2002 FINAL REPORT: CENSUS AND RADIO TELEMETRY OF BATS AT HEIL VALLEY RANCH

Rick Adams, Department of Biological Sciences,

University of Northern Colorado, Greeley, CO 80369,

The Colorado Bat Society, Boulder, CO 80302

(20 pages, 7 figures, 2 tables)

OVERSITE AGENCY & CONTACT
Boulder County Parks and Open Space
Mark Brennan, Wildlife Biologist

DRAFT SUBMISSION
23 October 2002

FINAL REPORT SUBMISSION
13 December 2002

2002 FINAL REPORT: CENSUS AND RADIO TELEMETRY OF BATS AT HEIL VALLEY RANCH.

Rick Adams, Department of Biological Sciences

University of Northern Colorado, Greeley, CO 80369

Abstract.–A total of 70 bats were captured over 30 net nights. Of these, seven individuals were tagged with Holohil, LTD, 0.47g transmitters. Of the seven bats radio-tagged, the signal was re-acquired for six individuals, and five roost sites were located. Minimum home ranges were determined for five individuals using nighttime tracking with telemetry receivers. Two transmitters failed and were returned to the manufacturer for repair, and along with another transmitter not deployed in 2002, these will be deployed in summer 2003. All roost sites located were located in in rocks. For *Myotis evotis*, roosts sites were found under rocks located on the ground, making them highly susceptible to disturbance.

INTRODUCTION

Eleven of 18 species of Coloradan bats occur in Boulder County (Adams, 1995, 1996; Adams and Thibault, 1998, 1999). Because roost sites and water resources are the most important ecological limiting factors to bats (Adams, 1988, 1990; Armstrong, 1972; Armstrong et al., 1994), such high diversity suggests the presence of a unique assortment of usable day/night roosts, as well as adequate water resources. In 1998, the Western Bat Working Group, of which the Colorado Bat Society is a member, published a Regional Priority Matrix for bats. Of the species listed for the Colorado region, Townsend's big-eared bat (*Corynorhinus townsendii*) is

designated to be of the highest priority for conservation actions, whereas the fringed myotis (*Myotis thysanodes*), the hoary bat (*Lasiurus cinereus*), and the silver-haired bat (*Lasionycteris noctivagans*) are designated 'of special concern,' indicating a lack of information necessary to determine their population status.

In addition, the annual Bat Trend Survey data gathered by the Colorado Bat Society since 1990 shows alarming downhill trends in population numbers throughout the state over the past eight years (Armstrong et al., 1994, Armstrong et al., 1995; Hall, 1995). This is particularly concerning in light of research revealing bats to be highly important components in the balance of ecosystems and overall forest health (Findley, 1993). At one end of the spectrum, they are voracious and unmatched predators of night-flying insects (many of which are human pest-species), and on the other, they are important prey to higher-level carnivorous animals, thereby comprising an important link in complex food webs (Findley, 1993). In addition, because bats form large colonies in caverns devoid of sunlight, they are keystone species that drive cave and abandoned mine ecosystems by acting as conduits of energy flow. Large piles of guano deposited by historic colonies of bats support up to several hundred species of co-evolved organisms.

Data gathered in Boulder County bats using mist netting, radio-tracking, and roost site temperature/humidity data loggers over the past seven years has provided important insight into bat populations in the area (Adams, 1995, 1996, 1999, 2000, 2001; Adams & Thibault, 1997, 1998; Thibault and Adams, 1996, 1998). This work has led to seasonal closures of climbing rocks and caves in the area that house maternity colonies of imperiled species. In addition, a previously undocumented record of the Brazilian free-tailed bat (*Tadarida brasiliensis*) occurred

(Adams and Thibault, 1999). In addition, we have documented that females and juveniles preferentially visit calcium-rich water holes that apparently aid in sequestering calcium not provided by an insectivorous diet (Adams et al., in press). Furthermore, through the use of thermal cameras we have discovered that there are distinct approach paths to drinking holes that all species use, apparently to avoid aerial collisions (Adams and Simmons, in press). This type of co-operative behavior among bat species was previously undocumented.

