BAT SURVEYS OF AZURE CAVE AND THE LITTLE ROCKY MOUNTAINS: 1996

A Progress Report to:

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October 1997

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This document should be cited as follows:

Hendricks, P., and D. L. Genter. 1997. Bat surveys of Azure Cave and the Little Rocky Mountains: 1996. Montana Natural Heritage Program. Helena, MT. 25 pp.

ABSTRACT

Surveys of bat activity at Azure Cave and the surrounding country of the Little Rocky Mountains, Phillips County, Montana were conducted during three visits in 1996: 3-5 June, 7-10 July, 22-24 October. Bats were detected and identified with use of ANABAT ultrasound detectors and mists nets. A count of bats in Azure Cave was undertaken during the first visit; during the last two visits only surface surveys were conducted. Other sites surveyed included stock ponds, forested ravines, a mine adit and a rock-shelter cave. A total of 14 sites in the Little Rocky Mountains was surveyed for bat activity during the 1996 inventory.

Nine species of bats were recorded during 1996: California Myotis (*Myotis californicus*), Small-footed Myotis (*M. ciliolabrum*), Long-eared Myotis (*M. evotis*), Little Brown Myotis (*M. lucifugus*), Long-legged Myotis (*M. volans*), Big Brown Bat (*Eptesicus fuscus*), Silver-haired Bat (*Lasionycteris noctivagans*), Hoary Bat (*Lasiurus cinereus*), Townsend's Big-eared Bat (*Corynorhinus* [=*Plecotus*] *townsendii*). All but the Silver-haired Bat were captured at least once in mist nets.

The estimated minimum bat population in Azure Cave on 4 June 1996 was 474; all bats noted during the count were *Myotis* of undetermined species. The species composition and population estimate were similar to results from previous surveys made in 1978. Distribution within the cave was also similar to previous findings, with >90% of the hibernating bats using the Lunchroom. Netting at the mouth of Azure Cave during each visit revealed that several species may use the cave for feeding and roosting during summer and fall. Species netted at Azure Cave were California Myotis, Small-footed Myotis, Little Brown Myotis, Long-legged Myotis, Big Brown Bat, and Townsend's Big-eared Bat. Most activity at the mouth of Azure Cave in October was by the Big Brown Bat, which has not been noted using the cave as a hibernaculum.

Ponds appear to be important sources of water and food for bats in the Little Rocky Mountains. Five species (12 individuals) were netted during 10 net-hours at "Pond #1," nearest Azure Cave, on 9 July. Activity appeared to peak at ponds during the first few hours after sunset, with a lesser peak in early morning. Bat activity at sites away from water showed a peak only during the first few hours after sunset, except at a mine adit, which may have been used as a day roost. Nonetheless, bat activity at water sources was several-fold greater than at sites away from water (except Azure Cave and the mine adit) during equivalent time periods, further showing the ability of water sources in the Little Rocky Mountains area to concentrate bat activity following evening emergence.

Mitigation of detrimental impacts on bats in the Azure Cave area should include protection of current water sources or the establishment of new sources to replace those lost. The probability of protecting Azure Cave as a hibernaculum can be increased by maintaining the entrance gate, limiting human access during winter (October-early June), and close monitoring of human and bat activity in and near the cave.

ACKNOWLEDGMENTS

This project was made possible through support of the Montana Natural Heritage Program - a collaborative effort of The Nature Conservancy and the Natural Resource Information System - and a Challenge Cost Share agreement with the Lewistown District, BLM. We especially thank Michelle Williams of the Lewistown District, BLM for support, encouragement and assistance in nearly all facets of this project. Sam Martinez, Kathy Jurist, Chris Novasio, and Dave Kampwerth all contributed to the collection of field data. We thank the "Missouri River Crew", under the guidance of Michelle Williams, for taking time off to help with the July sampling. K. Jurist analyzed tapes of bat calls, D. Kampwerth and S. Martinez provided invaluable leadership and support in conducting the underground exploration, surveys and mapping of Azure Cave. Tom Butts shared his information from a previous visit to Azure Cave. Kevin Ryan and his staff at Zortman Mining, Inc. provided logistical support and access to abandoned mines in the Zortman area. Joan Gableman, formerly of Zortman Mining, Inc. provided valuable information regarding the status and location of abandoned mines in the Little Rocky Mountains.

