieval	28 PIT tags scanned in mine.
	8/23/2018	video	701 COTO counted at emergence.
Hubbards Cave	2/1/2017	internal	600 hibernating bats observed.
	8/22/2017	gate check	No bats observed - only evaluated front of cave near entrances.
	2/13/2018	internal	613 COTO and 2 MYSP hibernating. Deployed roost loggers.
	8/24/2018	internal	No bats observed; roost logger retrieval.
Ice Cave	2/1/2017	internal	5 hibernating bats observed.
Spring Cave	1/23/2017	internal	12 COTO and 4 MYSP hibernating.
	12/5/2017	internal	20 COTO, 4 EPFU, and 6 MYSP hibernating.

Buffalo Cave

Location Information: White River National Forest, Eagle Ranger District, Garfield County, 9070 feet

2017 Survey Effort: An internal survey of the lower passages of the cave during the hibernation season was conducted on March 11, 2017. We observed a total of 41 *Corynorhinus townsendii* hibernating in locations throughout the lower passages (Ice Berg Room, Owl Passage, and Buffalo Falls) of the cave.

Buffalo Cave entrance in March 2017.

Use Comments: We conducted a partial internal survey in July 2012 and a swarming survey in September 2012 (Siemers *et al.* 2012) and found moderate nighttime bat activity throughout the feature with use by *Myotis evotis, M. ciliolabrum* and *C. townsendii*. During these surveys we did not enter the lower passages of the cave but conducted video, acoustic, and swarming surveys in the large room below the skylight as well as at the pit entrance that leads to the Iceberg Room. Findings from those surveys indicate this site is used as a night roost and a likely day roost during the summer and a swarming site during the fall (Siemers *et al.* 2012). Acoustic surveys were conducted in June 2007 (Mosch 2008) and July 2011 (Mosch 2011b) and both indicated a high level of nighttime bat activity.

Recommendations: The lower passages of this cave act as a cold air sink which lends it to use as a hibernaculum by bats (Table 3). Presence of torpid Townsend's big-eared bats during the winter season confirmed this use. Temperatures we recorded indicate a small gradient across which bats could move to find suitable roosting microclimates. The cave also appears to be used for swarming activity, although surveys during the swarming season has only occurred on one occasion in 2012 (Siemers and Neubaum 2014). Further examination of swarming activity at the cave, in terms of which species are present and to what level, could be investigated. The remote location of this cave makes access, particularly during the winter season, challenging. However, if *Pd* spores were transmitted to the cave accidentally during summer when access is more feasible, the fungus would likely be able to establish itself and persist. Consequently, management of the cave's continued access should be considered, particularly prior to the arrival of WNS to Colorado and during its spread, due to the risks an accidental introduction poses to the hibernating bats that use this site. It should be noted that at the time of this writing, Townsend's big-eared bats exposed to *Pd* have not exhibited signs of WNS (White Nose Syndrome Response Team, www.whitenosesyndrome.org).

Table 3. Observations and notations for Buffalo Cave internal survey on March 11, 2017. Locations refer to names as depicted on map by Reames (2011).

February 28, 2014 Survey	
Location	**Observation**
Portal	-1.7°C surface/7.4°C ambient/59.5% RH
Landing at bottom of The Pit	2 COTO (0.4°C surface).
Breakdown leading to Ice Berg Room	1.5°C surface/5.9°C ambient/60.3% RH
Ice Berg Room, 34 ft. dome	6 COTO (0.6°C surface/7.2°C ambient/66.0% RH).
Ice Berg Room, by large boulders	4 COTO (0.3°C surface).
Ice Berg Room, 20 ft. dome	18 COTO (-1.1°C surface/3.5°C ambient/67.5% RH).
Ice Berg Room, 4 ft. low ceiling area	10 COTO
Inclined passage of Ice Berg Room	Scattered guano on walls and floor suggest swarming, no piles (3.5°C surface/7.2°C ambient/66.5% RH).
Owl Passage	1 COTO

Note: *Pseudogymnoascus destructans* grows between 0°C and 19.7°C; optimal temperatures for growth: 12.5 – 15.8°C; upper critical temperature for growth: 19.0 – 19.8°C (Verant *et al.* 2012). Optimal RH values for *Pd* have not been determined, but values required for growth for other fungi (including *Geomyces*, a close relative of *Pseudogymnoascus*) range from 76 – 96% (Hayman *et al.* 2016 and references therein).

Large room below the skylight in Buffalo Cave.

Devil's Den Cave

Location Information: White River National Forest, Eagle Ranger District, Eagle County, 11,540 feet

2018 Survey Effort: An internal winter survey was conducted on January 24, 2018. Two hibernating *Myotis* (likely *M. volans* or *M. lucifugus*, but not confirmed) were observed during the internal survey. Internal surface temperatures ranged between 0.2° C and 3.9° C and relative humidity from 71.0% to 96.5%.

Use Comments: No previous bat use has been reported at this cave. An internal survey was conducted in September 2001, but no bats were observed at that time (Siemers 2002).

Devil's Den Cave entrance on January 24, 2018 following snow removal.

Recommendations: This cave is near an area of numerous abandoned mines and has a relatively conspicuous entrance during snow-free seasons. Winter access issues deter human visitation during the hibernation season, but a nearby ski hut supports some winter activity in the area. Situated at timberline, this cave has the potential to acquire heavy snow accumulation. During our survey in January of 2018, a large volume of snow (approximately 3 cubic yards) needed to be removed in order to gain access to the opening. This seasonal obstruction may melt off more slowly at higher elevations requiring bats that do use the cave to stay longer into the spring or summer.

Summer visitation is likely to be common given the easy access to the cave via forest roads. Two bats were found using this site for hibernation in 2018, but conditions indicate the cave could support more individuals despite the observation that most of the cave's walls and ceiling were wet. The wet surfaces likely reduce the potential for use by bats, but near-freezing temperatures were recorded for most of the locations in the cave (Table 4), indicating that suitable sites for hibernation could be found throughout. Additionally, the long decline within this cave provides a broad gradient of temperature and humidity profiles for bats to find suitable hibernation microhabitats.

Table 4. Observations and notations for Devil's Den Cave internal survey on January 24, 2018. Locations refer to names as depicted on map by Paris (1973).

February 28, 2014 Survey	
Location	**Observation**
Portal	-5.6°C surface/-3.3°C ambient/99% RH
First room past the Entrance near large stump on the floor	Dripping ceiling, wet floor (1.5°C surface/0.6°C ambient/71% RH)
Dump Room	traces of guano
Passage with large breakdown at highest elevation above Dump Room	3.7°C surface/9.1°C ambient/93.3% RH)
Bower Tunnel mine passage	Dripping ceiling and wet floor
Face of Bower Tunnel mine passage	2.2°C surface/3.6°C ambient/88.5% RH
Ski Slope	Dripping, muddy
Just downslope of adjacent passage along Ski Slope where ceiling gains height	1 MYVO/MYLU. Condensation on torpid bat (2.0°C surface/7.7°C ambient/96.5% RH)
Passage with elevated ceiling upslope from Waterfall	1 MYVO/MYLU (1.4°C surface/7.8°C ambient/93.4% RH).
Passage below Waterfall	Wet
Devil's Den	0.2°C surface/8.5°C ambient/91.0% RH)

Note: *Pseudogymnoascus destructans* grows between 0°C and 19.7°C; optimal temperatures for growth: 12.5 – 15.8°C; upper critical temperature for growth: 19.0 – 19.8°C (Verant *et al.* 2012). Optimal RH values for *Pd* have not been determined, but values required for growth for other fungi (including *Geomyces*, a close relative of *Pseudogymnoascus*) range from 76 – 96% (Hayman *et al.* 2016 and references therein).

Elephant Mountain Mine

Location Information: White River National Forest, Sopris Ranger District, Pitkin County, 7,200 feet

2016-2018 Survey Effort: During 2016-2018 we monitored the *Corynorhinus townsendii* maternity colony at Elephant Mountain Mine using both video methods and passive integrated transponder (PIT) tags. We monitored the colony using video once in 2016, twice in 2017, and once in 2018. We conducted our final efforts of PIT tagging individuals in July and August of 2016. The solar-powered PIT tag reader was deployed throughout 2016-2018 to continue to monitor use by Townsend's big-eared bats that were PIT tagged in 2011 and 2014-2016. Additionally, we conducted internal surveys during each of the winters from 2016-2018 to search for PIT tags lost from bats while roosting in the mine.