MATERIALS AND METHODS

Survey & Telemetry Methods.--Bats were captured using American-made mist nets stretched over water, erected approximated 20-30 minutes before dark. Number of nets erected per site was usually two. Captured individuals were distinguished to species, weighed, sexed, and checked for reproductive condition. Seven lactating females were fitted with LB-2, 0.47g radio transmitters produced by Holohil Systems, Ltd. Bats were tracked using a Wildlife Materials (Carbondale, IL) 48-Channel receiver outfitted with Yagi antennas. A Magellan 4000 GPS unit was used to gather coordinates roost and netting sites. TOPO, Inc. mapping software was used to determine distances between roost and capture sites. Minimum home ranges were documented by nighttime tracking using a telemetry receiver, and positions were mapped with TOPO. Inc. mapping software. Outflight counts at roost sites were conducted when possible.

RESULTS

Capture Data.--A total of 70 bats of eight species [*M. lucifugus* (n = 23), *M. evotis* (n = 20), *Myotis thysanodes* (n = 17), *M. ciliolabrum* (n = 1), *Eptesicus fuscus* (n = 7), *Lasiurus cinereus*

(*n* = 1), *Lasionycteris noctivagans* (*n* = 1), and *Corynorhinus townsendii* (*n* = 1) was captured over 30 net nights (Table 1). Of these species, two (*Corynorhinus townsendii* and *M. thysanodes*) are listed as "imperiled" by the Western Bat Working Group, the Colorado Natural Heritage Program, the Colorado Division of Wildlife, and the North American Bat Conservation Partnership. Successful netting locations were Upper Geer Canyon, Lower Geer Canyon, and Ingersol Quarry. Of the 70 bats captured, Ingersol Quarry accounted for 40 (57.1%) of those captures, Upper Geer Canyon accounted for 18 (25.7%) captures, and Lower Geer Canyon for 12 (17.2%) captures.

The Heil Valley Ranch Assemblage

Thus far, the Ranch bat assemblage is known to consists of 8 species, all of which are insectivores (Armstrong et al., 1994). Three species are fast-fliers with low maneuverability and are open-area foragers [hoary bat (*Lasiurus cinereus*), silver haired bat (*Lasionycteris noctivagans*), and big brown bat (*Eptesicus fuscus*). Two species fly at moderate speeds and forage along forest edges (western small-footed myotis (*Myotis ciliolabrum*), and little brown bat (*Myotis lucifugus*). Three species are slow-speed flyers that forage within cluttered forest [long-eared myotis (*Myotis evotis*), fringed myotis (*Myotis thysanodes*), and Townsend's big-eared bat (*Corynorhinus townsendii*)]. Of these, two species (*M. evotis* and *C. townsendii*) are specialized as gleaners, using slow maneuverable flight to pick insects from the surface of vegetation (Armstrong et al., 1994). Two of the species, *Corynorhinus townsendii* and *Myotis thysanodes*, are considered "imperiled" by the Western Bat Working Group, Colorado Natural Heritage Program, Colorado Division of Wildlife, and the North American Bat Conservation Partnership.

TABLE 1. *Capture data of bats at Heil Valley Ranch during the summer of 2002. TIME = time of capture, NS = nonscrotal, NLNP = nonlactating/nonpregnant, weight is in grams.*

