

**TEMPORAL AND SPATIAL DISTRIBUTION OF BATS
AT
PIPE SPRING NATIONAL MONUMENT
AND THE
KAIBAB PAIUTE INDIAN RESERVATION**

FINAL REPORT

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ABSTRACT

Pipe Spring National Monument represents one of the few perennial water sources within the Arizona Strip, a narrow stretch of land incorporating both southern Utah and northern Arizona. The water has been captured and stored in two historic ponds since the late 1800's. These ponds are a critical element of the cultural landscape for which the Monument was established in 1923. Because Pipe Spring remains one of the few water sources in the area, there is a tremendous amount of bat biodiversity. Historically, bat populations have only been studied sporadically and during a narrow window of the summer season. This study unifies past reports and has expanded the data collection window beginning in early spring and ending in late fall. Acoustical recording devices were deployed twice a month to record bat echolocation calls as well as monthly mist netting events. From hand capture methods we continued to find bats common to the area such as Allen's Big-Eared Bat, Western Pipistrelle, and the California Myotis. Using the acoustical equipment we have identified calls from the Western Red Bat, the Spotted Bat, and the Western Mastiff Bat, species previously unknown to the area. Additional data has also been provided by this project to the migratory patterns of the Mexican Free-Tail and Hoary bats. This project informs Park Management and land managers of the Kaibab Paiute Indian Reservation when certain bat species are present in the area, thereby influencing future decisions on when to conduct maintenance and other activities that may impact bat species.

Key words: Pipe Spring, Kaibab Paiute, bats, acoustics, SonoBat, ultrasound detectors, echolocation.

INTRODUCTION

Pipe Spring National Monument and the Kaibab Paiute Indian Reservation are located on the Arizona Strip spanning the border between Utah-Arizona. During the late 19th and early 20th centuries, Pipe Spring was used as the main water source for Mormon colonists traveling a primitive wagon road known as “the Honeymoon Trail.” The Monument is 40 total acres, and is currently surrounded by the Reservation. The water from Pipe Spring continues to be stored in two ponds near the Monument’s historic structures. These ponds are a contributing resource to the historic district and cultural landscape for which the Monument was established in 1923. There are currently two springs at the Monument fed by the Navajo Sandstone aquifer to the north and west, via the Sevier Fault (McKoy 2000).

Pipe Spring is located on the southern end of the Colorado Plateau, which is a dry desert landscape. Temperatures at the Monument range from 32 to 46 degrees Celsius in the summer and -17 to 4 degrees Celsius in the winter. The landscape is covered with sagebrush and rabbitbrush in the lower grassland areas with Pinyon-juniper trees dominating the higher elevations. Due to the scarcity of water in this region, there is a great diversity of life brought to the Monument. There are animals of all kinds located at the Monument, but bats are the most diverse and abundant. The ponds at Pipe Spring National Monument provide a constant water supply and insects for food. There are also many suitable areas for bats to roost with the fort, cliffs, and many pinyon-juniper trees nearby.

Other sources of open water that have been created in recent history. These additional sites were also of slight interest in this study and were consequently monitored acoustically for one night each. The first site is located directly north of the Monument within the Kaibab village. These two ponds are roughly 0.31 hectares each. The other two sites were Nails Crossing and Point Springs, both of which consist of very small water sources that have been used for watering livestock.

The identification of bat species that use the area has focused on the summer months of June through August (2001-2013). In addition, previous efforts have only included mist-netting methods. Currently, nine of the fourteen species confirmed present on the Monument are considered "Species of Special Concern" by the U.S. Fish and Wildlife Service (Hinman and Snow 2003). Bat activity data from this study will assist NPS management on how to maintain critical cultural resources while protecting sensitive wildlife species. Similarly, data from the project will also help the Tribe avoid disruptions

of bat habitat and bat populations on the Reservation. The objectives of the project are to:

- 1) synthesize existing data on bat species in the region
- 2) collect additional site-specific data on sensitive bat species
- 3) determine temporal and spatial distribution of bat species
- 4) collect data throughout the year including migration pulses
- 5) recommend best times to conduct pond maintenance activities at PISP
- 6) recommend long-term bat monitoring at Pipe Spring NM
- 7) increase cooperation between Pipe Spring NM and the Kaibab Band of Paiute Indians



Figure 1. PVC housing for Pettersson D240X. Used in 2012 & 2013 field seasons.