Use Comments: A series of internal and external surveys from 2004 to 2007 mapped Elephant Mountain Mine and noted use by bats. On July 13, 2005, use of the mine as a maternity colony by Townsend's big-eared bats was investigated by Kirk Navo (CPW) at the request of the Forest Service. Initial visual exit counts suggested the colony numbered in excess of 500 bats and a sample of 15 individuals captured in hand confirmed use by males and reproductive females. On April 23, 2006 members of the Colorado Cave Survey mapped the remainder of the mine/cave complex and observed some bats already present. On July 21, 2006, a video survey using a Sony night shot camera with infra-red lighting reported approximately 784 individuals and a subsequent visual exit count on August 3rd estimated 691 individuals. A fall visit to the mine was made on September 6th of that year and "hundreds" of bats were noted. A count made using video footage was conducted July 9, 2007 and totaled 761 bats. Counts of this magnitude easily make this feature the largest known maternity roost for Townsend's big-eared bat in Colorado.

During the summer of 2011 a CPW-led effort marked 98 individuals using PIT tags as part of a pilot test to see if Townsend's big-eared bats could handle the stress of such marking techniques. One of the objectives of this study is to determine other roosting locations for the bats using Elephant Mountain Mine as a maternity site. To date, only one other roosting location has been located at Hubbards Cave. Details regarding number of individuals and survey effort are summarized in the Hubbards Cave account of this report.

Two circular AVID hoop readers were deployed at Elephant Mountain Mine in September of 2012 and 4 additional marked bats were detected. A partial internal survey was conducted during that visit and "hundreds" of bats were noted in the back portions of both the upper and lower adits. Sex and age of the bats were not determined at that time as no individuals were handled but we believe that many were probably young of the year. Some bats may use the site as a transitional roost as well when moving between summer maternity colonies and winter hibernacula. A subsequent out-flight revealed that most bats were exiting off to one side of the hoops so many marked individuals were likely going undetected. A PIT reader with a 2-foot by 2-foot square antenna fabricated by USGS fish researcher Brian Hays was loaned to CPW and deployed in April 2013 with hopes of improving detectability and reducing disturbance to the bats. Over the course of the summer 41 individuals were detected using this enlarged hoop, including 9 bats previously detected in 2011 or 2012. Any of the bats marked with AVID tags that were detected in 2014 or 2015 were also detected in 2013. Only 1 (adult female) of the 4 bats detected in September 2012 has not been detected since.

On July 30, 2013 an updated count of the maternity colony using the site was conducted to confirm that prior activities during the last half decade, such as installation of the gate and preliminary PIT tag marking and monitoring efforts, have not led to reduced use of the site. Video counts made during this survey totaled 1,316 individuals using infra-red imaging and 1,336 individuals using thermal imaging. Using the lower count of the two, 1,316 individuals is easily the highest number of bats recorded during any one count to date. This high-count may be attributed to the improved sensitivity of the video equipment used, but an increasing colony size is also a possibility. The geothermal aspects of this site offer a unique advantage to female bats rearing young there as pups are likely maturing more quickly and fledging earlier which, in turn, improves the odds of them surviving the first year of life (Racey and Swift 1981). In addition, the high counts suggest that minimal or no effects from PIT tag marking and monitoring are occurring. From 2016-2018, we conducted additional video monitoring and the results of those efforts along with previous video monitoring efforts are summarized below (Table 5).

Table 5. Emergence counts of *Corynorhinus townsendii* at Elephant Mountain Mine using video methods.

Recording Date	Video Format	Season	Number of individuals
July 21, 2006	Night Shot IR	maternity	784
July 9, 2007	Night Shot IR	pre-volancy	761
July 30, 2013	near-IR	maternity	1,316
July 30, 2013	thermal	maternity	1,336
July 28, 2016	thermal	maternity	1,034
July 11, 2017	thermal	pre-volancy	839
August 22, 2017	thermal	post-volancy	1,289
August 23, 2018	Night Shot IR	post-volancy	701

On September 17, 2013 CPW installed a new Biomark reader with a 2-foot by 2-foot antenna that has the ability to read older AVID tags while also detecting newer model tags deployed in 2014. The new reader antenna can detect tags from greater distances and for faster moving objects which should improve detectability of marked bats. The reader only, not the antenna, was removed in late October of 2013 for the winter and re-installed on April 30, 2014. In May 2014, a larger solar panel with greater charging capacity was installed as the previous set up was discharging after several weeks. Further, during the tagging event in July, the sensitivity of the antenna was adjusted on the reader to better detect AVID tags. In order to better understand potential activity at this site during the winter, the reader was left in place during the winter of 2014-2015.

In 2014, after three years of pilot efforts, the survival and seasonal movement study was initiated with the capture and marking of 264 *C. townsendii*. In 2015 and 2016 we marked an additional 274 and 204 bats, respectively, bringing the total number of bats marked to 840 (Table 6).

Table 6. Number of *Corynorhinus townsendii* marked with PIT tags at Elephant Mountain Mine.

Tagging Dates	Juvenile Females	Juvenile Males	Adult Females	Adult Males	Total
July 19-20, 2011	0	0	70	28	98
July 15-16, 2014	0	0	163	52	215
August 27, 2014	15	25	7	2	49
July 15-16, 2015	0	0	159	54	213
August 24, 2015	21	30	9	1	61
July 20-21, 2016	0	0	126	53	179
August 30, 2016	14	11	0	0	25
					840

Bats continued to use the maternity site despite the capture and tagging disturbance with 90% (666/742) of individuals marked in 2014 – 2016 detected at least once. An additional 43 bats (44%) marked with AVID tags in 2011 were detected at least once, despite inconsistent monitoring prior to the installation of the current reader and solar panel. For individuals marked in 2014 – 2016, there is some variation in detections by sex with 92% (471/514) detected at least once compared to 82% (186/228) for males. When age is considered, more variation is apparent: 90% (45/50) of juvenile females, 97% (64/66) of juvenile males, 92% (426/464) of adult females, and 75% (122/162) of adult males were detected at least once. These data indicate adult males are most likely to abandon the roost without returning after marking. These results are not surprising as adult males are expected to have the lowest fidelity to a maternity site.

To explore fidelity to the roost site following marking, we also compared the number of individuals returning to the roost in subsequent maternity seasons following marking. Variation in fidelity by sex was noted with higher percentages of females (44%) detected in at least one subsequent maternity season following marking compared to males (38%). Additional variation by age is apparent between juvenile females (20%) and juvenile males (32%), and adult females (46%) and adult males (41%) returning to the site in maternity seasons after marking. These results were expected as adult females generally have the highest fidelity to a maternity site.

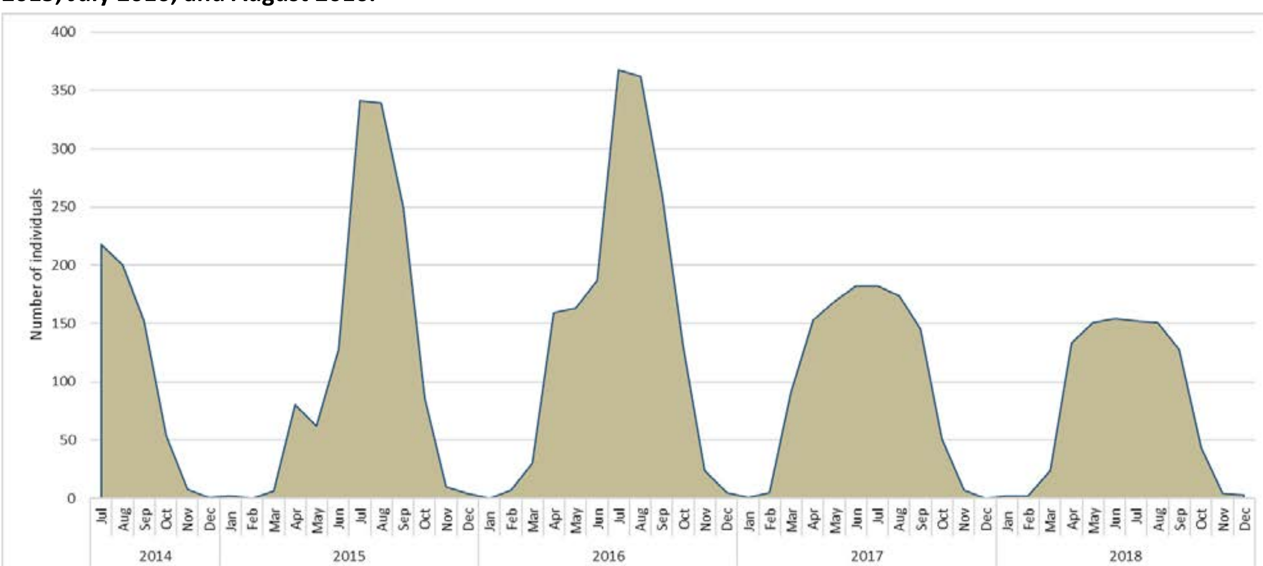
Eleven bats (one male and 10 females) marked in 2011 with AVID tags were detected at the mine by the reader in 2018. These bats were adults when tagged making them at least eight years old.