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INTRODUCTION

Knowledge of Montana's bat fauna is fragmentary. The most recent summary of bat distribution and habitat use in the state (Hoffmann and Pattie 1968, Hoffmann et al. 1969) has since been supplemented with the addition of two species new to the state (see Swenson and Shanks 1979, Shryer and Flath 1980) and several regional surveys (e.g., Jones et al. 1973, Swenson and Bent 1977, Worthington and Ross 1990, Worthington 1991, Roemer 1994, Hendricks et al. 1995, 1996). Nevertheless, site surveys have often been brief (lacking the thoroughness of an intensive survey), and many areas of Montana remain unsurveyed. Thus, much remains to be learned about the distribution, abundance, seasonal movements, and reproductive biology of bat species in the state.

Five species of bats found in Montana (Fringed Myotis, *Myotis thysanodes*; Northern Myotis, *Myotis septentrionalis*; Spotted Bat, *Euderma maculatum*; Townsend's Big-eared Bat, *Corynorhinus* [= *Plecotus*] *townsendii*; Pallid Bat, *Antrozous pallidus*) are on the 1997 Montana Natural Heritage Program (MTNHP) "Animal Species of Special Concern" list, with one additional species (Yuma Myotis, *Myotis yumanensis*) on the informal "Watch List." Four of these species were formerly listed by the U.S. Fish and Wildlife Service as Candidates (C2) for threatened or endangered status. Three bat species on the MTNHP lists (all but the *Myotis* species) are classified as Sensitive by the U.S. Forest Service or Special Status by the BLM. Listed species are of concern for various reasons including rarity, limited distribution, or loss of habitat. All listed species, with the exception of the Spotted Bat (*Euderma maculatum*), use caves or mines during some portion of their annual cycle. In Montana, 11 (79%) of 14 bat species (all but the Spotted Bat, Silver-haired Bat [*Lasionycteris noctivagans*] and Hoary Bat [*Lasiurus cinereus*]) rely primarily on caves or mines for roost or hibernaculum sites.

Several species of North American cave-dwelling bats have been adversly affected in recent decades by a variety of human-induced environmental changes to caves, including cave closures, impoundments, and vandalism or other human disturbances (e.g., Humphrey 1978, Tuttle 1979, LaVal and LaVal 1980). These, and landscape changes such as deforestation and agricultural development, have forced many bat species to abandon traditional sites in search of new roosts and hibernacula. As a result, some cave-dwelling species in the East and Midwest have been federally listed as threatened or endangered. Mines offer a variety of subterranean microclimates similar to those in natural caves (Tuttle and Stevenson 1978, Tuttle and Taylor 1994) and can provide suitable habitat for roosting and hibernating bats. In fact, abandoned mines now serve as principle roosts and hibernacula for many cave-dwelling species (Tuttle and Taylor 1994), and are important for populations occupying marginal habitats (Gates et al. 1984) in areas where there are continued threats to primary natural roosts. It is widely acknowledged that natural cave environments are the most stable and desirable long-term habitats for bats. They should be protected and conserved wherever possible to maintain healthy cave-dependent species, including bats.

Mine reclamation (including closure to restrict human access) is of interest to wildlife managers because reclamation activities can have significant negative impacts on bat populations (e.g., Richter et al. 1993), unless closure is done in such a way as to minimize disturbance to bats in the mines affected. Because the majority of bat species in Montana use caves and mines, it is especially important to determine the magnitude of mine use by bats in the state and identify situations where abandoned mines can be made safe for humans while maintaining their attractiveness to bats.

Azure Cave is located in the Little Rocky Mountains near Zortman, Phillips County, Montana. It was named after Pat Azure, who discovered the cave in the late 1950's. Various explorations, assessments and collections of the cave and its features were conducted in the early 1960's (Howard and Hintzman 1964). The cave was immediately recognized as an outstanding geological feature in Montana, with exceptional size and extent of its significant speleothems. Azure Cave (also known as Zortman Cave) was withdrawn from mineral development in 1963. A resource inventory and evaluation by several geologists and biologists was conducted in 1978 (Chester et al. 1979), representing the first documented bat census in the cave. Numbers and distribution of bats encountered at that time indicated Azure Cave to be a significant winter roost (hibernaculum), with several hundred individuals present.

Increased concern over bat populations nationally, and recognition that a good baseline inventory was necessary for future local management efforts, convinced BLM managers that a thorough assessment of bat activity in Azure Cave and the surrounding area was warranted. The Lewistown District, BLM Office contacted the MTNHP in Helena to solicit technical support for such a study. This report documents findings from work conducted in 1996, discusses observations from previous studies, and offers suggestions for ongoing monitoring in the Little Rocky Mountains. Our focus for 1996 was to 1) assess the numbers and significance of bats in Azure Cave, and 2) determine the extent of habitat use by bats in the general vicinity of Azure cave and identify important habitat attributes in the area.