A. Lower Geer Canyon

DATE	TIME	SPECIES	SEX	REPRO	WGT	AGE
24 June	2146	*E. fuscus*	♂	Scrotal	12.5	Adult
29 July	2033	*M. evotis:*		escaped net		
29 July	2052	*M. thysanodes*	♀(R-tag #90)	Lactating	none	Adult
29 July	2056	*M. thysanodes*	♂	NS	6.5	Adult
29 July	2106	*M. thysanodes*	♂	NS	none	Adult
4 August	2045	*M. thysanodes*	♀	Lactating	8.9	Adult
4 August	2050	*M. thysanodes*	♀	Lactating	6.9	Adult
4 August	2059	*M. thysanodes*	♂	NS	7.1	SubAdult
4 August	2059	*M. thysanodes*	♀	PostLactating	8.8	Adult
4 August	2112	*M. thysanodes*	♀	NLNP	5.1	SubAdult
4 August	2118	*M. thysanodes*	♀	NLNP	4.1	Juvenile
4 August	2129	*M. evotis*	♂	NS	6.5	SubAdult

B. Upper Geer Canyon

DATE	TIME	SPECIES	SEX	REPRO	WGT	AGE
27 June	2110	*M. thysanodes*	♀ (R-Tag #84)	Lactating	none	Adult
27 June	2110	*L. noctivagans*	♂	NS	9.2	Adult
27 June	2112	*M. thysanodes*	♂	NS	6.1	Adult
27 June	2143	*M. evotis*	♀ (R-tag #86)	Pregnant	none	Adult

DATE	TIME	SPECIES	SEX	REPRO	WGT	AGE
27 June	2152	*M. evotis*	♂	NS	7.1	Adult
5 July	2129	*M. evotis*	♂	NS	6.8	Adult
5 July	2129	*M. evotis*	♂	NS	5.5	Adult
5 July	2136	*M. thysanodes*	♂	NS	8.1	Adult
5 July	2210	*C. townsendii*	♂	NS	11.5	Adult
5 July	2221	*M. lucifugus*	♂	NS	6.1	Adult
30 July	2055	*E. fuscus*	♂	NS	18	SubAdult
30 July	2055	*M. evotis*	♂	NS	4.1	Juvenile
30 July	2055	*M. evotis*	♂	NS	none	SubAdult
30 July	2055	*M. evotis*	♀	NLNP	6.1	SubAdult
30 July	2055	*M. evotis:*		escaped net		
30 July	2123	*M. evotis*	♀	NLNP	5.9	Adult
30 July	2127	*M. evotis*	♀(R-tag #88)	Lactating	none	Adult
30 July	2159	*M. thysanodes*	♀	NLNP	5.2	Juvenile

C. Ingersol Quarry (in order of capture)

DATE	TIME	SPECIES	SEX	REPRO	WGT	AGE
2 July	2101	*E. fuscus*	♂	NS	17	Adult
2 July	none	*L. cinereus*	♂	NS	37	Adult
2 July	none	*M. lucifugus*	♀(R-tag #85)	Lactating	none	Adult
2 July	none	*M. lucifugus*	♀	Lactating	6.0	Adult
2 July	none	*M. lucifugus*	♀	Lactating	7.2	Adult
2 July	none	*M. lucifugus*	♀	Pregnant	none	Adult
2 July	none	*M. lucifugus*	♀	Pregnant	none	Adult

DATE	TIME	SPECIES	SEX	REPRO	WGT	AGE
2 July	none	*M. lucifugus*	♂	NS	none	Adult
2 July	none	*E. fuscus*	♂	NS	none	Adult
2 July	none	*M. evotis*	♀	Lactating	none	Adult
2 July	none	*M. lucifugus*	♂	NS	none	Adult
16 July	2110	*M. evotis*	♀(R-tag #81)	Lactating	5.5	Adult
16 July	none	*M. lucifugus*	♂	NS	7.0	Adult
16 July	none	*M. lucifugus*	♂	NS	6.5	Adult
16 July	none	*M. lucifugus*	♂	NS	6.5	Adult
16 July	none	*M. lucifugus*	♂	NS	6.9	Adult
16 July	none	*M. lucifugus*	♀	NLNP	7.3	SubAdult
16 July	none	*M. lucifugus*	♀	NLNP	7.1	SubAdult
16 July	none	*M. lucifugus*	♀	Lactating	7.3	Adult
16 July	none	*M. ciliolabrum*	♀(Rtag # 87)	Lactating	none	Adult
16 July	none	*M. lucifugus*	♀	NLNP	9.0	SubAdult
16 July	none	*M. lucifugus*	♂	Scrotal	8.5	Adult
16 July	none	*M. lucifugus*	♂	NS	5.5	Adult
16 July	none	*M. lucifugus*	♀	Lactating	8.0	Adult
16 July	none	*M. lucifugus*	♀	Lactating	4.1	Adult
16 July	none	*M. lucifugus*	♀	Lactating	6.1	Adult
16 July	none	*M. lucifugus*	none		5.1	SubAdult
16 July	2218	*E. fuscus*	♂	NS	none	Adult
31 August	2009	*M. lucifugus*	♂	S	6.0	Adult
31 August	2009	*M. lucifugus*	♂	NS	7.0	SubAdult
31 August	2009	*M. evotis*	♂	NS	4.5	SubAdult