Table 7. Number of marked *Corynorhinus townsendii*, by age and sex, detected within the same season as marking and detected in the following maternity season for each year marking occurred. Juveniles were not marked in 2011.

		Number detected during same maternity season as tagging event				Number detected in the maternity season or seasons following tagging event			
Year	Total Marked	Juvenile Females	Juvenile Males	Adult Females	Adult Males	Juvenile Females	Juvenile Males	Adult Females	Adult Males
2011	98	-	-	0	0	-	-	32	11
2014	264	13	25	151	43	1	12	80	25
2015	273	18	28	156	36	7	7	84	22
2016	204	14	11	119	43	2	2	48	19

Activity at the site continued throughout each year, with detections occurring every month except during some winter months (Figure 1). Noticeable increases in the number of bats detected occurred at each of the tagging events in July and August of 2014 – 2016. Declines in the number of individuals present at the mine began in September each year and these data correspond with previous observations that this site is not used to a significant extent in the winter.

Figure 1. Number of unique PIT tagged *Corynorhinus townsendii* recorded at Elephant Mountain Mine from July 16, 2014 to December 31, 2018 by month. Tagging events occurred in July 2014, August 2014, July 2015, August 2015, July 2016, and August 2016.



Townsend's Big-eared Bat Survival Analysis:

Using PIT tag data collected while the antenna was installed at Elephant Mountain Mine from 2011 to 2018, we conducted an analysis of annual survival for *Corynorhinus townsendii*.

One of the primary assumptions of any mark-recapture study is that marks are permanent (Seber 1982). At this site, we have noted some bats are losing their PIT tags while roosting. Because of the internal structure of the mine and the locations where bats roost within the mine, we have been able to retrieve PIT tags lost from bats. A summary of PIT tag recovery is provided in Table 8.

Table 8. Dropped PIT tag recoveries, number of individuals tagged, and tag recovery rate by age when tagged, sex, and year tagged for *Corynorhinus townsendii* at Elephant Mountain Mine.

	2011 Tag Year		2014 Tag Year		2015 Tag Year		2016 Tag Year		
Age/Sex Group	# recovered / # tagged	rate	# recovered / # tagged	rate	# recovered / # tagged	rate	# recovered / # tagged	rate	Total Rate
Juvenile Females	0 / 0	-	0 / 15	0	7 / 21	0.33	1 / 14	0.07	0.16
Juvenile Males	0 / 0	-	4 / 25	0.16	2 / 30	0.07	0 / 11	0	0.09
Adult Females	14 / 70	0.20	33 / 170	0.19	36 / 168	0.21	22 / 126	0.17	0.20
Adult Males	3 / 28	0.11	6 / 54	0.11	3 / 55	0.05	4 / 53	0.08	0.06
									0.16

We evaluated PIT tag retention by analyzing reader data for detections of bats that eventually lost tags that we retrieved. If we assume a relatively high detection rate of the reader (*i.e.*, when a tagged bat passes through the antenna, it is most likely recorded) and that individuals enter/exit the mine on a nightly basis during the active season, the last date a bat was detected should be close to the date the bat lost its tag. Using this information, we can generate a minimum tag retention length. This analysis is only possible with data for bats tagged in 2014-2016 as the reader data for bats tagged in 2011 were too inconsistent, and 17 of the 18 bats from 2011 that we know eventually lost tags were never detected again after initial marking. The one exception is for an adult male that retained its tag for over 4 years before its last detection at the mine in August 2015 and subsequent retrieval of its tag in February 2016.

Most bats tagged in 2014-2016 that lost their tags in the mine and that we recovered appeared to retain their tags from several days to nearly two months (Table 9). The average minimum tag retention length is 65 days for juvenile females, 10 days for juvenile males, 44 days for adult females, and 56 days for adult males (excluding the one adult male that retained its tag for at least 1483 days). These data indicate that tags were not simply being lost through the insertion wound of the skin shortly after tagging, but that, somehow, tags are being lost following healing of the insertion site.

Table 9. Summary of tag retention based on reader detections for dropped PIT tags by age when tagged and sex for *Corynorhinus townsendii* marked with PIT tags at Elephant Mountain Mine from 2014-2016.

Age/Sex Group	no detections following tagging	1-2 detections	<1 month	1-2 months	3-11 months	12+ months	Total
Juvenile Females	0	0	0	7	0	1	8
Juvenile Males	0	0	2	4	0	0	6
Adult Females	2	3	22	59	4	1	91
Adult Males	0	1	2	8	1	1	13
							118

We used methods for PIT tagging bats that were similar to other studies (*e.g.,* Wimsatt *et al*. 2005; Rigby *et al.* 2015) and even shared personnel with the Fort Collins Rabies Project, that did not show evidence of significant PIT tag loss in their study on *Eptesicus fuscus* (Ellison *et al.* 2007). We believe that there is some characteristic of *C. townsendii* anatomy or behavior that makes this species more susceptible to PIT tag loss than has been shown for other species. This could be due to thinner skin that allows the PIT tag to be lost over time, grooming behavior (either by the individual or between individuals) that increases PIT tag loss, or other roosting behavior that causes loss.

Other studies have evaluated tag loss and made adjustments within the population models to account for this loss. However, all of these studies have relied on double-marking techniques to establish a rate of tag loss within the study population. We did not double-mark individuals during this effort and are only aware of the tag loss issue because we were able to search the roost location for dropped PIT tags. Violation of the assumption that marks are permanent poses a significant problem for analysis of survival. Because of the significant tag loss, we cannot be sure of the fate of other tagged individuals unless they are detected at the reader. In those instances we can be assured that the individual is alive and present at the maternity site. The case where a marked bat loses its tag and we do not recover that tag from the mine floor cannot be differentiated from a tagged bat dying or a tagged bat permanently emigrating from the maternity site.

We evaluated survival of marked bats using individuals tagged in 2014-2016 and excluded bats tagged in 2011 because detections using the initial pilot reader set-up were too inconsistent to provide reliable detections. We also excluded individuals that we know to have lost tags (118 individuals). This leaves a sample size of 624 *C. townsendii.*

We analyzed mark-recapture data using the Huggins robust design model in Program MARK (White and Burnham 1999). Data recorded by the PIT antenna were compiled into three month-long secondary samples per yearly primary sample. We assumed closure for three months during the peak of the maternity season (June, July and August). Bats were combined into four groups based upon sex and age class (adult or juvenile) when tagged. We estimated annual survival (S), capture probability (p), recapture probability (c), and temporary movement probabilities (γ' and γ") by model averaging over the set of most-parsimonious models, and models were compared using Akaike's Information Criterion for small sample size (AIC_c) and AIC_c model weights (Burnham and Anderson 2002).

Using a step-down modeling approach following Lebreton et al. (1992), we developed possible models of p and c while using a highly parameterized model of S, γ' and γ'', then used the most parsimonious model of p and c from the initial model set to model S, γ' and γ''. Capture and recapture probabilities were modeled using time, year, sex, age when tagged, and as constant. Capture probability was set to equal recapture probability in all time-varying models, but p and c were modeled separately using combinations of sex, age when tagged, and as constant.

The most parsimonious model for capture probability and recapture probability had a group (sex and age when tagged) by time interaction with capture and recapture probabilities equal: S(group*time) γ''(group*time) γ'(group*time) p=c(group*time). To model S, γ'' and γ', we used the p=c(group*time) structure for all possible models. Covariates for modeling survival included combinations of sex and age when tagged, body condition index (BCI; body mass / forearm length) when tagged, and variation over time. After some investigation of modeling variation in temporary movement probabilities, we modeled γ'' and γ' as constant or varying by group (sex and age when tagged). Models of random movement (where $\gamma''=\gamma'$) for both constant and group model structures were also included. No time-varying models of movement probabilities were included.