METHODS

Field work on bat activity in and around Azure Cave (Little Rocky Mountains, Phillips County, Montana; see Campbell 1978) was conducted during three visits in 1996: 3-5 June, 7-10 July, 22-24 October. Azure Cave was entered on 4 and 5 June to conduct a thorough pre-emergence count of the bat population, gather climatological data, inventory cave formations, document evidence of human disturbance, and conduct additional mapping of the cave. Entry in early June may have been late for a reliable hibernation count of wintering bats, as events revealed many bats were ready for emergence at that time (see Results and Discussion). Care was taken to keep disturbance to a minimum during inspection of the cave. Therefore, bats encountered were not handled nor marked while we were in the cave. Because of our concern about disturbance, and inaccessibility of some hibernating individuals, species identification of all bats in the cave was not possible. Counts of all bats encountered were made independently by two observers to reduce bias of the total estimate. Location of bats within the cave was recorded to document portions of the cave most critical to the bats for hibernacula.

A preliminary assessment of old mine workings, based primarily on descriptions provided by Joan Gableman (formerly with Zortman Mining, Inc.), was conducted to determine their suitability as bat habitat. Several adits and shafts were visually inspected, and the Pink-eye Pearl Adit #1 was monitored overnight on 9 July. Attempts to visit other caves in the area were thwarted by time restrictions, but Two Hands Cave was checked on 9 July and monitored overnight for bat activity.

Bats were captured with mist-nets at the mouth of Azure Cave during each of our visits (early June, early July, late October); two nets were used during each period of netting. Mist-net surveys were also conducted in July at three of the ponds near Azure Cave; most netting effort was focused on "Pond #1" nearest the cave. Number of nets used per site varied from one to six. Mist-nets, set singly or in groups, were run for 3-5 hours beginning at dusk; nets were left open all night at the mouth of Azure Cave on 22 October. All bats captured were identified, sexed, weighed and measured, and marked with colored plastic bands (one band on the forearm, except *Lasiurus cinereus* with two bands). White was used for individuals captured at Azure Cave, other colors (light blue for *Eptesicus*, purple for *Myotis*, red and another color for *Lasiurus*) for bats captured elsewhere. Bats captured at Azure Cave in June were not color-marked, as bands were not yet available.

Ultrasound detectors were used at 17 different sites, mostly in July, to record overnight bat activity. Detectors were used at five sites on more than one night; two sites were monitored on more than one field trip. We paid particular attention to bat activity at water sources (stock ponds), but also set detectors at sites away from water in forest clearings and near rock outcrops. At a few sites (e.g., Azure Cave, Pond #1) detectors were used in conjunction with mist-nets, to obtain a more complete picture of activity by each species. At the time detector units were placed we recorded: 1) an index of sky conditions from 0-6 (clear to showers), 2) Beaufort wind scale from 0-5 (no wind to winds 19-24 mph), and 3) ambient temperature.

Thomas and West (1989) provide a general discussion of sampling methods for bats. Each method has strengths and weaknesses for survey work, with no single method being definitive. Ideally, a combination of mist-nets and bat detectors would be employed at a given site in order to obtain the most accurate picture of distribution and relative abundance. Mist-netting has the advantage of allowing in-hand identification of individuals and collection of data on sex and reproductive condition, neither of which are obtainable with bat detectors. Some bats may escape capture in nets, however, and some species present at a particular site may go undetected. Also, mist-netting is time-consuming, and therefore permits fewer sites to be surveyed within the allotted time period.

Data collected with bat detectors can supplement or serve in lieu of mist-net data. Microchiropteran bats use a variety of ultrasonic vocalizations as echolocation aids for navigation and prey capture. Fortuitously, a number of studies have determined that the signals emitted by bats can be used to distinguish among many species (e.g., Barclay 1986, Fenton and Bell 1981, Fenton *et al.* 1983, MacDonald *et al.* 1994). This characteristic permits the assessment of species-presence during inventory work through use of portable ultrasound bat detectors. Bat detectors are not without drawbacks, however. Call duration, time between calls, call structure, and call frequency can vary significantly with habitat and between individuals (Brigham et al. 1989, Erickson 1993), sometimes making species identification difficult. In the Little Rocky Mountains, *Myotis evotis* was the only species of *Myotis* which could be distinguished with accuracy from other members of the genus using a bat detector.