METHODS

Acoustic Methods

All acoustic surveys were conducted with Pettersson D240X full-spectrum detectors. In all deployments, the unit was placed at least 3 meters high in a near by tree overlooking the ponds or in a PVC housing. This housing was constructed using 4" PVC pipe, which was painted brown to conceal it in the nearby vegetation (See Figure 1). Power was supplied to the D240X by altering the power input on the device allowing it to be run from a steady AC power supply through an inverter.

The Pettersson D240X detected the bat calls, sending the digital signal to an H2 Zoom digital voice recorder. Once initiated, the H2 Zoom recorded the sound for an entire night, breaking the recording into four large wav. files. These files were saved on a 16GB SD flash card, which was then downloaded to a laptop for analysis.

SonoBat West v3.2 software (Szewzak) was used to process all recorded audio files. Before analysis, all files were “parsed and scrubbed” using SonoBat. This relatively quick process separated short snippets of audio calls that did not contain obvious bat calls. This process significantly reduced processing time. After

scrubbing, all remaining recordings were subjected to automated analysis using the species classification feature of the software. For a call to receive a bat species classification consensus, it had to have a discreet probability of likelihood of at least 0.90 and a minimum acceptable call quality of 0.80. These user-controlled settings are the software's default settings and were used for all call analysis.

Using SonoBat US West Summarizer, reports were generated to summarize individual monitoring nights. These reports include Consensus Counts, Corrected Counts, and the Estimated Likelihood of Presence (ELP) for each individual species. The Consensus

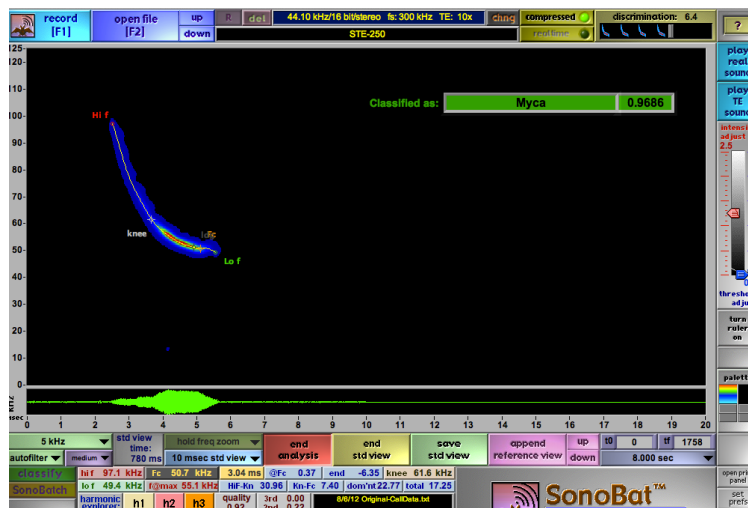


Figure 2. Typical spectrogram generated by SonoBat. This particular call is a *M. californicus*.



Figure 3. Picture of one 9 meter mist-net set up between the two ponds. The Winsor Castle is in the background.

Count is a species-specific tally of consensus decisions generated by the software. The Corrected Count considers a species respective call ambiguity and reduces the consensus count to minimize misclassifications and provides a more confident and conservative count. The ELP is a probabilistic estimate based on the known ambiguity and overlap of each particular species (SonoBat v3.2). A species with a very distinctive call will therefore require fewer recordings to generate a high ELP. Due to temporal variation of species compositions, and to limit false-positives due to large data sets, summary reports were generated from single night, single site data (Hayes 1997, SonoBat V3.2).

Once the acoustic results were tabulated, species were verified manually. All species of management

concern as classified by the Utah Division of Wildlife Resources (UDWR) as Tier II or III, species listed as "Candidate" species of concern by the Arizona Game and Fish

Department, as a species of high concern as denoted by the Western Bat Working Group (Hinman & Snow, 2003), or species with an ELP below 95% were hand confirmed by comparing the classified recordings to SonoBat provided voucher calls and known parameters (J. Szewczak 2011, J. Szewczak 2004). A sample spectrogram can be found in Figure 2.