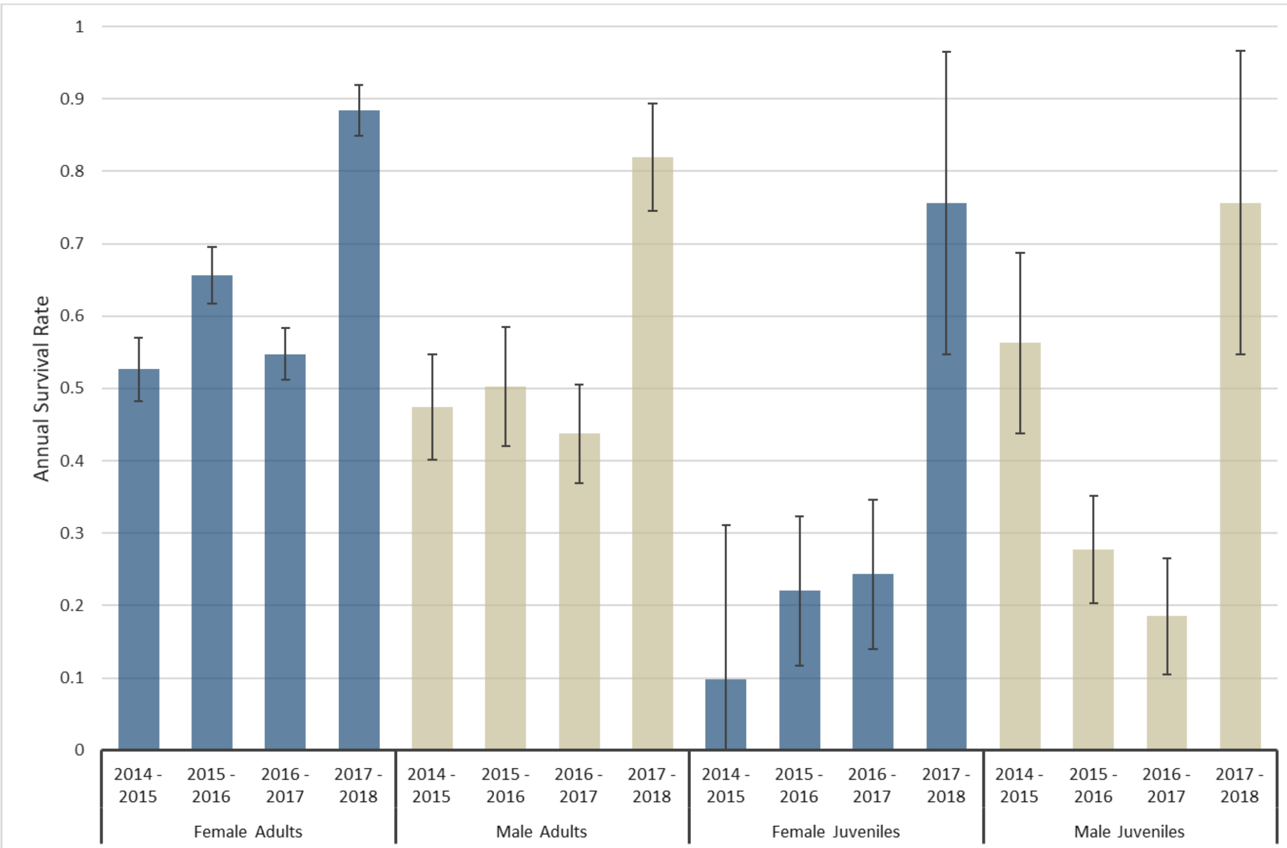
The most-parsimonious models of annual survival included time-variation, and either group (sex and age when tagged) or just age when tagged (Table 10). None of the top models for annual survival included BCI, group or sex alone without time variation, or survival modeled as constant. There was evidence for random movement ($\gamma''=\gamma'$) in the top model, however the ΔAIC_c between the top two models is slightly greater than 2.00 indicating the additional weight of the top model is due to the reduction in the number of parameters (74 to 73) from the model of constant movement among groups and constant and random movement.

Table 10. Set of most-parsimonious models for survival (S), temporary movement probabilities (γ'' and γ'), capture probability (*p*), and recapture probability (*c*) ordered by AIC_c. Models within the model set that had AIC_c weight >0 are included.

Model Name	AIC_c	ΔAIC_c	AIC_c weight	No. parameters
S(g*t) gam"=gam'(.) p=c(grp*t)	3661.5734	0	0.57532	73
S(g*t) gam"(.) gam'(.) p=c(grp*t)	3663.6793	2.1059	0.20073	74
S(age*t) gam"=gam'(.) p=c(grp*t)	3664.1713	2.5979	0.15696	65
S(g*t) gam"=gam'(g) p=c(grp*t)	3667.0738	5.5004	0.03677	76
S(age*t) gam"(.) gam'(.) p=c(grp*t)	3667.5082	5.9348	0.02959	66
S(g*t) gam"(g) gam'(g) p=c(grp*t)	3676.1584	14.585	0.00039	80
S(g*t) gam"(g) gam'(g) p=c(grp*t)	3677.2002	15.6268	0.00023	80

Model averaged estimates of annual survival were calculated using all models in the candidate set that had any AIC_c weight. Precision of these estimates was best for adult females followed by adult males (Figure 2). In general, sample size was too small (especially with the documented tag loss) to precisely estimate annual survival for juveniles.

Figure 2. Model averaged weighted annual survival (± unconditional SE) between maternity seasons of *Corynorhinus townsendii* at Elephant Mountain Mine by year, sex, and age when tagged.



Annual survival for adult females from the 2017 maternity season to the 2018 maternity season was 0.88 (95% CI: 0.79 – 0.94). This estimate is well within the range (and in some cases greater than) of estimates of female adult survival for other North American bat species including *Myotis lucifugus* (0.63 to 0.90; Frick *et al.* 2010), *Eptesicus fuscus* (0.61 to 0.99; O'Shea *et al.* 2011), and *M. yumanensis* (0.73 to 0.89; Frick *et al.* 2007).

Estimates of survival for all groups increased significantly between the 2017 and 2018 maternity seasons (Figure 2). We believe this is a reflection of a reduction in the tag loss rate each year following tagging for all groups. Most studies on tag loss assume that tag loss rate is greatest shortly after tagging and that tag loss rate decreases over time because the tag is lost through the insertion site (Lebl and Ruf 2009 and references therein). Based upon our data on minimum tag retention (Table

9), this decrease in tag loss rate over time is apparently true for this study as well, despite some individuals that retained their tags for more than one year before losing them. Our final tagging session was in August of 2016. If most of the bats that were going to lose their tags lost them within a year, our population of tagged bats should remain fairly constant and tag loss should be kept to a minimum following the 2017 maternity season. This is the most probable explanation for the significant increase in annual survival for 2017-2018.

Tag loss affects both accuracy and precision of estimates of population size and survival in mark-recapture studies (Arnason and Mills 1981). We acknowledge that in addition to the lost PIT tags we recovered, more bats likely lost their PIT tags, which will bias our estimates of survival. This rate of undiscovered tag loss is likely higher in males and juveniles that most likely do not use this roost with as high a fidelity as adult females and therefore would have a higher probability of losing their tags somewhere other than in the mine. However, as the time from our last tagging event increases, and presumably tag loss rate decreases, our estimates of survival will be more reliable especially for adult females.

Recommendations: The Townsend's big-eared bat maternity colony found at Elephant Mountain Mine is unique in its large size and the mine provides critical roosting habitat for a large portion of the local population for this species due to its unique geothermal traits. The White River National Forest should make this site a top conservation priority. Monitoring of the Elephant Mountain Mine for any evidence of WNS, including population declines that might be observed, should be continued through the use of PIT technology. These data will not only provide baseline levels for WNS monitoring at a large maternity colony, but will also improve our understanding of seasonal use at the site and provide presence/absence data that can be analyzed for accurate survival metrics of these bats. In turn, this information should allow for better management decisions not only at Elephant Mountain but at other sites throughout the White River National Forest and across Colorado.

Hubbards Cave

Location Information: White River National Forest, Eagle Ranger District, Eagle County, 7,000 feet

2017 and 2018 Survey Effort: Two full internal winter surveys were conducted on February 1, 2017 and February 13, 2018 to count hibernating bats and scan for PIT tagged individuals. In the past, winter surveys have occurred every three years, but due to the installation of gates at all of the entrances of this cave in the summer of 2017 a pre-construction survey was conducted in 2017 and a post-construction survey took place in 2018.

