

Surveying and Monitoring Bats in Mines in the Tucson Mountains,
with Emphasis on *Macrotus californicus* and *Myotis velifer*, 2004-2005

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CONTAINS SENSITIVE DATA

TABLE OF CONTENTS

LIST OF FIGURES	2
LIST OF TABLES	2
INTRODUCTION.....	3
METHODS	5
RESULTS	7
DISCUSSION	12
RECOMMENDATIONS.....	16
ACKNOWLEDGEMENTS	16
LITERATURE CITED	16
APPENDIX A: BLM Mine Numbers Cross-referenced.....	18
APPENDIX B: Photographs	19
APPENDIX C: Page 10: Figures 1 and 2 in black and white for photocopy	21
APPENDIX D: CONFIDENTIAL	
Part A: Tucson Mountains Mine Locations and Attributes	
Part B: Tucson Mountains Mine Field Notes 1 January 2004- 31 March 2005	
Part C: Maps of Mine Locations and Roost Sites	

LIST OF FIGURES

Figure 1. Proportions of cave myotis exiting through gate spaces during 15 minutes at the peak of emergence, Wildhorse Mine, Saguaro National Park.	10
Figure 2. Number of cave myotis exiting per minute during evening emergences at Wildhorse Mine, Saguaro National Park.	10

LIST OF TABLES

Table 1. Bats observed in mines in the Tucson Mountains January, 2004-March, 2005.	8
Table 2. Evidence of bats observed in mines in the Tucson Mountains January, 2004- March, 2005.	9
Table 3. Vertical shafts in Saguaro National Park surveyed for drifts by remotely-controlled videocamera, Tucson Mountains, 2005.	9
Table 4. Proportions of cave myotis exiting through Wildhorse Mine gate spaces during 15 minutes at the peak of emergence.	9
Table 5. Live vertebrates other than bats observed in mines in Tucson Mountains, 2004-2005.	11
Table 6. Recently-dead javelina observed in Tucson Mountain mines, 2004.	11
Table 7. Number of <i>Myotis velifer</i> counted at 400-Yard Mine, Tucson Mountains, 1995 and 2004.	13

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INTRODUCTION

The Tucson Mountains are on the western edge of Tucson, Arizona, in the Arizona Uplands Division of the Sonoran Desert (Turner and Brown 1994). Elevations range from about 2,400-4,600 feet. The mountains are managed by National Park Service, Pima County Parks and Recreation, and Bureau of Land Management (BLM). Boundaries are adjacent, so that except for some peripheral areas, the entire mountain range falls under the jurisdiction of these agencies.

Although the Tucson Mountains are adjacent to the city of Tucson and contain over 200 abandoned mines, there has been little work conducted on bats in these mountains. There is much yet to learn about the natural history of even common species of bats to make intelligent management decisions that may affect them. For example, a summer bachelor colony of cave myotis (*Myotis velifer*) has inhabited Wildhorse Mine in Saguaro National Park (SNP) for many years. From census counts, we know that the numbers at the mine vary throughout the summer as well as between years. After gating the mine in 2000, we observed a population decline, but do not have sufficient knowledge about the population's winter roosts and alternate summer roosts to determine whether the gate was the cause. Our lack of knowledge affects how we interpret observed human impacts on bats, which may in turn affect our management decisions.

The purpose of this project was to inventory mines in the Tucson Mountains for use by bats, to monitor colonies of California leaf-nosed bats (*Macrotus californicus*) and cave myotis to increase our knowledge of the ecology of these species in this area, and to provide information to wildlife managers so they can take appropriate actions to protect roost sites.

Objectives

Specific objectives were as follows:

1. Survey mines in the Tucson Mountains for use by bats on lands managed by Saguaro National Park, Pima County Parks and Recreation, and Bureau of Land Management. These are mines that have never been surveyed for bats, were surveyed many years ago but have not been monitored, showed evidence of use during one season and need to be checked in other seasons, or showed no evidence during an initial survey but are likely habitat based on structural characteristics.
2. Determine species, colony type (e.g., bachelor, maternity, winter mixed), and abundance of bats using mines as day-roosts.
3. Monitor roost sites of California leaf-nosed bats throughout the year for colony type, abundance, and seasonal movements.
4. Continue the post-gate monitoring of cave myotis in Wildhorse Mine by videotaping emergences. Determine if cave myotis still occupy 400-Yard Mine, and if so, census the colony. Monitor other colonies of cave myotis observed during surveys.
5. Compile data on bat roosts in mines in the Tucson Mountains and present it to the three land management agencies. Help agencies develop a "big picture" view of the needs of bats living in these mountains, and promote collaboration for research and management.

Background

This project is a continuation and expansion of our surveys January-March 2003 of the mines in the Tucson Mountain District of Saguaro National Park. Don Carter (Ranger, Pima County Parks and Recreation) has surveyed mines in Tucson Mountain Park (TMP) and adjacent BLM land and observed California leaf-nosed bats in at least one mine, but has not monitored mines throughout the year (D. Carter, pers. comm.). Tim Snow and Shawn Castner (Arizona Game and Fish Department) surveyed many mines on BLM land in summer 1995 (Snow and Castner 1996). The last known survey and census of the 400-Yard Mine on BLM land was in 1995 by Dave and Virginia Dalton.