The majority of the acoustic recordings took place near the Monument ponds each month throughout the two-year survey. Typically, a full night of recording was obtained once every two weeks. Three additional acoustic recording sessions occurred at alternative



Figure 4. Ariel photo of the Monument. White lines represent typical net set. Nets 1 & 2 were set up every netting event. Nets 3 & 4 were used sporadically with little success.

sites previously mentioned. These three recordings occurred specifically at 1) the large ponds directly north of the Monument near Kaibab village (UTM: 12S 344706 E, 4084623 N), 2) at Point Spring (UTM: 12S 346524 E, 4087516 N), and at 3) Nails Crossing (UTM: 350204 E, 4078091 N). The recording events at the large ponds in Kaibab village occurred while we were capturing bats at the nearby Monument and were stopped when the nets were taken down. The other two sites were monitored acoustically on separate days.

A National Park Service employee at Pipe Spring accomplished most these recordings. Data was also gathered using mist-netting once each month at the ponds in order to provide reference to our acoustical

recordings. These netting events were scheduled to be as near the new moon each month as possible in order to be consistent.

Data from all years and locations were merged together to create a better, more valid picture of when the various bat species used the park. As only the fall was recorded in 2010, and 2012 was sparse due to technical difficulties, this approach made the most sense.

The mist-nets set up around the Pipe Spring ponds were two 9m long nets set 10' high and one 6m long net also set 10' high (See Figure 4). Each netting session the mist-nets were opened at sundown and stayed open for three hours. The white-nose syndrome and

other transferable diseases in the eastern United States are currently decimating bat populations. To prevent the spread of transferable diseases, the nets were soaked in a Lysol® disinfectant for at least 2 hours before set up and gloves were changed after the handling of bats.

RESULTS

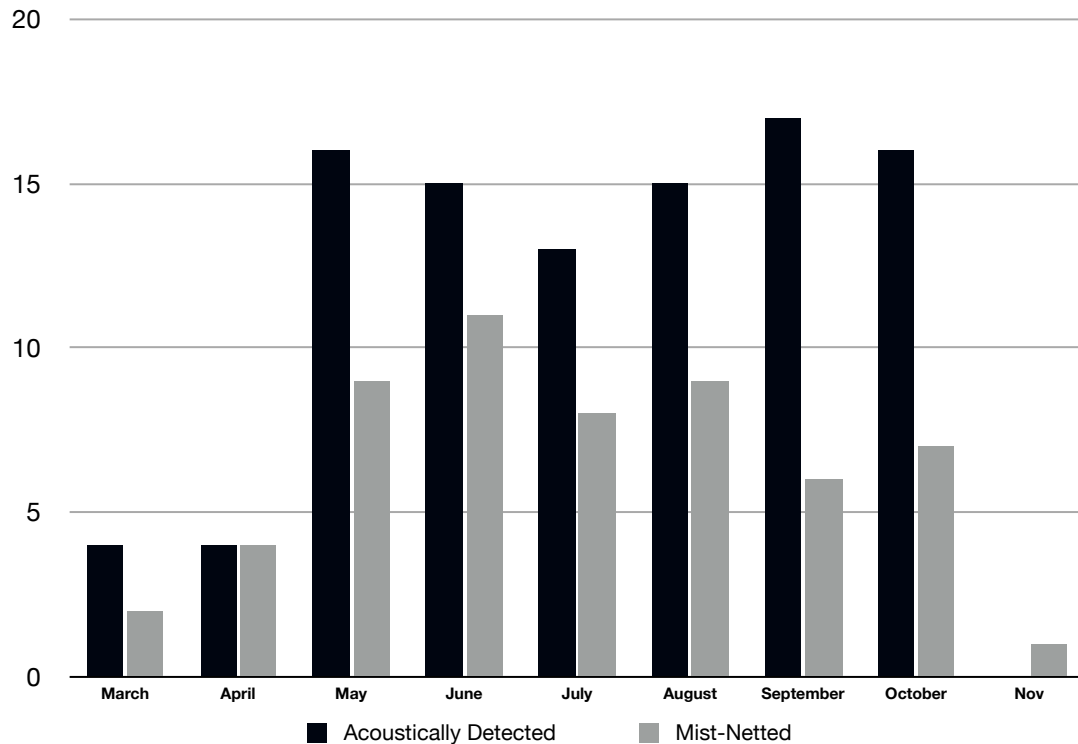
As previously mentioned, acoustic data from all years and locations were merged together to create a better, more valid picture of park use by bats. As was expected, most of the calls detected by the Pettersson D240x were from bats that had already been identified in previous studies. The most common bats found in the area were the Western Pipistrelle (*Parastrellus hesperus*), California Myotis (*Myotis californicus*), Mexican Free-tailed bat (*Tadarida brasiliensis*) and the Fringed Myotis (*Myotis thysanodes*). These bats were detected acoustically and captured regularly throughout the field season (April-October). In comparison, a few bats were only detected acoustically on a few occasions. *Myotis volans*, *Lasiurus borealis* (*blossevillei*), *Myotis evotis* and *Eumops perotis* were only detected a few times (Table 1).