A total of 601 bats, 600 *Corynorhinus townsendii* and 1 *Myotis* sp., were noted during the 2017 visit (Table 11). Two *C. townsendii* marked with Biomark PIT tags at Elephant Mountain Mine were confirmed, one of which was scanned during the 2015 Hubbards Cave survey. Elephant Mountain Mine is approximately 30 miles from Hubbards Cave. A total of 615 bats, 613 *C. townsendii* and 2 *Myotis* spp., were observed during the 2018 visit (Table 12). Fifteen *C. townsendii* marked with PIT tags at Elephant Mountain Mine were confirmed wintering in the cave in 2018.

Table 11. Observations and notations for Hubbards Cave internal survey on February 1, 2017. Locations refer to names as depicted on map by Reames (2011).

Location	Observation
Western Parallel	10 COTO
End of Western Parallel	27 COTO
Room after Western Parallel	70 COTO
Area with 20-foot ceiling before Mystery Pit	123 COTO
Mystery Pit	164 COTO
Room after Mystery Pit	118 COTO
Larger room after Mystery Pit with 35-foot ceiling	35 COTO
Main Parallel	1 COTO
Eastern Parallel	4 COTO; 1 MYSP
Dome in ladder room leading to Cherry Hill	4 COTO
Room with 6-foot ceiling off of the Far-Eastern Parallel	24 COTO
Far-Eastern Parallel	20 COTO

Table 12. Observations and notations for Hubbards Cave internal survey on February 13, 2018. Locations refer to names as depicted on map by Reames (2011).

Location	Observation
Inside Western Entrance at the beginning of Western Parallel	6 COTO
Middle of Western Parallel	5 COTO
End of Western Parallel	13 COTO
Room at end of Western Parallel with 45-foot ceiling	Roost Logger (#523) deployed
Room after Western Parallel	72 COTO
Area with 20-foot ceiling before Mystery Pit	75 COTO
Mystery Pit	87 COTO
Room after Mystery Pit	159 COTO; 2 MYSP
Larger room after Mystery Pit with 35-foot ceiling	139 COTO
Main Parallel section with 20-foot ceiling	4 COTO
Main Parallel section with 15-foot ceiling	3 COTO
Room at end of Main Parallel	1 COTO
Room between Main Parallel and Eastern Parallel	1 COTO
Eastern Parallel	2 COTO
Dome in ladder room leading to Cherry Hill	9 COTO
Room with 6-foot ceiling off of the Far-Eastern Parallel	6 COTO
End of Eastern Parallel with 25-foot ceiling before passage to Far-Eastern Parallel	Roost Logger (#617) deployed
Far-Eastern Parallel	31 COTO

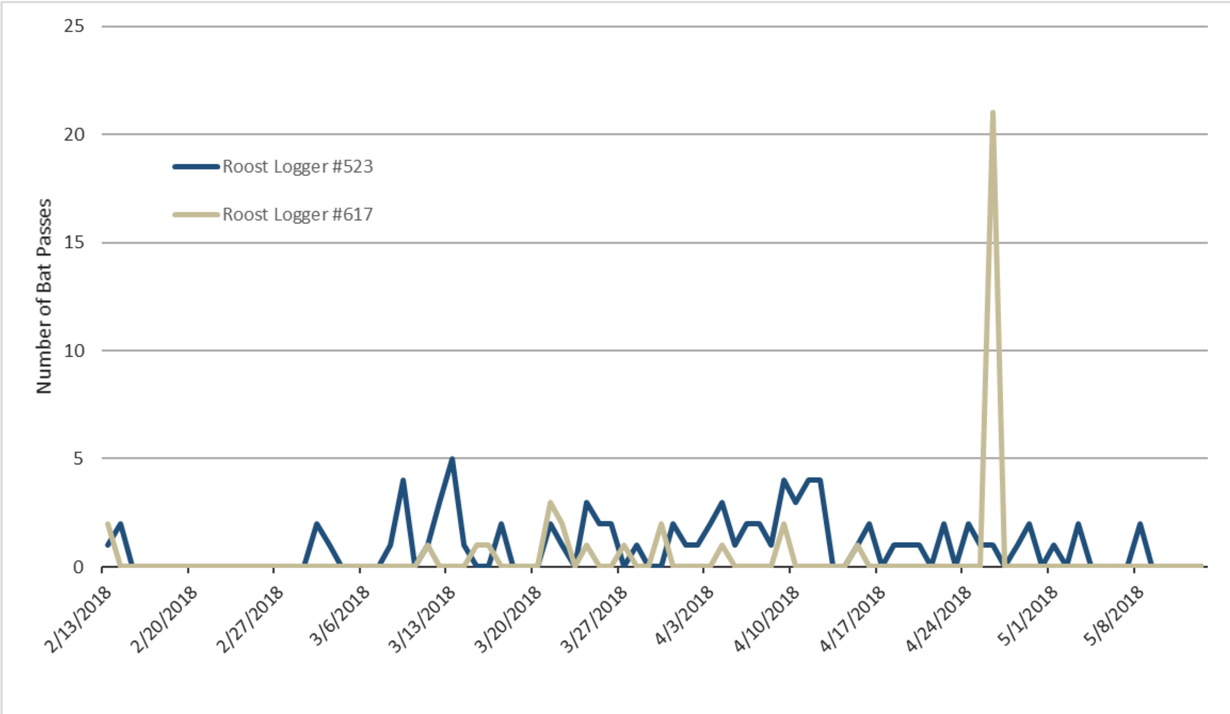
A summary of PIT tagged individuals marked at Elephant Mountain Mine and scanned at Hubbards Cave is provided in Table 13 below. In addition to the internal surveys, two acoustic roost loggers were placed in the cave during the 2018 hibernation survey to better understand winter activity levels within the cave. The roost loggers were retrieved on August 24, 2018 and the results are summarized below.

Table 13. Summary of *Corynorhinus townsendii* individuals PIT tagged at Elephant Mountain Mine and detected at Hubbards Cave during hibernation surveys.

PIT Tag Number	Summer Tagged	Sex	Age When Tagged	2012	2015	2017	2018
070 268 049	2011	F	A	Y			
FDT14NOH4CADV4DC	2011	F	A	Y	Y		Y
HU7A1P7CQ1G989PG	2011	F	A	Y	Y		
KUJFL0K7KE8VCESE	2011	F	A	Y	Y		
NASGQ2S8O8JUC0H4	2011	F	A	Y	Y		
50JU58AQM2ELR94Q	2011	F	A	Y	Y		Y
982000361973178	2014	F	A		Y	Y	Y
982000361968582	2014	F	A		Y		Y
982000361968731	2014	F	A		Y		
982000361968904	2014	F	A		Y		
982000361969186	2014	F	A		Y		Y
982000361969289	2014	F	A		Y		
982000361994247	2014	F	A		Y		
982000362044191	2014	F	A		Y		
982000363565932	2014	F	A		Y		
982000363566973	2014	F	A		Y		
982000361994125	2014	M	J				Y
982000361994034	2015	M	A				Y
982000363332604	2015	F	A				Y
982000363333389	2015	F	A				Y
982000363333814	2015	F	A				Y
982000363336085	2015	F	A				Y
982000363565568	2015	F	A			Y	Y
982000364294898	2015	F	A				Y
982000363784419	2015	F	J				Y
982000363794507	2016	F	A				Y

Bat activity through the winter was measured using acoustic Roost Loggers that are designed to count bat passes using minimal electrical power so that they can be deployed for long periods of time. We deployed two roost loggers on February 13, 2018 and retrieved them on August 24, 2018 at locations indicated above (Table 12). Following scrubbing of noise files, 84 bat passes were recorded from Roost Logger #523 and 39 passes recorded from Roost Logger #617.

Figure 3. Number of bat passes recorded by two acoustic Roost Loggers deployed in Hubbards Cave from February 23, 2018 to August 24, 2018. No passes were recorded at either logger after May 8, 2018.