DATE	TIME	SPECIES	SEX	REPRO	WGT	AGE
31 August	2009	*M. evotis*	♂	NS	4.9	SubAdult
31 August	2028	*E. fuscus*	♂	S	19.5	Adult
31 August	2028	*M. thysanodes*	♀(Rtag #83)	Lactating	8.5	Adult
31 August	2028	*M. thysanodes*	♀	Lactating		Adult
31 August	2028	*M. thysanodes*	♀	Lactating		Adult
31 August	2028	*M. thysanodes*	♀	Lactating		Adult
31 August	2059	*E. fuscus*	♂	Scrotal	19.5	Adult
31 August	2059	*M. evotis*	♂	NS	5.0	SubAdult
31 August	2101	*M. evotis*	♂	NS	8.8	SubAdult
31 August	2107	*M.evotis:*		escaped net		SubAdult

Telemetry Data. – Seven females were fitted with radio-transmitters. Of these, one transmitter was removed by an individual after tagging and was found below a ponderosa pine tree the following day. Two signals were reacquired during nighttime flights where minimum home ranges could be estimated, but roost sites were not located; and four maternity roost sites were located for three species. For summary see Table 2.

Upper Geer Canyon: On 27 June a lactating fringed myotis (*M. thysanodes*) was radio-tagged at upper Geer Canyon (Lat. 40° 08' 51", Long. 105° 18' 56"). Upon release the individual was tracked heading SW of the water hole. The following morning (28 June), I tracked the signal to a ponderosa pine tree (Lat. 40° 08' 39", Long. 105° 18' 48") approximately 0.4 km from the tagging site. The transmitter had been removed by the bat and was lying on the ground. It was recovered and reused at a later date. On 27 June a pregnant long-eared myotis (*M. evotis*) was transmittered and released. This individual headed south of the water hole immediately after release, but returned to the site several times over the following hour, after which the signal was lost. The following morning (28 June) I reacquired the signal from the upper Geer Canyon water hole and after about an hour I located the individual was located roosting under a thin slab of rock on the surface of a large boulder that faced NNW. Direct morning sunlight was illuminating the surface of the roost site boulder. I could peer into the crevice and see that this pregnant individual was roosting alone. I tracked this individual's foraging pattern over the following two nights and calculated a minimum home range of 5.2 kilometers (Fig. 1, blue line). The majority of its foraging activity during tracking was spent along the western edge of the most eastern Dakota ridge of the Ranch (Fig. 1, yellow line).

On 30 July, I tagged a lactating long-eared myotis (*M. evotis*) at upper Geer Canyon water