	Mar 1-15	Mar 16-31	Apr 1-15	Apr 16-30	May 1-15	May 16-31	Jun 1-15	Jun 16-30	Jul 1-15	Jul 16-31	Aug 1-15	Aug 16-31	Sept 1-15	Sept 16-30	Oct 1-15	Oct 16-31	Nov 1-15
<i>Antrozous pallidus</i>					24%		100%	23%	24%	62%		24%	24%	48%			
<i>Corynorhinus townsendii</i>					25%		25%	99%						100%		74%	
<i>Eptesicus fuscus</i>				23%			9%		23%	23%	23%			23%		23%	
<i>Euderma maculatum</i>									86%	86%		86%					
<i>Eumops perotis</i>						99%	99%										
<i>Lasionycteris noctivagans</i>		23%						100%						23%		67%	
<i>Lasiurus borealis</i>														38%		19%	
<i>Lasiurus cinereus</i>				33%	86%		39%		67%	33%	33%	78%	78%	33%	55%	65%	32%
<i>Myotis californicus</i>	98%	100%	79%	100%	19%	46%	100%	100%	53%	92%	98%	100%	19%	100%	99%	99%	99%
<i>Myotis ciliolabrum</i>		20%		71%		20%	100%	100%	97%	95%	76%	20%					
<i>Myotis evotis</i>								24%						20%			
<i>Myotis lucifugus</i>							20%	100%									
<i>Myotis thysanodes</i>				100%	100%	100%	100%	100%	100%	100%	100%	100%	99%	99%		99%	
<i>Myotis volans</i>								19%			19%						
<i>Myotis yumanensis</i>	10%	34%		19%			39%	58%				19%		27%	19%	19%	8%
<i>Parastrellus hesperus</i>	100%	100%	20%	40%	20%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	99%
<i>Tadarida brasiliensis</i>	86%	33%		33%		33%	100%	100%	100%	33%	100%	97%	97%	100%	33%	100%	33%

Table 1. Estimated Likelihood of Presence as determined by Sonobat. This table is a summary of all acoustic data.

June through September exhibited the greatest species richness. Two time periods, late May/early June and late September/early October, both resulted in over 15 of the 17 possible species being detected acoustically. Though these two time periods were well

represented by different species, most of the summer month time periods routinely resulted in over 10 species being detected (Figure 5). In all, Pipe Spring National Monument exhibits high species richness, similar to other areas recently surveyed using the same techniques. For example, the authors have been conducting a similar study in both Bryce Canyon National Park and Zion National Park. Though these parks, which



are close neighbors to Pipe Spring National Monument, differ in landscape and elevation, all three exhibit very similar levels of bat species richness. The only differences between these parks is the bat species composition. For example, Mexican Free-tailed bats are very common in Pipe Spring, but are not in Bryce Canyon and have never been detected or thought to live in the Bryce Canyon area. In contrast, *Myotis volans* are very plentiful in Bryce Canyon, but they were rarely detected in Pipe Spring NM.