ANABAT II bat detectors (Titley Electronics, Ballina, Australia) were used during our field work in 1996. These detectors are sensitive to broadband ultrasonic calls common in bat vocalizations (usually 20-180 kHz) . Ultrasonic signals in the range of bat vocalizations are captured, converted to an audible frequency (up to 10 kHz), and recorded on magnetic tape. Detector units (consisting of the detector, timer/tape-driver, and a voice-activated cassette tape recorder) were set up before dusk near bodies of water and forest openings (where bat activity would be expected) and left in place overnight; usually one cassette tape was sufficient to record activity at a single site. Detectors were sensitive to bats within a minimum range of 20-30 m. Recorded tapes were returned to the laboratory and analyzed on an IBM compatible PC using an ANABAT II ZCA Interface Module and software. Assignment of vocalizations to a particular species of bat was achieved by matching field recordings with a reference set of calls obtained from captured individuals, in addition to matching call characteristics with those reported in the literature.

Data collected with the detectors permitted us to perform some analyses of relative bat activity between sites and time periods. Activity is defined as the number of passes/hour. With these data it is not possible to determine how many individuals were actually present; we assume that there is a positive relationship between activity and number of individuals. Statistical analyses, where used in this report, follow standard procedures described in Sokal and Rohlf (1981), with statistical significance assumed when $P < 0.05$.

RESULTS AND DISCUSSION

Azure Cave--A total count of bats in Azure Cave was made on 4 June. Bats were found in three locations in the cave (Figure 1): Lunchroom, Music Room, passages beyond the Lunchroom. Respective location counts were 421 (88.9%; individual counts of 419 and 423), approx. 35 (7.4%; individual counts not available), and 18 (3.8%; individual counts of 15 and 20). Thus, estimated minimum bat population in the cave at the time of the census was about 474 (range = 469-478). All bats noted in the cave during the count were *Myotis* of some species. It is likely that other individuals were using the entrance Big Room, but it was impossible to see or verify their presence, due to height and surface texture of the room. Over 20 bats were active in and around the cave entrance, further indicating the likelihood that some bats were overlooked in the Big Room. Typically, most bats in the cave were present as scattered individuals, but clusters of up to seven individuals were seen. Fewer than 200 individuals were counted in the same areas on 5 June, indicating that most bats were emerging from hibernation at the time of the survey.

The estimated minimum number of individual bats (474) using Azure Cave during our 4 June 1996 census was remarkably similar to earlier counts of 529 (1 April 1978) and 492 (30 September 1978) reported by Chester et al. (1979). Location of hibernating bats was also similar during the two surveys, with 91.1% of the population in spring 1978, and 95.5% in fall, using the Lunchroom (Chester et al. 1979); 88.9% of the population was in the same room in spring 1996. Butts (1993) entered Azure Cave on 5 March 1993 and estimated 250-300 bats hibernating in the Lunchroom, 94.3-95.2% of his total count, and consistent with other findings of hibernation sites within Azure Cave. Because Butts terminated his cave investigation prematurely, however, (due to disturbing the bats) his estimate of total bats using the cave is suspect. The best available estimates through 1996 suggested that the number of bats using Azure Cave as a hibernaculum was relatively stable and in the range of 475-550. A more recent survey (20 April 1997; to be discussed in detail in the next progress report) resulted in a count of 1174-1318 hibernating *Myotis*, indicating that population size of bats using Azure Cave as a hibernaculum may flutuate more drastically than previously indicated. *Myotis lucifugus* and *M. volans* were identified from remains recovered during the April 1997 count. What remains unknown regarding the hibernating population in Azure Cave is 1) the species composition of the population, 2) the proportions of different bat species using the cave, and 3) the relative annual stability of the total hibernating bat population.

There are few published records of winter (1 November-1 April) bats in Montana. Swenson and Shanks (1979) found *Myotis lucifugus, M. septentrionalis, M. evotis, M. volans,* and *Corynorhinus townsendii* hibernating in mines in Richland County near Sidney. Swenson (1970) also found *M. ciliolabrum* and *C. townsendii* hibernating in coal mines in the Bull Mountains of Musselshell County. Other published observations on Montana bats (Hoffmann et al. 1969, Jones, et al. 1973, Swenson and Bent 1977) provide no additional records of hibernating

Figure 1. Map of Azure Cave showing major hibernation aggregations within the cave. (unavailable)

individuals. Additional winter records from the Pacific Northwest of Idaho, Oregon, Washington, British Columbia, and Alberta are available for all species identified in the Little Rockies area (Schowalter 1980, Genter 1986, Perkins et al. 1990, Nagorsen and Brigham 1993, Nagorsen et al. 1993), indicating the possibility of a diverse winter assemblage of species in and near Azure Cave. Hibernating species collected in Azure Cave, and tentatively identified, include *Myotis lucifugus*, *M. volans*, and *Corynorhinus townsendii* (Chester et al. 1979, Butts 1993). Certainly, the vast majority of bats using Azure Cave as a hibernaculum are species of *Myotis*.