Use Comments: Cavers reported large numbers of hibernating bats using Hubbards Cave in 1958, most of which were *C. townsendii* (Potter 2005). A monitoring effort 10 years later by J. S. Altenbach counted 500 *C. townsendii* in December verifying this site as the largest known hibernaculum in Colorado and one of the largest *C. townsendii* hibernaculum known in North America. In 2005, efforts began to survey the cave in winter once every 3 years with counts ranging from 473 in 2005 to 585 in 2009. A full internal survey with the exception of the Cherry Hill passage was conducted February 24, 2012 to count hibernating bats and scan for individuals marked with PIT tags at Elephant Mountain Mine the previous summer and revealed 605 *C. townsendii*. Six marked individuals from that effort were verified hibernating in Hubbards Cave, which is approximately 30 miles from the mine. A second full survey with the same exceptions as the previous visit was conducted to swap 7 dataloggers and collect swarming data in late August. Five bats were observed during the internal survey, at least one of which was on the wing. Swarming data were collected that evening during an external acoustic and visual survey with moderate levels of activity noted at the West Entrance and lower levels at the Main and East Entrances. An additional swarming survey was conducted on September 20, 2013 at the West Entrance where low levels of activity were noted (Siemers and Neubaum 2013). During the summer of 2017, three large gates were constructed at each of the three main entrances to Hubbards Cave following strict specifications known to be bat friendly when used on numerous mines around the state. Currently, the White River National Forest is enforcing a year-round closure of the cave.

Microclimate data collected at Hubbards Cave suggest the site supports temperatures that are highly suitable for hibernating bats with humidity levels that range widely depending on location within the cave; conditions throughout the cave were also noted to be suitable for supporting *Pd* (Siemers and Neubaum 2015).

Recommendations: Although this site receives a relatively low number of visitors in winter, its location is well known to the public and visitation historically was common in the summer by individuals not familiar with proper caving etiquette and WNS decontamination procedures. The roosting habitat this cave provides to an exceptionally large winter colony of *C. townsendii*, a state and federal species of concern, is rare in Colorado and protection of the site should be considered critical to the persistence of this species' local population. Protection of this bat colony during winter has been a top priority for the White River National Forest with installation of gates on all three entrances. Internal winter surveys should resume the three-year rotation used prior to gating as monitoring of this large colony will be important when WNS progresses through the state. Scanning for PIT tagged individuals should be conducted during the hibernation surveys that are scheduled to occur on a three-year rotation to further the understanding of roost use by this species. If *C. townsendii* continues to show resistance to WNS after its arrival to Colorado despite exposure to *Pd,* as has been shown elsewhere within the range of the disease, the Forest Service should consider allowing summer use of the cave by grottos that have a demonstrated record of following WNS decontamination procedures and a high caving ethic.

Hibernating cluster of *Corynorhinus townsendii* in Hubbards Cave.

Ice Cave

Ice Cave entrance on February 1, 2017.

Location Information: White River National Forest, Eagle Ranger District, Eagle County, 7,000 feet

2017 Survey Effort: An internal winter survey was conducted on February 1, 2017. Five hibernating bats were observed during the internal survey, but could not be identified due to the height at which they were roosting. One bat was observed near the 50-foot ceiling label on the map for Hubbards Cave by Reames (2011) which depicts Ice Cave as well. Two bats near the middle of the cave, and two more near the back of the cave near the 25-foot ceiling label (Reames 2011) were also documented. Internal surface temperatures ranged between -2.5° C and 0.7° C and relative humidity from 77.3% to 78.0%.

Use Comments: No previous bat use has been reported at this cave. An internal survey was conducted in August 2001, but no bats were observed at that time (Siemers 2002).

Recommendations: The entrance to this cave is northeast of and less than 100 yards from the Eastern Entrance of Hubbards Cave. This cave was not gated during the Hubbards Cave gating project in 2017 due to its mostly solid rock wall that it shares with Hubbard Cave. The Far Eastern Parallel within Hubbards Cave comes in close proximity to Ice Cave. If a connection between Hubbards and Ice Cave were to be found, or created, there would be open access to all of Hubbards Cave. We did note some evidence of digging present in the northeast end of the Far-Eastern Parallel of Hubbards Cave, presumably an effort to connect the two caves. The natural rock barrier between Ice Cave and the nearby passages of Hubbards Cave should be monitored to maintain the protection to the *Corynorhinus townsendii* hibernaculum provided by the Hubbards Cave gating effort.

Spring Cave

Location Information: White River National Forest, Blanco Ranger District, Rio Blanco County, 8,000 feet

Spring Cave gated entrance with typical ice formations.

2016 and 2017 Survey Effort: During the summer of 2016 a gate was installed on both the east and west entrances of Spring Cave. Two partial internal winter surveys were conducted on January 23, 2017 and December 5, 2017 to count hibernating bats post gate installation in 2016 (Table 14). A total of 12 *Corynorhinus townsendii,* 2 *Eptesicus fuscus*, 3 *Myotis* spp., and 1 *M. lucifugus/M. volans* were observed in the passages before the Ladder during the first visit. Early the following winter, a total of 30 bats, 20 *C. townsendii,* 4 *E. fuscus*, 5 *Myotis* spp., and 1 *M. ciliolabrum* were counted. These counts match those made prior to 2016 suggesting there were no lasting negative effects from gate installation.

Use Comments: Spring Cave was first noted as a hibernaculum in 1977 when approximately 100 bats were reported (Potter 2011). Subsequent trips have recorded much smaller numbers in the low twenties. The entrance portions of the cave before the Living Room (BigDaddyMaps.com 2008) have been vandalized by graffiti and formations broken. Vandalism along with frequent public visitation may have led to the decline in use by bats at Spring Cave. Internal visits from the entrances back to the Ladder during the winters of 2011 and 2012 confirmed that bats still hibernate in the cave but in lower numbers. The cave also appears to provide transitional roosting for migratory species as noted by the *Lasionycteris noctivagans* captured on August 30, 2001 (Siemers 2002). Scattered guano under domes in the East Entrance suggests that night roosting during the summer and transitional periods occurs at the site as well. Video surveys during October of 2011 suggest at least low levels of swarming occur here (Mosch 2011c). An additional swarming survey was conducted in September of 2013 and also noted low levels of swarming (Siemers and Neubaum 2013). In 2013, a partial winter survey was conducted on February 25 with 27 bats (21 *C. townsendii*, 5 *Myotis* spp., 1 unknown) roosting between the entrance and the ladder (Siemers and Neubaum 2013). Concentrations were noted where the East Entrance meets the West Entrance and in the deeper half of the Living Room with *C. townsendii* roosting out in the open and the *Myotis* spp. generally using tight cracks or fissures. In 2014, findings from the February 18 survey were similar to those in 2013 with 32 bats (19 *C. townsendii*, 2 *E. fuscus*, 10 *Myotis* spp., 1 unknown) roosting between the entrance and ladder. As noted in other surveys, *C. townsendii* roosted in the open, sometimes in small groups, and *Myotis* spp. roosted alone and were tucked into small solution tubes, cracks or fissures. In February 2015, 22 bats (19 *C. townsendii*, 1 *E. fuscus*, and 2 *Myotis* spp.) were observed in passages to the first sump past Jones Beach (Siemers and Neubaum 2015).

Table 14. Observations and notations for the Spring Cave internal survey on January 23, 2017 and December 5, 2017. Locations within the cave follow names provided by BigDaddyMaps.com (2008).