The Spotted Bat (*Euderma maculatum*), the Western Mastiff Bat (*Eumops perotis*), the Western Red Bat (*Lasiurus blossevillei*), and the Long-Eared Myotis (*Myotis evotis*) are a few of the bats that have never been caught at Pipe Spring National Monument, but that were detected acoustically. The Silver-Haired Bat (*Lasionycteris noctivagans*) was also detected acoustically, but has not been caught on the Monument since 2004. There were no bat species caught during the two-year study that had not been caught prior (Table 2).

As previously explained, the Consensus Count is a species-specific tally of consensus decisions generated by the Sonobat software. The Corrected Count considers a species

Figure 5. Graph comparing the number of different species captured and acoustically detected each month. Acoustic data is based on Consensus Count as determined by Sonobat.

respective call ambiguity and reduces the consensus count to minimize misclassifications and provides a more confident and conservative count. The ELP is a probabilistic estimate based on the known ambiguity and overlap of each particular species (SonoBat v3.2). A species with a very distinctive call will therefore require fewer recordings to generate a high ELP. Due to temporal variation of species compositions, and to limit

	Netted Taylor 2013	Acoustic Taylor 2013	Bogan 2005	Johnson 2005	Tyurbec 2013
<i>Antrozous pallidus</i>	20	7	X	X	
<i>Corynorhinus townsendii</i>	1	16	X	X	X
<i>Eptesicus fuscus</i>	14	1	X	X	
<i>Euderma maculatum</i>	0	3	P		X
<i>Eumops perotis</i>	0	3			X
<i>Idiocyleris phyllotis</i> *	7	0*	X	X	X
<i>Lasionycteris noctivagans</i>	0	3	X	X	
<i>Lasiurus blossevillei</i>	0	1	P		
<i>Lasiurus cinereus</i>	3	7	X	X	X
<i>Myotis californicus</i>	23	178	X	X	X
<i>Myotis ciliolabrum</i>	4	28	X	X	X
<i>Myotis evotis</i>	0	1		X	
<i>Myotis lucifugus</i>	2	1	X	X	X
<i>Myotis thysanodes</i>	40	64	X	X	X
<i>Myotis volans</i>	13	1	X	X	
<i>Myotis yumanensis</i>	9	8	X	X	X
<i>Parastrellus hesperus</i>	50	740	X	X	X
<i>Tadarida brasiliensis</i>	9	569	X	X	X

Table 2. Listing of the number of species netted and acoustically detected over the course of the study in comparison to past studies. Taylor's Acoustic numbers represent the conservative Corrected Count as determined by the Sonobat software.

* *Idiocyleris phyllotis* does not have a reference call library in Sonobat as yet. These calls were most likely detected by not classified by the software.

The letter "P" means that the species is possibly present.

false-positives due to large data sets, summary reports were generated from single night, single site data (Hayes 1997, SonoBat V3.2). The Corrected Count is a very conservative number, which is why many species were captured in greater numbers than were actually "counted" by the Sonobat software. For example, 20 pallid bats were captured over the course of the study, yet only 7 calls resulted from acoustic analysis. The same can be said for the Big Brown bat.

Taking into account this and all previously known studies conducted at Pipe Spring National Monument it is suggested that the list of confirmed bats within the park be updated to include all of the above listed species (Table 2). This will bring the current list up to 18 confirmed species. However, of these 18, *E. maculatum*, *E. perotis*, *L. blossevillii*, *M. evotis* have only been documented acoustically.

DISCUSSION

A significant setback to the study occurred for the acoustical recordings during 2012. After the winter of 2011, the Pettersson D240x and Zoom H2 both stopped recording with the quality found in 2011. The level of background noise within the files rendered the data unusable. This problem would come and go and replacement equipment eventually was found. Unfortunately, this setback has hindered the study, resulting in unreliable data between the months of March to July 2012. However, this impediment did not nullify the study, because significant comparisons could still be drawn from the 2011 and late summer-fall 2012 acoustical data.