Chester et al. (1979) conducted counts of bats in Azure Cave on 9 July and 11 August 1978, and found zero and four individuals, respectively, indicating the cave is used primarily as a hibernaculum. We did not enter the cave during summer, although we did monitor activity at the cave entrance during each field trip using mist-nets and bat detectors. Fifteen *Myotis lucifugus*, one *M. ciliolabrum*, and one *M. californicus* were captured on 3 June (Table 1) during 6 net-hours (2.8 captures/net-hour). On 7 July, one *Eptesicus fuscus* and one *Corynorhinus* (= *Plecotus*) *townsendii* were captured during 9 net-hours (0.2 captures/net-hour). During our final field trip to the cave, 10 *Eptesicus fuscus*, one *M. ciliolabrum*, and one *M. volans* were captured on 22 October during 24 net-hours (0.5 captures/net-hour; 10 captures occurred during the first 9 net-hours, for a rate of 1.1 captures/net-hour), and five *E. fuscus* were captured on 23 October during 8 net-hours (0.6 captures/net-hour). Butts (1993) netted four *Myotis lucifugus*, one *M. evotis*, five *Eptesicus fuscus* and one *Corynorhinus townsendii* at the cave mouth on 28 and 29 September 1992 (0.4 and 0.7 captures/net-hour, respectively). The pattern of captures is consistent with Chester et al.'s (1979) finding of greatly reduced use of the cave during summer. Bats captured by us in June were both entering and leaving the cave, the two bats captured in July were entering the cave, and about equal numbers were caught entering and leaving the cave in October. Our bat detector data showed *Corynorhinus townsendii* present during the June sample and *Myotis evotis* present in July. Thus, at least seven species of bats use Azure Cave as a hibernaculum, a feeding site, and/or a roost.

Patterns of evening activity at the cave entrance varied significantly (G = 88.424, df = 4, $P \ll 0.001$) between the 3 June and 7 July samples (Figure 2). Activity in June was late relative to dusk, with peak activity beginning about midnight (ca. 3 hours after dusk). In contrast, bats became most active within the first hour after dusk on 7 July. Peak activity in July (55 passes in an hour) was nearly three-fold that in June (20 passes in an hour), which is probably related to the June bats just beginning to emerge from hibernation. *Myotis* sp. was identified on 83% of the 3 June passes, 75% of the 7 July passes. *Corynorhinus* (= *Plecotus*) *townsendii* was detected on 15% and 9% of the passes, respectively, with most (93%) *Corynorhinus* activity on both dates occurring between midnight and 02:00. *C. townsendii* typically emerge from their roosts at dusk in the deserts of Oregon in May, and forage nearby for the first few hours before moving to more distant locations to feed (Dobkin et al. 1995). This pattern of activity, if applicable to populations in the Little Rockies, would indicate that most *C. townsendii* detected at Azure Cave during July were roosting at other sites.

Table 1. Bats captured with mist nets in the Azure Cave area (Little Rocky Mountains), Phillips County, Montana in 1996.

Species	Locality[a]	Date	Number and Sex
California Myotis (*Myotis californicus*)	Azure Cave	3 Jun	1M
Western Small-footed Myotis (*M. ciliolabrum*)	Azure Cave	3 Jun	1F
		22 Oct	1F
	Pond #1	9 Jul	1M
Western Long-eared Myotis (*M. evotis*)	Pond #1	9 Jul	1M
Little Brown Myotis (*M. lucifugus*)	Azure Cave	3 Jun	12M 3F
	Pond #1	9 Jul	1M
Long-legged Myotis (*M. volans*)	Azure Cave	22 Oct	1M
Big Brown Bat (*Eptesicus fuscus*)	Azure Cave	7 Jul	1M
		22 Oct	9M 1F
		23 Oct	5M
	Pond #1	8 Jul	2M
		9 Jul	5M
	Pond #2	8 Jul	1M
Hoary Bat (*Lasiurus cinereus*)	Pond #1	9 Jul	2M 2F
Townsend's Big-eared Bat (*Corynorhinus townsendii*)	Azure Cave	7 Jul	1M

[a] see Appendix 1 for legal descriptions of locations.