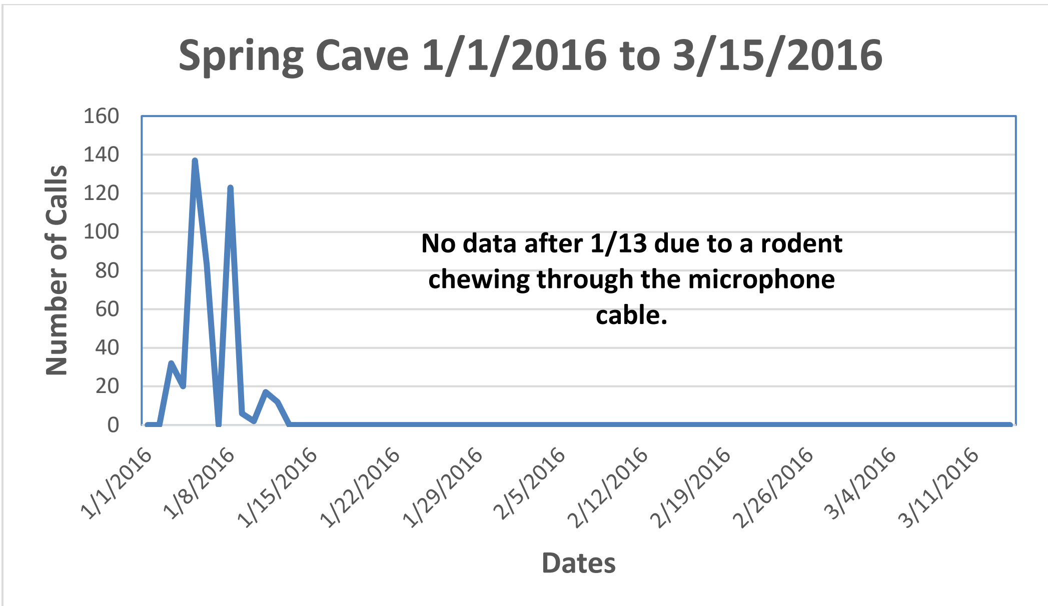
Location	Observation
January 23, 2017	
West Entrance portal	-3.0°C surface/4.2°C ambient/63.0% RH
Inside West Entrance	1 COTO
Junction of West Entrance passage with East Entrance and Living Room	5 COTO, 1 EPFU, and 2 MYSP (2.7°C surface/10.8°C ambient/58.2% RH)
Beginning of Living Room	2 COTO
Midway through the Living Room	3 COTO and 1 MYSP (3.5°C surface/9.7°C ambient/64.4% RH)
Dome in Living Room by passage leading to Pirates Den	1 EPFU and 1 MYLU/MYVO
Ladder Room	1 COTO (3.9°C surface/8.7°C ambient/62.5% RH)
December 5, 2017	
West Entrance portal	-1.5°C ambient/44.0% RH
East Entrance portal	1 EPFU (0.5°C ambient/54.0% RH); 2 COTO (2.0°C ambient/57.0% RH)
Junction of West Entrance passage with East Entrance and Living Room	3 COTO (6.0°C ambient/59.0% RH)
Junction of East Entrance and Living Room	2 COTO
Beginning of Living Room	1 COTO, 3 EPFU, 1 MYCI, 1 MYSP
Midway through the Living Room	6 COTO
Low side pocket off Living Room	1 MYSP (7.1°C ambient/55.0% RH)
Living Room just before Pirates Den	2 COTO, 3 MYSP
Junction of Living Room and Pirates Den	3 COTO
Ladder Room	1 COTO (11.1°C ambient/51.4% RH)

Acoustic monitoring from January to March of 2016 and 2018 suggests continued low levels of activity during winter months with occasional spikes that may correspond with short periods of bat activity. Technical challenges of keeping the acoustic detector were experienced in 2016 when the microphone was severed by what appeared to be rodent bites in mid-January. In 2017, a malfunctioning solar panel connection kept the battery from being charged and no calls were classified to species or either of the broader frequency groups. In general, most calls recorded at this site are not classified to species but assigned to high and low frequency groups. However, six calls in 2018 were classified as *E. fuscus,* a species that is generally noted during internal winter surveys in small numbers. Internal surveys indicate high proportions of *C. townsendii* using the cave relative to other species, but acoustic records were not classified for this species. These findings are not surprising as *C. townsendii* is known to emit "soft" calls with a low intensity that make it challenging to record at a quality level that allows classification. In addition, placement of the microphone high above the cave entrance, the only location that provides a clear projection, may play a role in lowering call quality since it increases the distance to the bats. Data presented here are for the core winter months only (January 1st to March 15th) to maintain consistency in comparisons with previous years. Despite the truncated season in 2016, the number of calls recorded during the spikes of activity in January were twice as high as those seen the previous year. This increase may suggest that bats were circling or calling more before entering the cave due to the presence of the new gate installed at the portal. Patterns for activity level by date recorded in 2018 were similar to those seen in years without technical constraints (2012 – 2014) with low but persistent numbers of calls interrupted periodically by small spikes in number of calls during the winter months (Siemers and Neubaum 2014). Total numbers of bat passes recorded during the 2018 winter were lower than those from 2016 which may suggest that bats have acclimated to the new gate and do not need to circle or "test" the gate with several calls before entering. Peaks in activity occurred during typical evening hours of the day (Figure 4).

Recommendations: This site has received high levels of vandalism (graffiti and trash deposition) in comparison to other Colorado caves due to its well-known location by the public. Installation of a gate in 2016 should eliminate potential disturbance during the winter season. However, access during the summer season may allow for *Pd* to be transferred to the cave by users choosing not to follow decontamination requirements. Given the consistent use of this site by bats, particularly as a hibernaculum, and its decline in numbers of individuals in comparison to historic counts, use by *Myotis* species, and seasonal access, Spring Cave should continue to be ranked high on the White River National Forest's list of caves needing action to address threats from WNS. Development of a cave management plan would assist with future decisions on how to manage this cave as the threat of WNS arriving to the state gets closer. Spring Cave is one of the few caves in Colorado with modest numbers of *Myotis* species documented during most internal winter surveys. Given the typical high rates of mortality for these species at infected sites, efforts to monitor this cave on a yearly basis will be necessary to determine the impacts of WNS on local bat populations (Neubaum et al. 2017).

Figure 4. Acoustic activity levels during the hibernation season by date (A) and time of day (B) for Spring Cave, Rio Blanco County from January 1st to January 13th, 2016. Recording was truncated due to the microphone cable being severed by an unidentified rodent. Calls classified to species or to one of the frequency groups are included in the total number of calls for each time period.

A



B

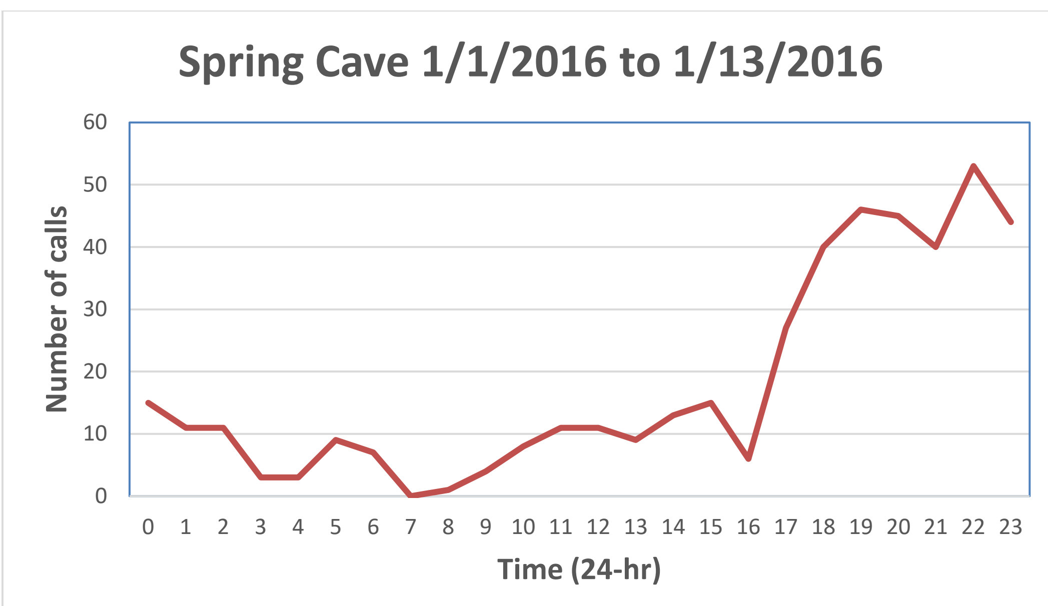
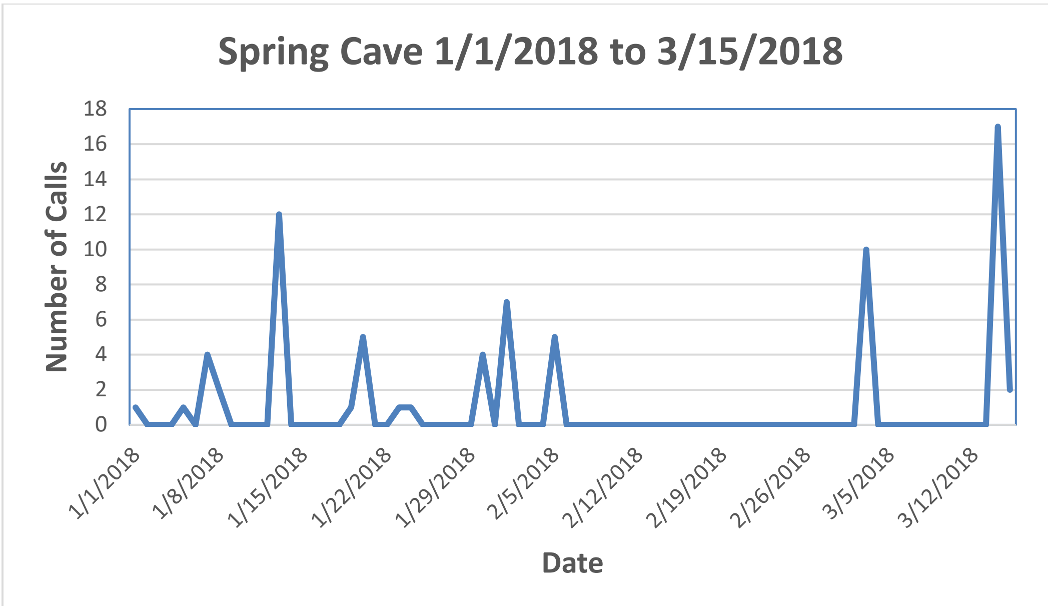


Figure 5. Acoustic activity levels during the hibernation season by date (A) and time of day (B) for Spring Cave, Rio Blanco County from January 1st to March 15th, 2018. Calls classified to species or to one of the frequency groups are included in the total number of calls for each time period.