There were a number of interesting anomalies encountered within this study when comparing hand-capture data and the acoustic results. For example, the Big Brown Bat (*Eptesicus fuscus*) was captured and heard frequently from May-Oct. in 2011. However, this bat was not heard in 2012, but was caught during the same summer-fall months as 2011. This lack of acoustic detection may be due to the similar echolocation call characteristics of the Big Brown bat to other bats, which could potentially cause Sonobat to misidentify the calls. Still, Sonobat regularly identified the Big Brown Bat in 2011, which leaves other possible explanations open for why they were not around the recorder as much in 2012. Along with the Big Brown bat, the Spotted bat, the Western Mastiff bat, the Long-Eared Myotis, and Townsend's Big-Eared bat were all heard in 2011, but not in 2012. However, there were no bats heard in 2012 that were not heard in 2011.

Another inconsistency between recording and hand catching involves the Allen's Big-Eared Bat (*Idionycteris phyllotis*). This bat is fairly common at Pipe Spring and has been caught seven times during the two-year study during the summer months, and at least once a year prior to this study. However, this bat has never been identified by the Sonobat system because Allen's Big-Eared Bat is not in the Sonobat reference call library. This was not revealed until near the end of the study, so unfortunately it is probable that the Allen's Big-Eared Bat calls were heard, but misidentified. We have since gone through the discarded files in Sonobat and are collecting possible *I. phyllotis* calls along with others, as described in the next two paragraphs.

The reverse situation of the Allen's Big-Eared bat appears to occur at Pipe Spring for the Western Red Bat (*Lasiurus blossevillii*). This bat has not been known to be in the area and has never been caught by mist nets at Pipe Spring, but Sonobat frequently identified it during the summer months. This finding leaves the door open for speculation that these bats are in the area, however, the Western Red Bat has relatively similar call

Regular Presence	Sporadic Presence
<i>Antrozous pallidus</i>	
	<i>Corynorhinus townsendii</i>
<i>Eptesicus fuscus</i>	
	<i>Euderma maculatum</i>
	<i>Eumops perotis</i>
	<i>Idionycteris phyllotis</i> *
	<i>Lasionycteris noctivagans</i>
	<i>Lasiurus blossevillii</i>
<i>Lasiurus cinereus</i>	
<i>Myotis californicus</i>	
<i>Myotis ciliolabrum</i>	
	<i>Myotis evotis</i>
	<i>Myotis lucifugus</i>
<i>Myotis thysanodes</i>	
	<i>Myotis volans</i>
<i>Myotis yumanensis</i>	
<i>Parastrellus hesperus</i>	
<i>Tadarida brasiliensis</i>	

Table 3. An alphabetized list of bat species who tend to use the park regularly vs. sporadically.

characteristics as the Western Pipistrelle, which may be a cause for misidentification. One subtle difference between the calls is a U-shaped curve near the end of the Western Red bat's call. At the time of this report, the authors were beginning the process of going through the thousands of *P. hesperus* calls looking for this subtle characteristic. In future months the authors may submit a suggestion of change to the National Park Service regarding the presence of the Western Red bat in the park.

The authors are also working towards building a reference library for *Nyctinomops macrotis*, *Eumops perotis* and *Idionycteris phyllotis*. If successfully completed, this addition to the Sonobat reference call library may shed new light on the presence of these species in Pipe Spring National Monument and other areas. This process has required the collective call libraries of

multiple researchers throughout the area and will most likely take over a year to develop a reliable call library. Once completed, this updated information will be given to the National Park Service and other federal and state agencies

The sporadic nature of which bats were caught on any given night was thought to be minimized by the addition of using acoustical recording equipment. It was supposed that if the bats were in the area, then we would frequently hear them on the recordings. So far,

however, there has continued to be inconsistencies in how often the bats are heard. In 2011 over 250 Pallid bats (*Antrozous pallidus*) were heard (Consensus Count) and in 2012 only 2 bats of this species were heard. Strangely, there were actually more Pallid bats caught in 2012 than in 2011. The same case can be made for the Mexican Free-Tailed bat (*Tadarida brasiliensis*). In 2011 the Mexican Free-Tailed bat was heard 731 times (Consensus Count) and in 2012 it was heard only twice. These numbers are very strange considering that these bats were caught three times in 2011 and five times in 2012. The discrepancies of how often the bats were heard each year in relation to how many times they were caught could be explained by lack of sample recordings in 2012.