Although the Tucson Mountains are largely protected from development, there is an increasing risk of disturbance and vandalism to bat roosts from visitors. Land surrounding the mountains is being developed rapidly. The increase in the human population has, and will continue, to increase the number of people hiking in the mountains. Unfortunately, disregard of signs for closed trails and warning signs and fences around abandoned mines is common (pers. obs.). Over half of the gates at mines in SNP have been breached, and evidence of human visitation at mines is abundant (pers. obs.). Visitor safety is a concern of the land management agencies, as is adequate protection for bats roosting in abandoned mines. It is important, therefore, to have current data on mines used as roosts by bats. This knowledge is necessary for understanding the ecology of the species roosting in mines, to assess the amount and effect of human disturbance on bats, and to make intelligent management decisions regarding an appropriate closure method for a particular mine.

Terminology

Use of erroneous or inconsistent terminology when describing mines leads to confusion in readers and difficulty in categorizing mines a priori based on previous descriptions. We use the following terminology:

shaft- vertical or decline $>50^\circ$, open to the surface

adit- horizontal passage, or decline $< 40^\circ$, with entrance to the surface; usually on a hillside

decline- technically neither an adit or shaft, about 45°

drift- passage off a shaft, adit, or decline; always horizontal, parallel to the ore vein
(we do not distinguish drifts from cross-cuts, which intersect the vein)

winze- vertical opening sunk downward from the floor of an adit or drift

raise- vertical opening driven up from the ceiling of an adit or drift

cribbing- wooden frame around the walls of a shaft

portal- entrance from the surface of an adit or decline

collar- entrance of a shaft

antlion trap- lay term for a particular dangerous condition- collapsed collar with loose debris and slope is steeper than angle of repose (resembles an antlion trap)

incline- a decline viewed from the lower end

dripline- where surface water would drip from above a portal to the floor

face- the wall at the end of a passage

To avoid confusion for lay readers, we do not use correct terminology when describing walls (ribs) and ceiling (back) of a mine. In data forms and this report, the back of a mine refers to the end of the passage.

METHODS

Mine Locations and Numbering System

Mines were located by GPS, using coordinates given by the agency, or by using topo maps, old records, and field reconnaissance. We used SNP's numbering system to identify their mines; in our records the number is prefaced with an "S." For TMP and BLM we created a sequential numbering system, prefacing TMP's mines with "T," and BLM's mines with a "B." We cross-referenced our identification numbers for mines on BLM land with their system when we were positive we were referring to the same mine (Appendix A).

Surveys

On surveys, we carried standard safety equipment for fieldwork in rough, desert terrain. In addition, for underground work, we each had MSHA-approved hard hats with mounted lights and two back-up lights. We used a gas meter (Gastech GX-82) to check for bad air. We used standard safety techniques for underground work. For example, we evaluated the competence of rock at the portal of each mine before entering, and continued the evaluation as we proceeded through the mine. We used respirators with ammonia cartridges to enter 400-Yard Mine (B11) because previous surveys indicated high ammonia levels. We did not enter a mine alone if the end could not be seen from the portal, and we avoided touching ceilings and walls of adits and declines. For gated adits where the gate was not breached, we shone lights in and used binoculars to look for guano and bats.

We did not enter shafts that could not be safely free-climbed. If we could not enter, we looked into the shaft, getting only as near to the edge as was safe. We then used a mirror on a telescoping pole to reflect sunlight to view the walls and bottom of the shaft and look for drifts. We used binoculars when necessary to help see drifts. If we could not confirm the absence or presence of drifts, we determined whether the shaft could be safely rappelled, considering competence of the rock, collar stability, and presence of an anchor point for ropes.

During previous work (Wolf and Dalton 2003), we were unable to determine whether some shafts or winzes in SNP had drifts, which could be potential bat habitat. Because these shafts were not safe to rappel, we used a "downhole camera", which is a remotely-controlled videocamera and light mounted in a case (Appendix B), and lowered down the shaft to check for drifts. We watched from a monitor on the surface that was connected to the camera, and also viewed the tapes later.

If bats were present, we identified species and estimated numbers as quickly as possible, then exited the mine to minimize disturbance and prevent the possibility of driving bats out of the mine. We used white light to minimize time of disturbance and to obtain an accurate count. If no bats were present, we looked for insectivorous guano, distinguishing it from rodent scat by size and texture (bat guano crumbles between your thumb and fingers, rodent scat does not), and also looked for red or yellow fecal splats left by lesser long-nosed bats (*Leptonycteris curasoae*). We recorded the location and description of guano. We also looked for stringy green guano that is associated with California leaf-nosed bats, and culled moth wings and insect parts dropped from feeding bats.

We measured the length of adits and drifts with a reel tape, or estimated length by pacing. For adits, we measured from the face to the dripline at the portal. For drifts, we measured from the face to

where it entered the main passage. We estimated depths of shafts using a rock tied to the end of a reel tape, or estimated it visually.

We measured temperature and humidity with a sling psychrometer. Inside the mine, we took a reading at the end of the adit or drift, or above guano. If bats were present, we took a reading as close as possible to their location without disturbing them. All readings inside the mine were taken near the ceiling. We also measured temperature and humidity outside the portal. Temperatures were recorded as wet bulb/dry bulb in degrees Fahrenheit.

We recorded use of a mine by other wildlife species, evidence of human visitation, and the condition of fences and gates if noteworthy.

Censuses

At several mines, we counted bats exiting during their evening emergence. We set up a videocamera (Sony DCR-TRV19) outside the mine entrance, and used supplemental infrared (not visible) lighting to obtain sufficient light for an accurate count. On one night, we conducted simultaneous counts at Wildhorse Mine (S050) and 400-Yard Mine (B11) to begin to get baseline data for a comparison of seasonal trends between the two mines. We also censused 400-Yard on one night and Wildhorse the next night. Although not simultaneous, these data were also used to compare seasonal trends.