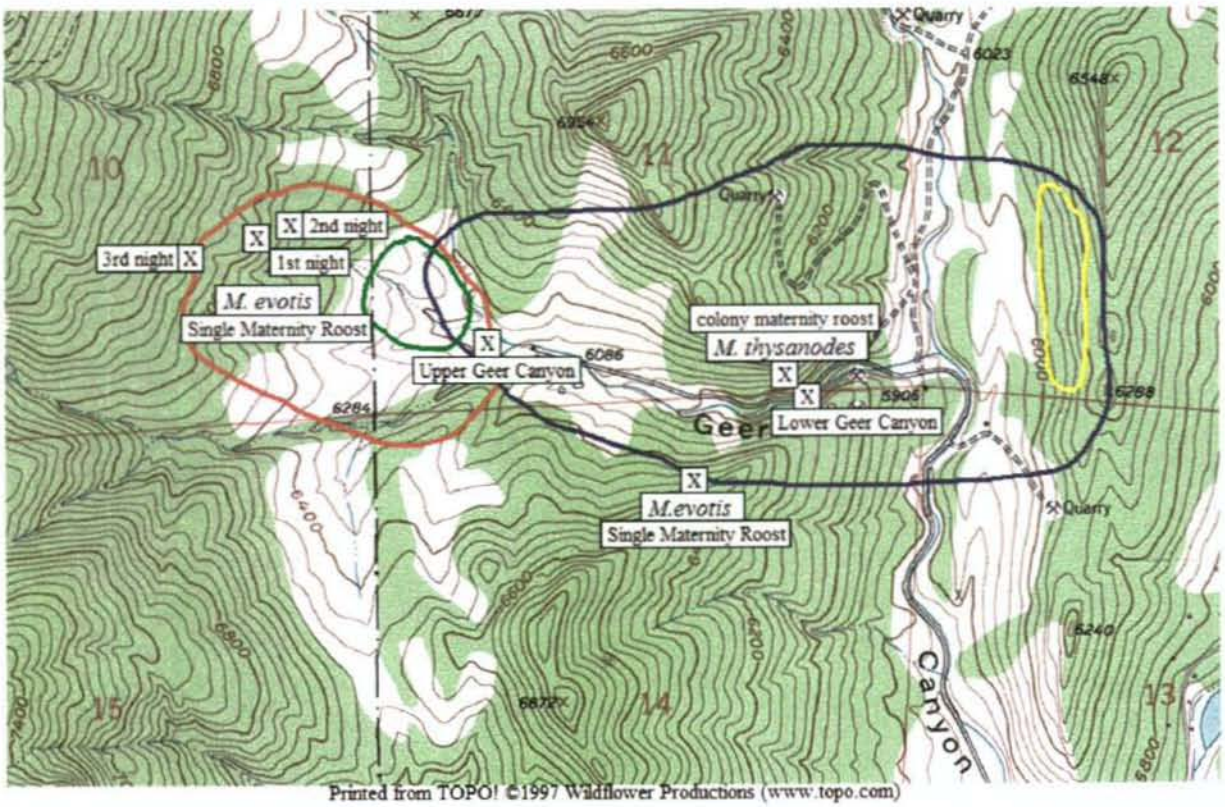

Figure 1. Roosting locations of bats radio-tagged in Geer Canyon. Roost sites for two *M. evotis* were documented. For one female and her offspring, different sites were used over a three night period in the same general location. A maternity colony of approximately 15 *M. thysanodes* was located in a rock crevice in proximity to and NNW of the lower Geer Canyon water hole. Home ranges for one *M. evotis* (red, blue) are depicted. Yellow and green ellipses indicate primary foraging areas. See text for further discussion.

hole. After release it flew SW of the site and returned on several occasions thereafter for about an hour. The following day (31 July) I tracked this individual to a roost site NW of the water hole where it was roosting under a rock on the ground (Lat. 40° 09' 00", Long. 105° 19' 28"). The lactating female exited the rock at 2041, followed by a second individual at 2042. No other bats were observed leaving the roost site. On 3 August, I tracked the lactating *M. evotis* to a different, but nearby roost site also located under a rock on the ground (Lat. 40° 09' 02", Long. 105° 19' 26"). At 2042 the lactating female left the roost followed by another individual at 2045. On 4 August, I tracked the tagged female to yet another roost site under a nearby rock (Lat. 40° 09' 02", Long. 105° 19' 26"). The female left the roost at 2043, followed by a second individual at 2045. It seems plausible to assume that the second individual viewed leaving the roost on each of these nights was the single offspring of the tagged lactating female. Fig. 1 shows the location of roosting sites used over three days by the two individuals as well as the female's minimum home range (red line). The green line indicates the female's dominant foraging area over the three nights of tracking. Minimum home range was calculated to be 2.61 km.