The bat species deemed sensitive by the U.S. Fish and Wildlife Service found at Pipe Spring included: the Yuma Myotis (*Myotis yumanensis*), the Long-Eared Myotis (*Myotis evotis*), the Fringed Myotis (*Myotis thysanodes*), the Long-Legged Myotis (*Myotis volans*), the Small-Footed Myotis (*Myotis ciliolabrum*), the Spotted bat (*Euderma maculatum*), the Allen's Big-Eared bat (*Idionycteris phyllotis*), the Townsend's Big-Eared bat (*Corynorhinus townsendii*), and the Western Mastiff bat (*Eumops perotis*) (Hinman and Snow 2003). The Western Mastiff bat and the Spotted bat were the only two sensitive species bats not caught on site during the two-year study, but both were recorded in 2011. Townsend's Big-Eared bat, the Long-Eared Myotis, the Western Mastiff bat, and the Spotted bat were recorded in 2011, but not 2012. This could suggest a small population size of these sensitive species at Pipe Spring, although this hypothesis could be affected by the smaller sample size in 2012. Further monitoring needs to be done to confirm this further.

One of the strengths of acoustic monitoring is the tremendous amount of sampling hours gathered through very little effort. The ease of this system provides a relatively easy way to monitor the park for bat presence throughout the year, spotting interesting patterns that may not be elucidated by mist-netting alone. One such pattern can be found in Table 3. Half of these species were captured *and* acoustically detected, appearing to be present in area for much of the year. Of these, *P. hesperus* and *T. brasiliensis* seem to be perennial to the area (Table 3; see also Table 2). The other 9 species proved difficult to capture or acoustically detect each field season. These species appear to be in the area sporadically, possibly using the area as a migration stop or wintering location.

The general list of species detected at the ponds within the Kaibab Paiute Indian Reservation were identical to what was detected at the Monument. Originally, we hypothesized that perhaps the larger bats would be found at these ponds due to their larger size and ease of approach when drinking. This hypothesis may still be valid, though we detected acoustically large bats at both sites. Netting around these ponds may not be as fruitful as the Monument, in that the Paiute Tribal ponds are mostly surrounded by low shrubs and grasses. In contrast, the Monument ponds are surrounded by very tall trees that allow flyway access in reduced areas. Our netting set up made use of these restricted flyways. Both locations are very near to highly suitable habitat for the larger

bats with plentiful nearby sandstone cliffs. In summary, both of these water sources provide much needed water and insects for the bats in the area and should be maintained.

Recommendations

The incredible bat species diversity of Pipe Spring National Monument is definitely a strength of the educational outreach programs. The numerous evenings spent with the public is a successful educational model that should be encouraged. Bats routinely suffer from a poor public image, engulfed in myths, and superstitions (Harvey, 2011). They are also associated with objects viewed as scary, dark, and something that should be feared and avoided. These educational outreach programs are an exceptional opportunity to change the minds of the participants (Fig. 6). We recommend that these programs be



Figure 6. Chief of Interpretation, Andrea Bornemeier, shows a bat to eager participants during one of the educational outreach programs.

continued. However, we caution that

netting the ponds be kept to a few events a year, avoiding June when the females are giving birth. Should netting be done in the late spring and early summer we would hope that there is a clear scientific reason for doing so.

It is difficult to determine the best time for pond maintenance according to the data obtained from this study. The data shows that there are more bats caught during the summer months at Pipe Spring than in the spring or fall, and there were a higher number of bat calls detected

in the fall than in the summer. It is certain to say that the highest amount of bat activity at Pipe Spring is during the summer and fall seasons. It may be concluded that the most appropriate time to work on pond maintenance is during the winter and early spring.

Long-term bat monitoring at Pipe Spring may be simply done using similar methods as performed in this project. Continued mist-netting during the summer and fall seasons is expected, as high numbers of visitors attended netting events to learn more about bats and witness the amazing bat diversity. The ultrasound equipment and Sonobat program is the most cost effective way to continue to monitor the bat species located at Pipe Spring. The authors would suggest switching to a Pettersson D500X full-spectrum bat recorder. These units were used in Bryce Canyon and Zion National Parks with tremendous success. Using this equipment also eases data analysis. Recording twice a month should provide enough time to monitor all species of bats, even migratory species passing through the park. The use of the ultrasound equipment and Sonobat program may be used

to increase relations with the Kaibab Band of Paiutes. This would provide a non-invasive method of providing bat data to the Tribe as well as gaining a better picture of bat species distribution across the local region.