Wildhorse Mine gate

We removed the removable bar (6th from the top) from the gate at Wildhorse Mine on April 4, 2004 (before bats arrived) to determine if the behavior of bats exiting changed from behavior observed as they exited from the full gate in previous years. We videotaped evening emergences to observe the proportion of bats exiting from each space between the bars, as well as obtain a count of the total number of bats exiting. The bar on the gate was replaced at the end of the season on September 11, 2004 to prevent human access.

Data analysis and compilation

We created a database to store information on the location and physical features of mines, and information on our visits.

We obtained census data by watching the videotapes of evening emergences. Tapes were viewed in slow motion to obtain the most accurate counts. From these data, we created spreadsheets that show the number of bats exiting per minute, number of bats entering the mine per minute, net number exiting, and cumulative number exiting.

For Wildhorse Mine, we selected the 15 minutes at the peak of 5 exits (1 from 2001, 1 from 2002, 1 from 2003, and 2 from 2004) and counted the number of bats exiting from each of the nine spaces in the gate to compare the proportion of bats exiting through each space. We determined the 15-minute peak by using the minute where the number exiting per minute was highest and the seven minutes before and after that minute. We watched the videotape in slow motion to obtain the most accurate count, and counted bats in spaces 1-4 on separate viewings. We also compared the maximum number of bats exiting per minute among years, and the total length of emergence time. Data from

1999-2003 are from censuses we conducted using the same methods. To help gain perspective on the data at Wildhorse, we researched the effect of gates on other colonies of cave myotis.

RESULTS

We made a total of 134 visits to 73 mines from January 15, 2004 - March 26, 2005, (Appendix D). There were 23 visits to nine mines in TMP, 77 visits to 43 mines in SNP, and 34 visits to 21 mines on BLM land. We had not previously surveyed 42 of these mines.

We observed California leaf-nosed bats in eight mines, one in TMP, four in SNP, and three on BLM land (Table 1). Size of colonies ranged from 2-100+ bats. We observed cave myotis in 11 mines, two in TMP, four in SNP, and five on BLM land (Table 1). For five of these mines, we tentatively identified the bats as cave myotis based on visual appearance, but in order to minimize disturbance, did not capture any to confirm species identification. In addition to these mines, we observed evidence of bats in 15 mines, five in TMP, nine in SNP, and one on BLM land (Table 2).

We visited 11 vertical shafts in SNP and used the downhole camera to determine if drifts were present (Table 3). We were able to determine that five of these shafts did not have drifts. We were unable to send the camera all the way to the bottom of six shafts because of bees, collapsed timber, or the shaft's angle of decline. One of the shafts (S019) looked like it had a drift, but we were not able to verify this.

Three evening emergences of California leaf-nosed bats at one TMP mine were videotaped June-September, 2004 (Table 1). Evening emergences of cave myotis were videotaped at two SNP mines and one BLM mine (Table 1). These included simultaneous counts at Wildhorse Mine (SNP) and 400-Yard Mine (BLM).

We were unable to determine whether bats used one SNP adit (S085) because a rebar gate across the entrance blocked access. Although we used a light and binoculars to view this adit from the gate, and did not see bats or guano, we cannot definitively state it is not used by bats.

Wildhorse Mine gate

We conducted emergence counts on 30 June, 14 July, 28 July, and 6 August, 2004. Abundance ranged from 1159 to 3077 bats (Table 1). Lengths of emergences were 35, 32, 32, and 38 minutes.

We analyzed the proportion of bats flying through each space between the bars of the gate for 15 minutes during the peak of the emergence for the following dates: 15 July 2001, 19 July 2002, 19 July 2003, 30 June 2004, and 15 July 2004. We compared the average proportion for each space for the three years of full gate with the average proportion for the two dates in 2004 when the bar was removed. The average proportion of bats exiting from spaces 5 and 6 with the bar in was 5%. With the bar out, the proportion of bats exiting increased to 32% (Table 4, Figure 1).

Maximum number of bats exiting per minute was higher in 2004 than the three previous years but lower than in 1999 (Figure 2). Data are from the census with the highest number of bats for each year: July 15, 1999; August 3, 2000; July 21, 2001; July 30 2002; July 19, 2003; August 6, 2004.

Table 1. Bats observed in mines in the Tucson Mountains January, 2004- March, 2005. Mine: T = Tucson Mountain Park, S = Saguaro National Park, B = BLM land. Species: MACA = *Macrotus californicus*, MYVE = *Myotis velifer*, MYVE? = probably *Myotis velifer*. Method: external census = evening emergence videotaped from outside the mine entrance, from gate = bats observed near portal from outside the gate, internal = internal survey

Mine	Species	Method	Date	Number of bats
T001	MACA	from gate	6/18/04	20+
		external census	6/28/04	14
		external census	9/3/04	81
		from gate	9/5/04	30
		external census	9/9/04	43
		from gate	10/10/04	70+
		from gate	11/17/04	10
		internal	12/4/04	30+
		internal	1/15/05	20+
		internal	2/20/05	20+
T007	MYVE?	internal	9/25/04	1
T009	MYVE?	internal	9/25/04	1
S021	MYVE?	internal	6/5/04	100+
		external census	6/27/04	39
		external census	8/5/04	7
		external census	9/11/04	462
S022	MACA	internal	9/11/04	2
	MYVE?	internal	9/11/04	11
S036	MACA	internal	2/28/04	50
		internal	11/27/04	20
		internal	3/22/05	6+
S043	MACA	internal	3/6/04	50
		internal	11/13/04	50+
S50 (Wildhorse)	MYVE	external census	6/30/04	1159
		external census	7/14/04	1786
		external census	7/28/04	2697
		external census	8/6/04	3077
S147 (Old Yuma)	MACA	internal	1/10/04	9+
		internal	12/18/04	50
B05	MYVE?	internal	9/5/04	9
B08	MYVE	internal	9/18/04	5
	MACA	internal	12/11/04	12
B09	MYVE?	internal	9/18/04	3
B11 (400-Yard)	MYVE	external census	7/27/04	1558
	MYVE	external census	8/6/04	1362
	MYVE	external census	9/11/04	274
	MACA	internal	1/23/05	10
	MACA	internal	2/20/05	25+
	MACA	internal	3/25/05	9
B13	MYVE?	Internal	9/18/04	200+
	MACA	internal	1/23/05	20