Figure 2. Nocturnal bat activity at Azure Cave on two nights, based on ANABAT detector data: open bars - 3 June, shaded bars - 7 July. (unavailable)

Activity at ponds--Bats were detected at five (83.3%) of six ponds monitored in July (see Appendix 1 for locations). Mean number ($\pm$SD) of passes/hour during peak activity at the five ponds was 89.4$\pm$25.6. In four of five cases the peak occurred between 22:00-23:00; at the fifth pond the peak occurred from 03:00-04:00 (this pond, too, showed elevated activity between 22:00-23:00). The difference in peak activity between ponds may be a sampling artifact (see below). Only the pond with the early-morning peak had an all-night record of activity. Detectors ran out of tapes by midnight at the other ponds.

Activity was monitored most intensively at Pond #1 (the pond nearest Azure Cave). On two consecutive nights, bat activity reached a peak between 22:00-23:00 and remained high until midnight (Figure 3), when tapes ran out. Although peak activity was about 33% greater on the second night (8 July), the pattern of activity until midnight was nearly identical on both nights ($G = 1.064$, df = 2, $P > 0.5$). Thus, the use of this pond by bats, and the pattern of activity displayed, was not an isolated event;. Pond #1 probably attracted considerable bat activity throughout the summer, although this is not known with certainty.

The significance of ponds for the bats can be illustrated by comparing activity on 7 July at Pond #1 and a stock tank (full of water) with guzzler located about 50 m downstream from the pond. The pattern of bat activity at both sites was similar ($G = 0.272$, df = 2, $P > 0.5$), with peaks reached at 22:00-23:00 (Figure 4) and maintained to midnight, at least. Peak activity was ten-fold greater at Pond #1, however, than at the nearby guzzler and stock tank. This indicates a relatively large magnitude of bat activity tightly concentrated over the pond, even though water was also present (but in a much smaller amount) only 50 m distant.

Activity at the guzzler peaked again from 02:00-03:00 (9 passes). Given the similar distributions of activity at Pond #1 and the guzzler earlier in the night (Figure 4), 98 passes would have occurred over the pond from 02:00-03:00 (calculated from ratios between the two sites for the 22:00-23:00 period). This suggests that the all-night pattern of bat activity at ponds discussed earlier (early evening and early morning peaks at one pond sampled all night) was probably the norm in July at most ponds in the immediate area of Azure Cave. Bimodal patterns of nocturnal activity are typical elsewhere for many of the bat species found in Montana (van Zyll de Jong 1985, Nagorsen and Brigham 1993), including those detected in the Azure Cave area.

Data are available for comparing bat activity between 21:00-24:00 (during 7-9 July) at ponds versus caves/adits and forested sites away from water bodies. Mean activity was greatest near caves/adits (mean = 16.5 passes/hour, n = 3 sites) during the first hour after dusk (Figure 5). The pattern changes dramatically from 22:00-24:00, when mean activity at ponds (n = 4 sites) is three- to five-fold greater than at caves/adits, and nine- to eleven-fold greater than in dry forested areas (n = 6 sites). Again, it is clear that bats are concentrating their foraging activity at ponds. Ponds are important for bats as sources of drinking water and places to hunt concentrations of insect prey (e.g., Brian et al. 1995, Krusic et al. 1996); distance to water may also be a limiting factor for nursery colony location (Tuttle and Taylor 1994).

At least six species of bats foraged over Pond #1 during 7-9 July. *Myotis ciliolabrum* (1), *M. lucifugus* (1), *M. evotis* (1), *Eptesicus fuscus* (5), and *Lasiurus cinereus* (4) were captured on 9 July during 10 net-hours of trapping (Table 1); *E. fuscus* (2) was netted during 4 net-hours the previous night. Two of four *Lasiurus cinereus* were lactating females, all other individuals were non-scrotal males. Because we marked all captured bats, and none were recaptured, it is

Figure 3. Nocturnal bat activity at Pond #1 (below Azure Cave) on two consecutive nights, based on ANABAT detector data: open bars - 7 July, shaded bars - 8 July. (unavailable)

Figure 4. Nocturnal bat activity at Pond #1 (below Azure Cave) and guzzler on 7 July, based on ANABAT detector data; guzzler (with stock tank) was located 50 m downstream from the pond. Open bars - pond, shaded bars - guzzler. (unavailable)

Figure 5. Early-night bat activity over three habitats in the Azure Cave area during 7-9 July. Squares are ponds (4 samples), circles are caves/adits (3 samples), triangles are forested ravines (6 samples). (unavailable)

highly probable that 14 individuals using the pond is an under-estimate (probably large) of actual activity during our trapping. *Corynorhinus* (= *Plecotus*) *townsendii*, though not captured, was detected over the ponds 7-8 July and likely was present on 9 July. This further indicates that several bats active at Pond #1 were not captured during our trapping sessions.