The use of acoustical recording with standard mist-netting techniques has provided a broader view of bat ecology at Pipe Spring National Monument. As acoustical recording is a cost-effective way to continually monitor bats, it is expected that this will become a longstanding practice at Pipe Spring. It is also likely that the use of this technology and methodology will spread throughout agencies throughout the Colorado Plateau. As more and more researchers use this set up, data may be compared and contrasted together, providing an even greater understanding of bats in this area. These future studies may choose to focus more on the migratory patterns of bat species and how these bats use the Colorado Plateau seasonally and may even be able to elucidate the migratory routes for certain bats. Together, these methods will also help researchers understand more about bat populations that are in low numbers regionally and that may use a wider area for habitat.

This project has added much to our understanding of the bats that use this area and has generated even more questions for future research. Additionally, the NPS employees at Pipe Spring National Monument should be commended for their willingness and excitement to create educational outreach programs with the hope of dispelling the myths about bats. It is efforts like this that will increase public awareness of the importance of bats to this landscape and encourage park visitors to get involved with bat conservation efforts in their own backyards.

LITERATURE CITED

- Bogan, M., & Haymond, S. United States Department of the Interior, United States Geological Society. (2001). Summary of mammal inventories for the northern colorado plateau network. Albuquerque, NM: University of New Mexico.
- Cryan PM, Bogan MA, Rye RO, Landis GP, Kester CL (2004) Stable hydrogen isotope analysis of bat hair as evidence for seasonal molt and long-distance migration. J Mammal 85: 995–1001.
- Hinman, K. E. and T. K. Snow, eds. 2003 Arizona Bat Conservation Strategic Plan. Version 1.0. Nongame and Endangered Wildlife Program Technical Report. Arizona Game and Fish Department, Phoenix, AZ.
- Harvey, M. (2011). Bats of the united states and canada. (1st ed., p. 3). Baltimore, Maryland: The Johns Hopkins University Press.
- Hayes, J. P. (1997). Temporal variation in activity of bats and the design of echolocation-monitoring studies. Journal of Mammalogy 78: 514-524.
- Johnson, S. (2005). Bat surveys at pipe spring national Monument 2002-2005. Unpublished manuscript, Northern Arizona University, Flagstaff, AZ, .
- Kim, H. S., & Johnson, S. (2004). Bat surveys at pipe spring national Monument 2002-2004. Unpublished manuscript, Northern Arizona University, Flagstaff, AZ, .
- McKoy, K. L. 2003. Cultures at a Crossroads: An Administrative History of Pipe Spring National Monument.
- Szewczak, J.M. 2010 Instructional PowerPoint presentation. <http://www.sonobat.com/download/ZoomAutorecording.ppt>
- Tyburec, J. Bat Conservation International, (2011). Acoustic analysis for: usdi national park service, pipe spring national Monument

APPENDIX A

Pettersson Ultrasound Detector D240x Settings

Gain Switch	High
Normal/TE-HET Switch	Normal
HET/TIME EXP Switch	TIME EXP
Audio Cable Plugged Into	TAPE jack
Volume	Lowest Setting
Frequency	40.2 Hz
TRIG Switch	AUTO
MEM SIZE Switch	1.7 sec
TRIGGER LEVEL Switch	LOW
TRIGGER SOURCE Switch	HF

ZOOM H2 Digital Recorder Settings

Low cut off filter:	Off
Recording format:	44.1 kHz/16 bit
Automatic gain control:	Off
Folder:	Folder 01
Monitor:	Off
Plug-in power:	Off
Pre record:	Off
Autorecord:	AUTO REC
On/Off:	On
Start level:	-42 dB
Stop level:	-44 dB
Auto stop:	1 sec
Mono mix:	Off
Left/right position:	N/A
Metronome:	N/A
Tuner:	N/A
Play mode:	N/A
AB repeat:	N/A
Light:	15 sec
Contrast:	5
Battery:	Alkaline
USB:	N/A
Date/Time:	Set to current date and time