Table 2. Evidence of bats observed in mines in the Tucson Mountains January, 2004- March, 2005. Mine: T = Tucson Mountain Park, S = Saguaro National Park, B = BLM land. MACA = *Macrotus californicus*

Mine	Date	Evidence of bats
T002	12/4/04	guano
T003	12/4/04	guano
T004	12/4/04	dead MACA, guano
T005	12/4/04	guano
T006	12/4/04	dead MACA, guano
S017	2/28/04	guano
S037	3/22/05	guano
S042	11/13/04	guano
S084	7/3/04	guano
S089	7/3/04	guano
S113	2/28/04	guano (also same dead MACA seen in 2003)
S114	2/29/04	guano
S132	11/27/04	guano
S152	1/18/05	guano
B18	9/25/04	guano

Table 3. Vertical shafts in Saguaro National Park surveyed for drifts by remotely-controlled videocamera, Tucson Mountains, 2005.

Absence of drifts verified	Absence of drifts not able to be determined	Probable drift
S028 (winze) S057 S065 S067A S092	S061 bees S093 decline S095 collapsed timber S096A debris S098 decline	S019

Table 4. Proportions of cave myotis exiting through Wildhorse Mine gate spaces during 15 minutes at the peak of emergence. Space 1 = top space, all bars = full gate 2001-2003, bar removed = 2 censuses in 2004 with the removable bar taken out. Percentages may not sum to 100% because of rounding.

Space	All bars % bats	Bar removed % bats
1	58 ± 2	47 ± 2
2	18 ± 1	13 ± 2
3	12 ± 2	5 ± 1
4	7 ± 1	2 ± 1
5-6	5 ± 0	32 ± 2
7	0 ± 0	0 ± 0
8	0	0
9	no data	0

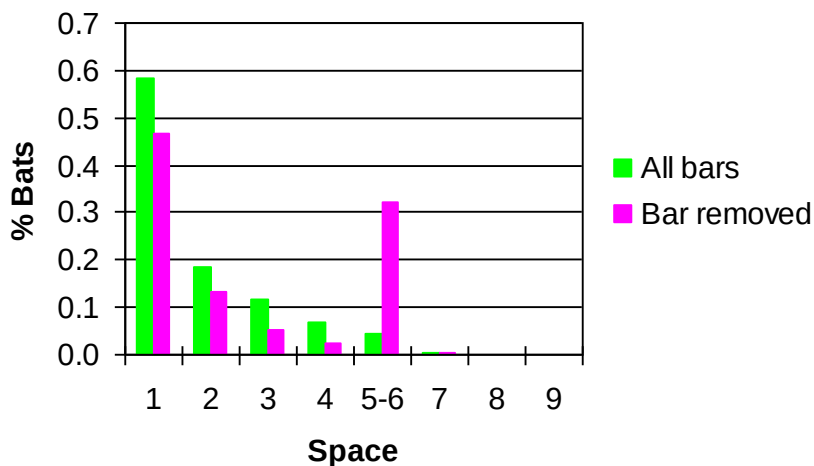


Figure 1. Proportions of cave myotis exiting through gate spaces during 15 minutes at the peak of emergence, Wildhorse Mine, Saguaro National Park. Space 1 = top space, all bars = full gate, one census each from 2001-2003; bar removed = 2 censuses in 2004 with the removable bar taken out.