Lower Geer Canyon: On 29 July, a lactating female fringed myotis (*M. thysanodes*) was radio-tagged at the lower Geer Canyon water hole (Lat. 40° 08' 46", Long. 105° 18' 14"). On 30 July, I tracked the signal to a roost site located above and NW of the water hole. It was located in a rock crevice (Lat. 40° 08' 49", Long. 105° 18' 18") that faced SW (Fig. 1). An outflight count estimated the colony size to be 15-17 individuals. Unfortunately, the tagged female removed the radio-tag from her dorsum while in the roost, therefore, no tracking data are available for this individual.

Ingersol Quarry: On 2 July, two of three transmitters brought to the site failed before

deployment. The remaining tag was attached to a *M. lucifugus*, lactating female (Table 1). The signal was reacquired over several nights while the bat was foraging SW and NW of the Quarry, however, despite several days of reconnaissance the roost site was never located. On 16 July, three individuals were transmittered. A lactating female *M. evotis* (Tag # 81), a female lactating *M. thysanodes* (Tag # 83), and a female lactating *M. ciliolabrum* (Tag #87). The roost site of the female *M. evotis* was never found, although the signal was reacquired from below Ingersol Quarry in a SSW direction at a distance of 1-1.5 km. After four days of searching and three nights of radio telemetry from various points in the park, the direction of the signals for the female *M. thysanodes* and female *M. ciliolabrum* were pinpointed and the location of their roost sites was located (Fig. 2). Both of these species were roosting on a a large rock canyon wall, facing SE and located approximately 2.3 km SSW of Ingersol Quarry. On the three nights of telemetry, these bats left their roost sites on the canyon wall and flew NW appearing from over the farthest mountain top, and foraging in this area for about 30 minutes. After this initial foraging bout, they would visit the quarry to drink, and then return to foraging. The rest of the time they spent in and out of range of the telemetry receiver in a direction SSW of Ingersol Quarry. Comparing these data with those of the *M. lucifugus* female tagged on 2 July, it seems reasonable to assume that the *M. lucifugus* roost site was also located on, or near, the same rock canyon wall because the initial reception of the signal was received from the same direction and its flight route was highly similar to that of the individuals tagged on 16 July (Fig. 2). Minimum home range estimates for all three species were about 5.85 km. (See Table 2 for summary of telemetry data).

Flight Profiles.–Figure 3 gives a flight profile for a pregnant *M. evotis* radio-tagged on 27 June at Upper Geer Canyon. Its flight path involved traversing elevations exceeding 2,000m as it foraged