Activity patterns away from ponds--Nocturnal activity by bats away from ponds was also bimodal. All-night bat detector data collected during 7-9 July from seven sites other than ponds and Azure Cave show a broad peak (mean = 6.5-8.7 passes/hour) for the first three hours after dusk, with a second moderate peak (mean = 3.8-4.1 passes/hour) between 02:00-04:00 (Figure 6). This corresponds roughly to the bimodal pattern detected at water sources, but the activity level was much weaker. Most of the pattern is driven by *Myotis* sp. and *Eptesicus fuscus*; 94.8% of the detections were these two "species." Three species (*Myotis*, *E. fuscus*, and *Corynorhinus townsendii*) showed two major activity periods. *Myotis* and *Corynorhinus* peaked at 22:00-24:00 and again at 02:00-04:00; *Eptesicus* was most active slightly earlier, at 21:00-23:00 and again at 01:00-03:00.

Nocturnal activity at sites away from water was not uniform among sites during any single night. Two Hands Cave (a rock shelter with about 30 m of passage), Azure Cave Road #1 (at the beginning of the trail head to Azure Cave) and the Pink-eye Pearl Adit were monitored with bat detectors all night on 9 July. Activity at Two Hands Cave and Azure Cave Road #1 showed peak activity at 21:00-22:00 and again at 23:00-24:00, while activity was relatively constant at the Pink-eye Pearl Adit until a peak at 02:00-04:00 (Figure 7); the activity patterns differed significantly among the three sites ($G = 127.08$, df = 14, $P << 0.001$). Perhaps the mine adit was a day roost and a foraging site, while the other two sites were foraging areas only, used mostly by bats recently emerged from day roosts.

Peak activity was similar in magnitude among sites (27 passes/hour at Two Hands Cave, 20 passes/hour at Azure Cave Road #1, 21 passes/hour at the Pink-eye Pearl Adit), but the proportions of activity attributable to various bat species differed significantly among sites ($G = 22.154$, df = 4, $P < 0.001$). Percentage of total passes attributable to *Myotis* was 60.0, 89.8, and 71.4 for Two Hands Cave, Azure Cave Road #1, and Pink-eye Pearl Adit, respectively; percentage for *Eptesicus* was 38.3, 5.1, and 23.8, respectively, with the remaining (1.7%, 5.1%, and 4.8%, respectively) attributable to *Lasionycteris noctivagans* at the first two sites, and *Corynorhinus townsendii* at the mine adit.

The above analyses show that different bat species use areas away from ponds unevenly over relatively small landscapes on the same night. This may complicate management activities intended to enhance bats or bat habitat away from water sources, and could necessitate species-specific management rather than a broad plan to cover all bat species.

Figure 6. Nocturnal bat activity at seven sites (other than ponds or Azure Cave) in the Azure Cave area, 7-9 July, based on ANABAT detector data. Species codes are MYSP - *Myotis* sp., EPFU - *Eptesicus fuscus*, COTO - *Corynorhinus townsendii*, LACI - *Lasiurus cinereus*, LANO - *Lasionycteris noctivagans*. (unavailable)

Figure 7. Nocturnal bat activity at three sites on 9 July. Open bars - Two Hands Cave, black bars - Azure Cave Road #1 (a forested ravine), shaded bars - Pink-eye Pearl adit. (unavailable)

RECOMMENDATIONS

The following recommendations are presented with the understanding that events in the future may dictate actions not identified during this and previous surveys as addressing immediate needs to maintain viable populations of bats in and around Azure Cave. In some cases, recommended action may already have been taken; such recommendations are included here to emphasize their continued applicability to the Azure Cave area.

1) The gate on Azure Cave does not quite follow recommended construction specifications (Tuttle and Taylor 1994) of minimum horizontal distance between vertical supports of two feet, with greater distance preferred. Vertical distance between horzontal spacings are variable but near the recommended range of 5 3/4 inches to 6 inches. Several species of bats obviously use the cave with the present gate in place, but some individuals may be inhibited from entering the cave. Furthermore, the design of the current gate is not as secure from human intrusion as that recommended in Tuttle and Taylor (1994). Replacement of the gate with a recommended design should be considered as a future management activity.

2) Change the lock on the cave gate every year or two to reduce the likelihood of unsupervised access.