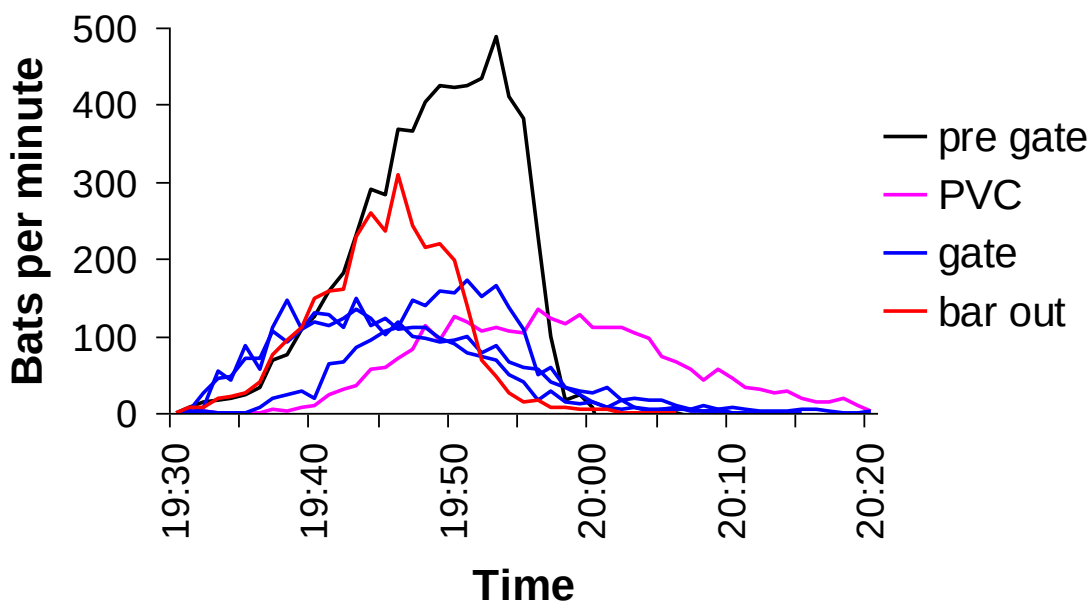


Figure 2. Number of cave myotis exiting per minute during evening emergences at Wildhorse Mine, Saguaro National Park. Pre-gate = 1999; PVC = PVC mock-up gate, 2000; gate = full steel gate 2001, 2002, 2003; bar out = removable bar taken out, 2004. Data are from the census with the highest number of bats for each year. Beginning times of emergences are shifted so lengths of emergences can more easily be compared.

Other wildlife species observed

In addition to bats, live vertebrates observed during mine surveys were barn owls, rattlesnakes, skunks, javelina, turkey vulture, Gila monster, and spiny lizard (Table 5). Active bee hives were observed in two mines, S061 and B10. We also observed dead pack rats and rock squirrels, the old remains of coyote and javelina, and sign such as whitewash, and scat from various animals (Appendix D: Tucson Mountain Mine Field Notes). We have often found javelina remains in mines, however, in 2004, we found an unusually high number of rather freshly dead javelina (Table 6).

Table 5. Live vertebrates other than bats observed in mines in Tucson Mountains, 2004-2005. Mine: T = Tucson Mountain Park, S = Saguaro National Park, B = BLM land.

Mine	Date	Species
T009	9/25/04	spiny lizard in ceiling crevice
S021	6/5/05	black-tailed rattlesnake
S022	6/5/05	turkey vulture and chick
S036	6/5/05	black-tailed rattlesnake
S036	3/22/05	skunk (probably hooded)
S037	3/22/05	skunk (hooded or hog-nosed)
S043	2/29/04	javelina
S065	2/5/05	barn owl
S067	2/5/05	barn owl
S084	7/3/04	black-tailed rattlesnake
S085	7/3/04	snake
S089	7/3/04	Peromyscus and baby
S092	1/30/05	2 barn owls
S093	1/30/05	barn owl
S095	1/30/05	barn owl
S096	1/30/05	barn owl
S098	2/13/05	barn owl
B02	12/11/04	lyre snake
B08	9/18/04	Gila monster
B14	9/5/04	2 barn owls

Table 6. Recently-dead javelina observed in Tucson Mountain mines, 2004. Mine: S = Saguaro National Park, B = BLM land.

Mine	Date	Notes
S017	11/27/04	2 dead, adults, not present on last visit 2/28/04
S036	11/27/04	1 dead, not present 6/5/04
S037	11/27/04	5 dead, 3 adults, 2 half-grown, not present 2/28/04, same amt of decomposition as one in S036
S084	7/3/04	fresh bones of 1 small jav
S089	7/3/04	1 dead, baby
B03	9/18/04	1 dead, adult

DISCUSSION

Macrotus californicus

California leaf-nosed bats are listed as a species of special concern by Arizona Game and Fish Department. In California, in the Colorado River subdivision of the Sonoran Desert, these bats form colonies of up to 2,000 animals; however, colony size in the Arizona Upland subdivision is typically < 400 (pers. obs., second author). Within a limited geographic area, groups of California leaf-nosed bats can occupy multiple sites simultaneously, moving among the sites as individuals (Dalton 2001). Groups can also move from site to site within a season. All bats of this species that live in the Tucson Mountains should be considered part of the same population. In addition, all mines (and caves) used by this population must be considered collectively as roost habitat. A particular mine may be the “best” roost for a period of time based on factors that change, not only seasonally, but also perhaps within a season, and also from year to year. A mine that served as a minor alternate roost one year may be the preferred roost when conditions change the next year.

California leaf-nosed bats do not migrate or hibernate, and therefore inhabit an area year-round. Winter roosts, which are deep sites with stable, relatively warm temperatures, are usually different from summer roosts, which are typically small, shallow caves or mines, often with multiple entrances allowing greater airflow and warmer temperatures than unventilated sites.

We observed California leaf-nosed bats in eight mines; six mines were used as winter roosts, one mine was used in fall, and one mine (T001) was used year-round. Although all these sites should be considered important habitat, T001 is especially significant. This mine, historically called the Tucson Bat Mine, is the only known site in the Tucson Mountains used in summer by this species. Other summer roost sites may exist, indeed are likely to exist, but they have not been located. Unfortunately, we were not able to obtain a full year of observations at T001. Except for one census, we purposely avoided monitoring this site and others nearby until the fall of 2004. Other researchers captured bats here in spring, 2004 and made several visits to the mine throughout the summer. Because of this disturbance and unknown effects on behavior and natural movement patterns, we thought it best to avoid additional disturbance and possible misinterpretation of data, and therefore postponed monitoring until the fall. Five other mines in the immediate vicinity of T001 had evidence of use (guano or dead bats) on our winter visits; we intend to monitor these sites spring through fall, 2005 to determine when they are used, and by how many bats.