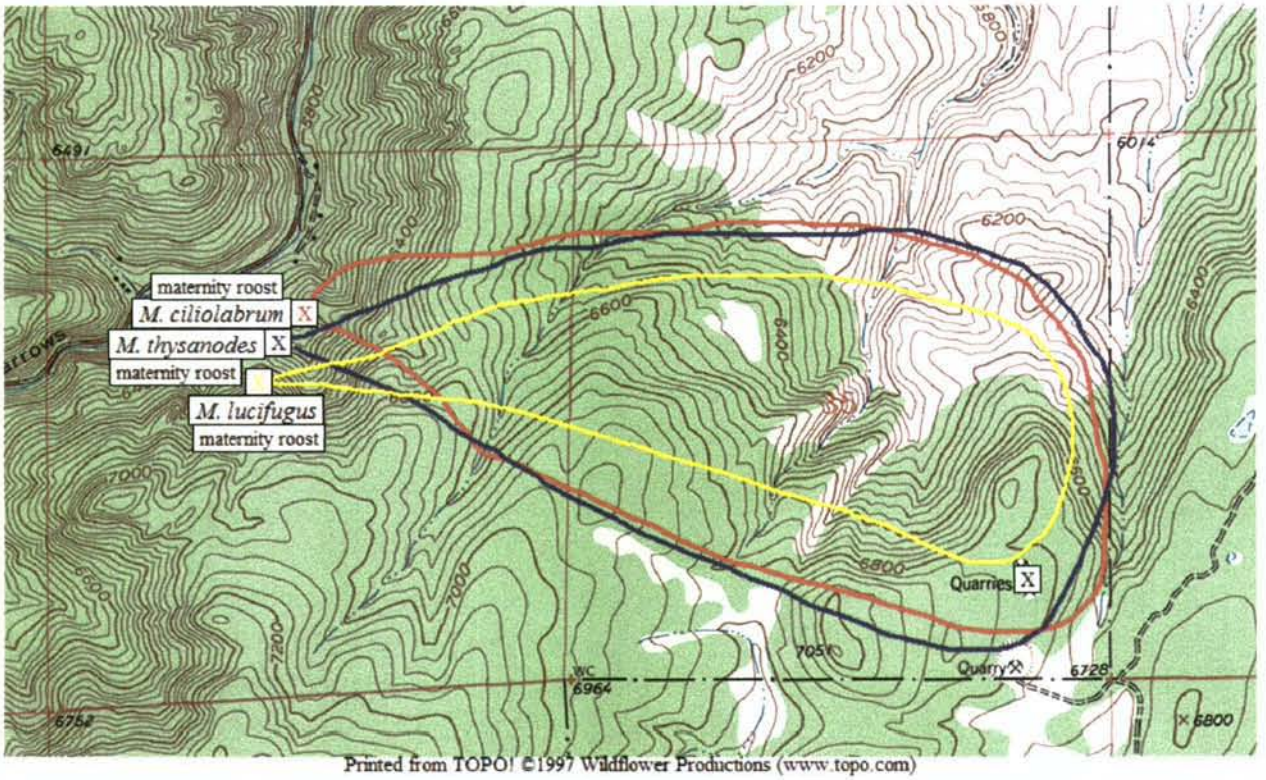

Figure 2. Roost site locations of bats tagged at Ingersol Quarry. For *M. ciliolabrum* and *M. thysanodes*, rock crevices were located. For *M. lucifugus*, the telemetry signal was never reacquired, however, this marks probable location of roost site (see text). Red line indicates minimum home range of *M. ciliolabrum*, blue line marks minimum home range of *M. thysanodes*, yellow line indicates probable minimum home range for *M. lucifugus*. No dominant foraging area was discernable for these species as they tended to forage almost equally in areas throughout the minimum home range.

TABLE 2. *Telemetry data gathered from seven individuals radio-tagged in 2002. Date indicates date of tagging, TAG SITE = water holes where individuals were radio-tagged, MIN HR = minimum home range estimate, DISTANCE = distance between tagging site and roost site, LOCATION = coordinates of roost site locations. For* M. evotis *tagged on 30 July, three different roost sites were used over three consecutive nights in the same relative area. Coordinates are given for those roost sites, with two sites located almost next to each other.*

SPECIES	DATE	TAG SITE	MIN HR	DISTANCE	LOCATION
M. evotis	27 June	Upper Geer 40.08.52 105.18.56	5.20 km	0.68 km	40.09.00 105.19.28
M. evotis	30 July	Upper Geer	2.61 km	0.72 km	40.09.02 105.19.28 40.09.02 105.19.26
M. thysanodes	29 July	Lower Geer 40.08.46 105.18.56	NA	0.14 km	40.08.49 105.19.26
M. lucifugus	2 July	Ingersol 40.10.43 105.18.15	5.85 km	2.3 km	40.11.06 105.19.51
M. evotis	16 July	Ingersol	5.85 km	2.3 km	40.11.06 105.19.51
M. ciliolabrum	16 July	Ingersol	5.85 km	2.3 km	40.11.06 105.19.51
M. thysanodes	16 July	Ingersol	5.85 km	2.3 km	40.11.06 105.19.51