3) Maintain a logbook of visitors at the District Office and the cave entrance. This will provide a record of activity at the cave, upon which future changes in admission policy can be based, and identifies individuals and groups that may be solicited for assistance in future management activities involving the cave.

4) Conduct annual counts of hibernating bats in Azure Cave for 2-3 years, then conduct counts once every 2-3 years.

5) Access to Azure Cave during winter (October-late May) should be permitted only in exceptional circumstances, to minimize disturbance to hibernating bats. Groups entering the cave during winter should be knowledgable about the need to keep disturbance of bats to a minimum.

6) Monitor bat activity at nearby ponds. Water sources in the area are extremely significant to the bat fauna as sites for feeding and drinking, and also serve as important habitat for amphibians. Three amphibian species, Northern Leopard Frog (*Rana pipiens*), Western Chorus Frog (*Pseudacris triseriata*) and Tiger Salamander (*Ambystoma tigrinum*), were noted using the ponds in the Azure Cave area during 1996. New ponds should be constructed closer to the cave in appropriate sites that will retain water if current ponds are to be removed or filled.

7) Continue surveys of abandoned mines and caves in the area for bat activity and use. The information gained will provide a more complete picture of the significance of Azure Cave to the bat fauna of the Little Rocky Mountains.

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APPENDIX 1. SURVEY SITES FOR BATS DURING 1996, LITTLE ROCKY MOUNTAINS, AND BAT SPECIES DETECTED

Figure 8. Map of locations for bat surveys in the Azure Cave area in 1996. (unavailable)

Appendix 1. Survey sites for bats in the Little Rocky Mountains, Phillips County, Montana during 1996, and bat species detected.

Location	Date	Bat species[a]
Azure Cave (T25N R25E S29NW)	3 June	MYCA MYCI MYLU COTO
	7 July	MYSP MYEV EPFU COTO
	22 October	MYCI MYVO EPFU
	23 October	EPFU
Azure Cave Road #1 (T25N R25E S20SW)	9 July	MYSP LANO EPFU
	22 October	MYSP EPFU
Azure Cave Road #2 (T25N R25E S20SW)	9 July	MYSP LANO
Azure Cave Road #3 (T25N R25E S20SE)	9 July	MYSP LANO EPFU
Pond #1, below Azure Cave (T25N R25E S21SW)	7 July	MYSP EPFU LACI COTO

Appendix 1 (cont.). Survey sites for bats in the Little Rocky Mountains, Phillips County, Montana during 1996, and bat species detected.

Location	Date	Bat species[a]
Pond #1, below Azure Cave (cont.) (T25N R25E S21SW)	7 July (guzzler)	MYSP EPFU LACI COTO
	8 July	MYSP EPFU LACI COTO
	9 July	MYCI MYEV MYLU EPFU LACI
Pond #2, below Azure Cave (T25N R25E S21SE)	7 July	MYSP EPFU LACI
	8 July	EPFU
Pond #3, below Azure Cave (T25N R25E S33NE)	8 July	MYSP EPFU LACI COTO
	23 October	No calls
Pond #4, below Azure Cave (T25N R25E S33SW)	7 July	No calls
Pond #4 cottonwood grove (T25N R25E S33SW)	7 July	No calls
	8 July	MYSP LACI

Appendix 1 (cont.). Survey sites for bats in the Little Rocky Mountains, Phillips County, Montana during 1996, and bat species detected.

Location	Date	Bat species[a]
Highway Pond (T25N R25E S34SE)	8 July	MYSP EPFU LACI
Pink Eye Pearl Adit #1 (T25N R25E S7/ T25N R24E S12)	9 July	MYSP EPFU COTO
Two Hands Cave (T25N R25E S30SE)	9 July	MYSP LANO EPFU
Dry Gulch, Canyon Mouth (T25N R24E S35NW)	8 July	MYSP EPFU COTO
Dry Gulch Pond (T25N R25E S7NW)	8 July	MYSP EPFU LACI

[a] MYSP-*Myotis* sp., MYCA-*Myotis californicus* (California Myotis), MYCI-*Myotis ciliolabrum* (Western Small-footed Myotis), MYEV-*Myotis evotis* (Western Long-eared Myotis), MYLU-*Myotis lucifugus* (Little Brown Myotis), MYVO-*Myotis volans* (Long-legged Myotis), EPFU-*Eptesicus fuscus* (Big Brown Bat), LANO-*Lasionycteris noctivagans* (Silver-haired Bat), LACI-*Lasiurus cinereus* (Hoary Bat), COTO-*Corynorhinus* (= *Plecotus*) *townsendii* (Townsend's Big-eared Bat).