Mine T001 is one of the most complex mines we have surveyed in the Tucson Mountains. Mines with multiple drifts and longer passages are likely to have a variety of micro-habitats that bats will exploit at different times of the year, so we were not surprised to observe bats here year-round. The bats roost far back in the mine in the winter, where temperatures are more stable, but in the summer they roost very close to the portal and can be observed without an artificial light source. A steel gate was installed several feet inside the portal in 2001 by Pima County Parks and Recreation after dead bats were found. This gate has no doubt deterred people from entering the mine, but there are spaces at the top that are large enough for many people to climb through. Because of the mine’s urban location and ease of access, the colony is vulnerable to extirpation by acts of direct vandalism or through too-frequent disturbance that can lead to abandonment of the roost. This mine is a significant roost site for California leaf-nosed bats in the Tucson Mountains, and we recommend replacing the existing gate with a bat-compatible gate that cannot be bypassed by humans. California leaf-nosed bats are slow, maneuverable fliers, and seem to accept the current standard bat-compatible gate

design. A large colony in California has increased after installation of the gate to about 3,000 animals (S. Henry, pers. comm.).

At six mines, we observed both California leaf-nosed bats and cave myotis, although except for one instance, the bats used the sites in different seasons. At five sites (B08, B11, B13, S021, S147), California leaf-nosed bats were observed in the winter, and cave myotis in the summer or fall. At S022, small numbers of both species were observed in September.

Myotis velifer

From the results of this project, in addition to previous work, we are beginning to develop a picture of how cave myotis use mines in the Tucson Mountains, although much remains to be learned. Cave myotis use two mines as summer roost sites. Wildhorse Mine (S050) is a bachelor colony, although we have usually observed a few (<9) young every year. The make-up of the present colony at 400-Yard Mine (B11) has not been confirmed. In May 1995, 92 males and 80 females were captured there (Dalton, field notes). In August 1995, 44 males and five females were captured; four of the five females were post-lactating (Dalton, field notes). From these data, it is unclear whether bats using the 400-Yard Mine comprise a maternity colony, or both a bachelor colony and a maternity colony. Males and females typically roost together in the spring, and then separate, so either sex may have moved on to another roost. However, the large percentage of males present in August suggests they stayed throughout the summer. It is not unusual for females to migrate from the maternity colony before the young leave. This would account for the small number of females, but if those bats captured in August were young of the year from a maternity colony, the sex ratio would have been about 1:1. Therefore, it seems likely that this mine is used primarily by males and only a few reproductive females, as is Wildhorse Mine. Work in summer 2005 should determine if the mine is used as a maternity colony.

To our knowledge, Wildhorse and 400-Yard mines are the longest adits in the Tucson Mountains, 700 feet and 329 feet long, respectively (400-Yard is obviously misnamed). They are also the only two adits that are perennially wet. This is not surprising, as cave myotis have often been found in roosts with high humidity and standing water (D. Dalton, pers. obs.).

Bats begin arriving at Wildhorse in April and leave in September. The number of bats varies throughout the season, but peaks mid-July to early August (Table 1). Preliminary census data show that this same pattern holds for bats at 400-Yard Mine (Table 7).

Table 7. Number of *Myotis velifer* counted at 400-Yard Mine, Tucson Mountains, 1995 and 2004 (1995: Dalton field notes).

Date	Number of bats
4/10/1995	a few hundred
5/8/1995	1413
8/5/1995	201
7/27/04	1558
8/6/2004	1362
9/11/2004	274

Although species identification was not confirmed by capturing bats, bats observed using nine mines as late summer transitory roost sites were most likely cave myotis (based on physical characteristics such as size, ear length, facial features, coloring, and the positive identification of a dead bat found in one of the mines). These mines were adits that varied in length from 36 to 208 feet, and in complexity from simple, straight adits to more complex mines with multiple levels and drifts. For eight of these mines, we have data for only one visit at each mine in September; surveys are needed in the spring and summer to complete the picture of seasonal patterns. For Mine 021 in SNP, we have data beginning in early June; numbers decreased to a low in early August and then increased in September (Table 1). This pattern is very similar to the seasonal pattern of cave myotis at bridges in the Tucson metropolitan area, which were also used as transitory roost sites. Numbers of cave myotis in bridges peaked in May and September, with the lowest number in July (Wolf 2003).

We conducted internal surveys at 12 adits in September and observed bats in 75% of them on the day we surveyed. It is very likely that almost every adit in the area, regardless of length, is used by cave myotis at some time during the migratory season. Short-term use by small numbers of bats may be difficult to detect because only small amounts of guano are left and the floors of mines are frequently churned up by javelina. Some mines are no doubt used more often and by larger numbers of bats, but it seems that when viewed collectively, all adits in the Tucson Mountains are important migratory habitat for this species.

Wildhorse Mine gate

Because all variables potentially affecting the use of Wildhorse Mine by cave myotis were not known or controlled before and after gating, it is impossible to determine if the gate caused the decline in numbers from the pre-gate high in 1999. However, we hypothesize that the gate may be limiting the maximum number of bats able to use the mine. Cave myotis are more direct, and therefore less maneuverable, fliers than many other species. The congestion caused by a large colony attempting to exit the mine in the evening results in a longer emergence time than if no gate were present. This results in less foraging time available for the bats emerging later. One might think that 30 minutes less foraging over an entire night would be insignificant. However, cave myotis forage primarily during the first two hours after emergence when insect prey are most abundant (Kunz 1974), and therefore missing 30 minutes of foraging would significantly affect food availability. Emergence times since the permanent gate was installed have been about 30-40 minutes, the same as in 1999 before the gate was installed (Dalton 2002). However, the maximum number of bats exiting per minute post-gate is about half the number pre-gate, and total bats exiting dropped from a high of about 7,000 pre-gate to stabilize at 2,200-3,000 bats in post-gate years 2001-2003. From these data, it appears that in order to emerge in less than 40 minutes, the colony cannot be larger than about 3,000. Again, this is a hypothesis; we cannot infer cause and effect because of the many confounding factors.