A



B

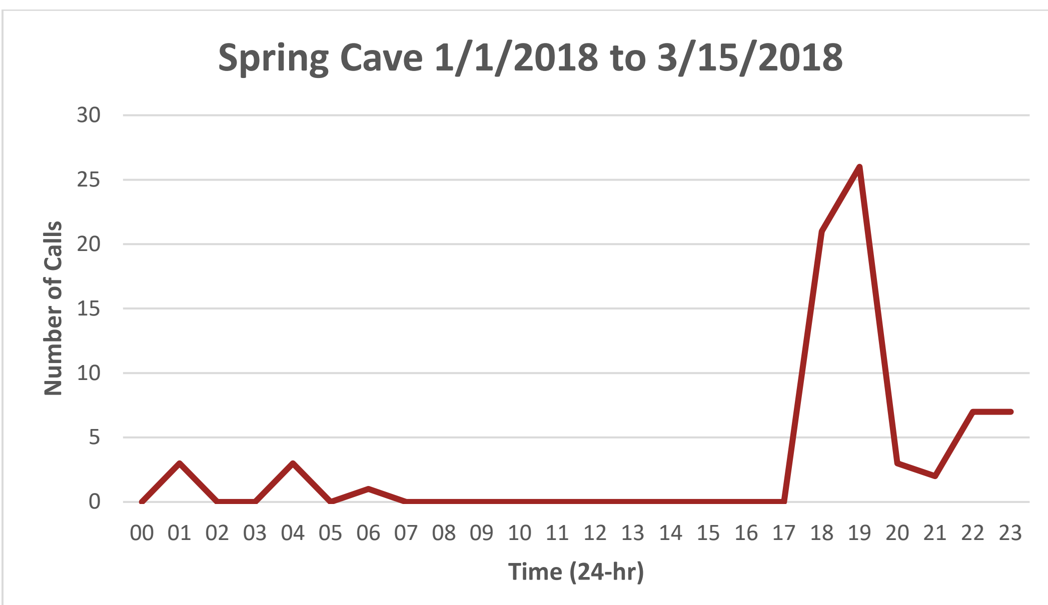


Table 15. Summary of documented use of caves and mines by bats on the White River National Forest visited in 2012-2018.

Site	Use Type							Species	Year	Source
	Hibernaculum	Transient	Day	Night	Maternity	Bachelor	Swarming			
Bair Cave	confirmed	confirmed	confirmed	confirmed			possible	COTO, MYVO	2008-2009, 2012-2013	Mosch 2009a, 2009d; Siemers and Neubaum 2013; Siemers *et al.* 2012
BC-2 Mine	possible	possible	possible	confirmed						Siemers and Neubaum 2013
Bulldog Mine		possible	possible	confirmed	confirmed			COTO, MYCI, MYVO	1998, 2015	Siemers and Neubaum 2013, 2015; Siemers, unpubl. data
Buffalito Cave			possible					unknown	2009	Mosch 2009d; Siemers *et al.* 2012
Buffalo Cave	confirmed	confirmed	probable	confirmed			confirmed	COTO, MYEV, MYCI, MYLU	2008, 2011-2012, 2017	This study; Siemers *et al.* 2012; Mosch 2008, 2011b
Charlotte's Cave	possible	probable	possible	confirmed			possible	COTO, MYCI, MYEV, MYLU, MYVO	2009, 2013	Siemers and Neubaum 2013; Mosch 2009c
Columbine Cave				possible						Siemers and Neubaum 2013; Mosch 2009b
Copper King Mine										Siemers and Neubaum 2014
Devil's Den Cave	confirmed							MYSP	2018	This study
Dry Tunnel Roost				probable				MYVO	2012	Siemers *et al.* 2012
Elephant Mountain Mine		confirmed	confirmed		confirmed			COTO	2012-2018	This study; Siemers and Neubaum 2013, 2014 & 2015; Siemers *et al.* 2012

Table 15 (continued).

Site	Use Type							Species	Year	Source
	Hibernaculum	Transient	Day	Night	Maternity	Bachelor	Swarming			
Five Windows Cave			possible	possible						Siemers and Neubaum 2013; Siemers *et al.* 2012
Fixin'-to-Die Cave	probable	confirmed	confirmed	probable	possible		confirmed	MYLU, MYTH, MYVO, MYYU	2002, 2012-2013	Siemers and Neubaum 2013; Siemers *et al.* 2012; Siemers 2002
Flycatcher Cave				possible						Siemers and Neubaum 2013
Fulford Cave	confirmed	confirmed	confirmed	confirmed				COTO, MYEV, MYLU, MYVO, MYYU	2002, 2014-2015	Siemers and Neubaum 2014, 2015; Siemers *et al.* 2012; Mosch 2010a; Siemers 2002
Fulton Cave	probable	possible	possible	confirmed			possible			Siemers and Neubaum 2013
Fulton Resurgence Cave			confirmed	confirmed			possible			Siemers and Neubaum 2013
GC-3 Mine	possible									Siemers and Neubaum 2014
Groaning Cave	confirmed	confirmed	confirmed	probable		probable	confirmed	MYLU, MYVO, MYEV, MYYU, MYCI, COTO	2002, 2012-2013	Siemers and Neubaum 2013; Siemers *et al.* 2012; Navo et al. 2002
Hubbards Cave	confirmed	confirmed	confirmed	confirmed		probable	confirmed	COTO, MYEV, MYLU, MYCI, EPFU	1958-2018	This study; Siemers and Neubaum 2015; Siemers *et al.* 2012; Potter 2005; Siemers 2002

Table 15 (continued).

Site	Use Type							Species	Year	Source
	Hibernaculum	Transient	Day	Night	Maternity	Bachelor	Swarming			
Ice Cave	confirmed							unknown	2017	This study
Indian Cave			possible	confirmed				COTO, LACI, LANO, MYEV, MYLU	2009, 2011-2012	Siemers *et al.* 2012; Mosch 2009d, 2011a
Lime Creek Cave	confirmed	probable	possible	confirmed			confirmed but very low activity	*Myotis* sp.	2012, 2014	Siemers and Neubaum 2014; Siemers *et al.* 2012; Mosch 2010c
Only Eight Cave				possible				MYLU	2012	Siemers *et al.* 2012
Powerline Cave		probable	probable				confirmed	MYEV, MYLU, MYVO	2013-2014	Siemers and Neubaum 2013, 2014
Premonition Cave	probable	confirmed	probable	probable	possible	probable	confirmed	COTO, *Myotis* sp.	2012	Siemers *et al.* 2012
Spring Cave	confirmed	confirmed	confirmed	confirmed		probable	confirmed	COTO, EPFU, LANO, MYCI, MYEV, MYLU, MYVO	1977-2018	This study; Mosch 2011c; Potter 2011; Siemers and Neubaum 2014, 2015; Siemers *et al.* 2012; Siemers 2002
The Tomb		confirmed	confirmed		confirmed			COTO, MYEV	2000-2015	Siemers and Neubaum 2015; Navo, unpubl. data
Thursday Morning Cave	confirmed	confirmed	probable	confirmed			confirmed	COTO, MYLU, MYTH, MYVO	2010, 2012-2013	Siemers and Neubaum 2013; Siemers *et al.* 2012; Mosch 2010b
Wednesday Afternoon Cave				probable					2012	Siemers *et al.* 2012

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