In 2004, we began conducting simultaneous counts with 400-Yard Mine to see how within-season and between-season changes in abundance compared with Wildhorse. If we had such data 1999-2003, it may have helped us interpret the post-gate change in abundance at Wildhorse. After a few years of simultaneous counts, we hope to have some understanding of area-wide trends and perhaps evidence of roost-switching between the two sites. These data may also shed light on what happened before and after gating.

In 2004, we also removed the removable bar from the gate to observe changes in exit behavior. The huge increase in the proportion of bats exiting through the lower, larger space indicates that they prefer larger spaces. The maximum number of bats per minute also increased greatly from the years with the full gate, to about 300 bats per minute. For the three years with full gate, numbers were relatively stable from late June into August. In 2004, numbers steadily increased throughout the season, almost three-fold. All these data seem to indicate that the removal of the bar did affect behavior and possibly abundance. We intend to leave the removable bar out again in 2005, and depending on results, modify the top bar to provide a larger space for bats to exit, but still prevent human access. It will probably take several more years of monitoring and experimentation before we can make valid interpretations of how the gate has affected this species.

A literature search for other gated velifer sites did not prove very helpful in providing insight to the situation at Wildhorse. One site was used by cave myotis as a hibernaculum (Jagnow 1998); because that type of use is different from a summer colony that exits every night, the sites are not comparable. A maternity colony of cave myotis inhabits a mine in the Quillin Mine complex, in southeastern Arizona on BLM land. The adit was gated in 1997 and determined to be successful. The size of the portal, the type of gate, and the spacing between the bars were similar at the two sites. Why then, was the Quillin gate called a success, but there may be problems at Wildhorse? A closer look at the details of the Quillin project suggests a possible answer, and illustrates why species-wide generalizations can be misleading. The environmental assessment for this project provided information (Dansby 1997). A survey in July, 1996 estimated 3,000-4,000 adult and volant young in the mine. About 75% of the colony exited out of the adit, the other 25% used the interconnected shaft. The bottom portion of a steel gate was erected in April, 1997, before the bats returned for the summer. In July, plastic bars were installed to complete the gate, and the exit was observed. Except for some circling of bats behind the gate, the flight was the same as the one observed in 1996. The plastic bars were replaced with steel bars before October, 1997. Three quarters of 3,000- 4,000 bats is 2,250-3,000 bats flying out of the adit, which is almost exactly the same range as the colony size of 2,200-3,075 for the three years of the full gate at Wildhorse Mine. If a gate was limiting the numbers of bats to about 3,000 for that sized entrance, the Quillin colony would not be constrained as long as the colony size remained stable and no other changes occurred. It is possible then, that the difference in perceived success between the two gates is because of the difference in pre-gate colony size. It is also possible that, because maternity colonies have more stringent requirements for a roost site than do bachelor colonies, there are few or no alternate sites for the Quillin colony and they will tolerate the gate to remain in the mine. We have not been able to find any records of monitoring conducted after the permanent gate was installed at Quillin. We do know that a cupola-style gate was constructed over the shaft entrance after the adit entrance was gated. It is possible that emergence behavior and colony size has changed since both entrances have been gated. Unfortunately, because the colony has not been monitored sufficiently, the effects of the gates are really unknown.

Roost protection

Only two mines used extensively by bats in the Tucson Mountains (T001, S050) have deterrents to human visitors (other than warning signs and barbed wire) and these mines have already been discussed. Over the last 25 years, gates have been designed and installed across the U.S. to protect people from the hazards of abandoned mines, and to protect bats from the hazards of human visitors. However, how bats respond to these gates is variable and complex, and depends on many factors. Because gates themselves do not help bats (it is the absence of humans that helps), gates should be used only when the colony is at some risk from disturbance. Determining the level of risk for a

particular site can be difficult, and in addition, managers must factor in the possible negative effects of a gate on the bats. Some mines occupied by bats in the Tucson Mountains are relatively remote; others however, are easily accessible. We think it is important to monitor sites to determine the amount of visitor use prior to concluding a gate is necessary. We are planning to install data loggers in six mines in summer, 2005 to quantify such human visitation.

Future Work

We are just beginning to get a picture of how California leaf-nosed bats and cave myotis use mines in the Tucson Mountains. Both species show variability in their abundance and use of roost sites, both within a season and between years. Because of their lability, more monitoring must take place within a year and for many years in order to discern their natural patterns in the Tucson Mountains. In addition, we do not have information on the home range of these bats and the extent of their migratory movements. Cave myotis certainly leave the area, most likely to hibernate in higher elevations. California leaf-nosed bats may also move to mines or caves in nearby mountain ranges during the course of the year. We also do not know how far foraging areas extend from the mines, and whether these foraging habitats are wholly contained within lands managed by SNP, TMP, and BLM. If populations of these bats are to be protected, roost sites and foraging areas outside the boundaries of these agencies must also be located and protected.

RECOMMENDATIONS

1. Replace the existing gate at the Tucson Bat Mine (T001) with a more vandal-resistant gate that cannot be bypassed by humans.
2. Monitor human visitation at mines to determine the level of disturbance to bats.
3. Continue monitoring Wildhorse Mine, experimenting with gate design if necessary to see if acceptance of the gate increases. Continue simultaneous monitoring of 400-Yard Mine to compare seasonal trends and abundance.
4. Continue monitoring known roost sites and search for undocumented roost sites.

ACKNOWLEDGEMENTS

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APPENDIX A

BLM Mine Numbers Cross-referenced

Wolf/Dalton number	Snow/Castner number	Comments
B01		shallow pit 8 ft deep
B02	Cat Mtn 28-2	
B03	Cat Mtn 28-3	
B04	Cat Mtn 28-4	shallow pit, Snow/Castner has location marked incorrectly in report
B05	Cat Mtn 28-5	adit, Snow/Castner has location marked incorrectly in report
B06	Cat Mtn 28-6	10 ft pit on east side of road, fenced, "Ded end" sign
B07	Cat Mtn 28-7	shaft 30 ft
B08	Cat Mtn 28-8	
B09	Cat Mtn 28-9 Iron Door	
B10	Cat Mtn 28-10	
B11 400-Yard	400Yard Mine	
B12		
B13		upper adit marked on topo, ne corner sec 28 just south of section line, Snow/Castner map labels as 28-4 but description doesn't match this mine
B14		shaft at top of hill, marked as prospect on topo ne corner sec 28
B15	Brown Mtn 28-3	
B16		
B17		
B18	Brown Mtn 28-1	
BSH1		Saginaw Hill, number obtained from Bill Aubey, BLM
BSH11		Saginaw Hill, number obtained from Bill Aubey, BLM
BSH14		Saginaw Hill, number obtained from Bill Aubey, BLM
didn't find	Cat Mtn 28-1	
didn't find	Cat Mtn 28-11	

APPENDIX B



Remotely-controlled downhole camera used to inspect shafts for the presence of drifts.

Wildhorse Mine, Saguaro National Park



Full gate



Bar removed

APPENDIX C

Page 10: Figures 1 and 2 in black and white for photocopies

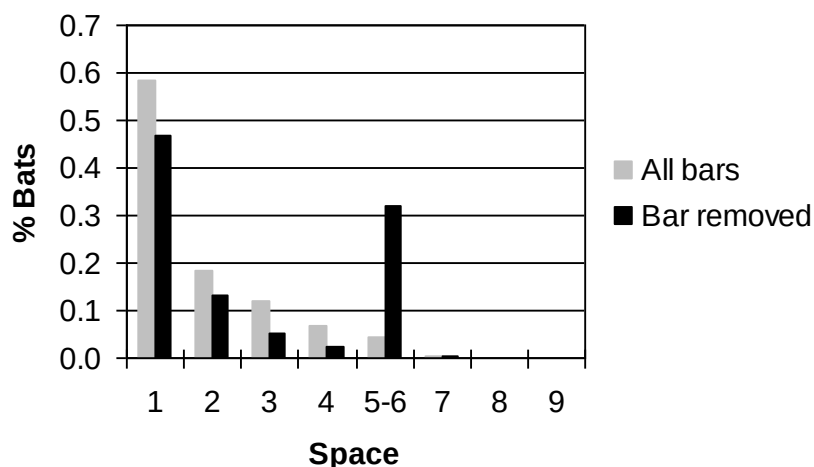


Figure 1. Proportions of cave myotis exiting through gate spaces during 15 minutes at the peak of emergence. All bars = full gate 2001-2003, bar removed = 2 censuses in 2004 with the removable bar taken out.

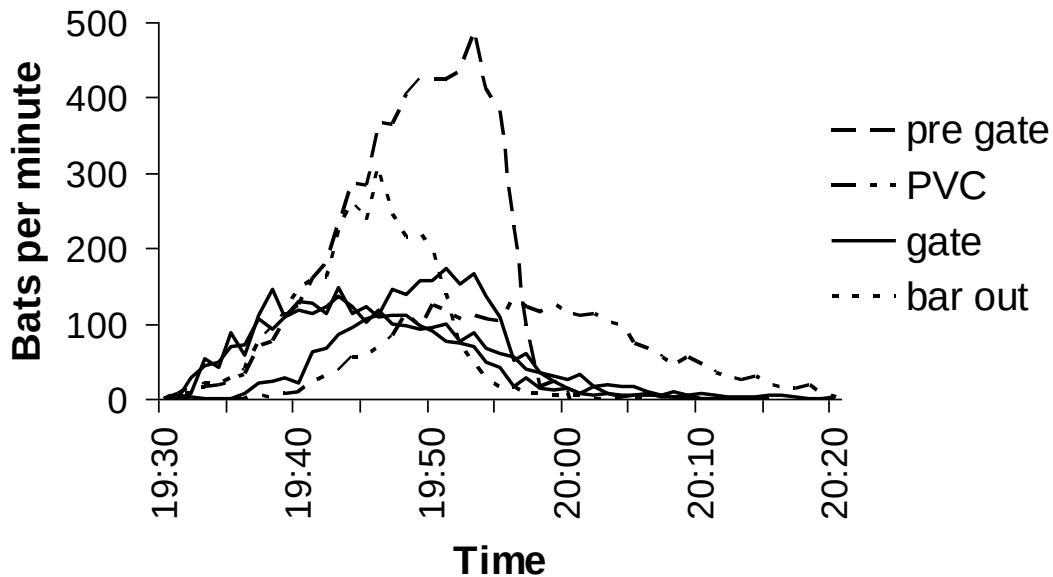


Figure 2. Number of *Myotis velifer* exiting per minute during evening emergences at Wildhorse Mine, Saguaro National Park. Pre-gate = 1999; PVC = PVC mock-up gate, 2000; gate = full steel gate 2001, 2002, 2003; bar out = removable bar taken out, 2004. Data are from the census with the highest number of bats for each year. Beginning times of emergences are shifted so lengths of emergences can more easily be compared.