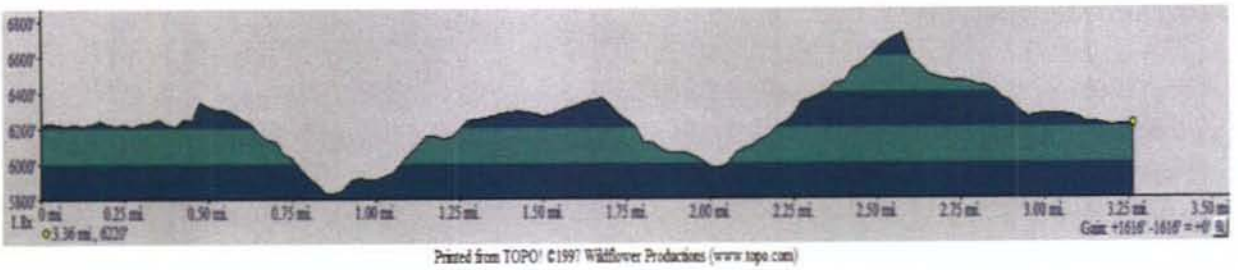

Figure 3. Profile of estimated circuit flown by a pregnant *M. evotis* radio-tagged at upper Geer Canyon water hole. See text for further discussion.

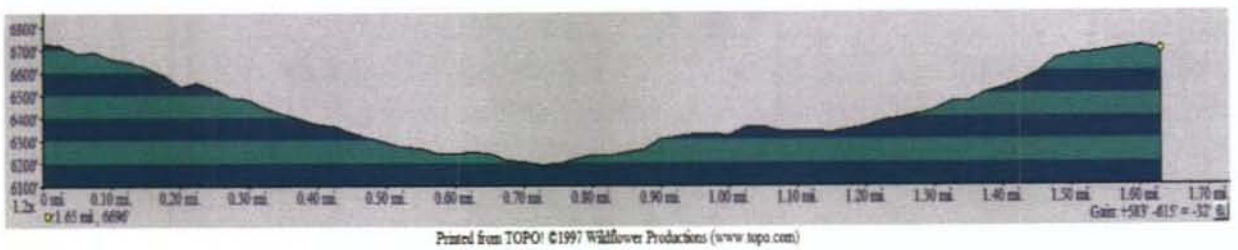

Figure 4. Profile of estimated circuit flown by a lactating female *M. evotis* radio-tagged at upper Geer Canyon water hole. See text for further discussion.

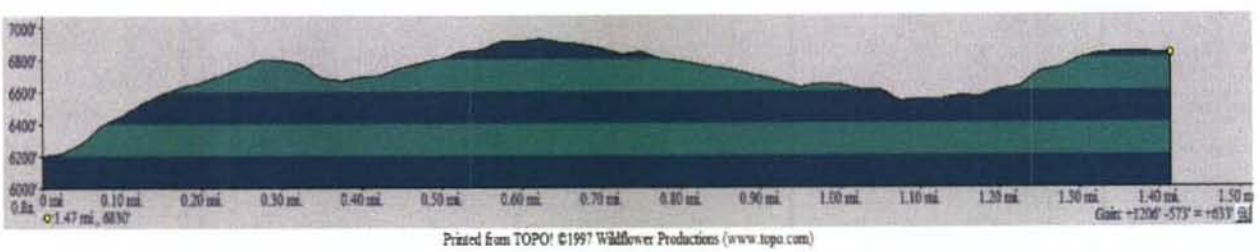

Figure 5. Terrain between Ingersol Quarry and the rock canyon wall located approximately 2.3 km SSW of the Quarry where maternity roost sites of *M. thysanodes*, and *M. ciliolabrum*, and probably *M. lucifugus,* occur. See text for further discussion.

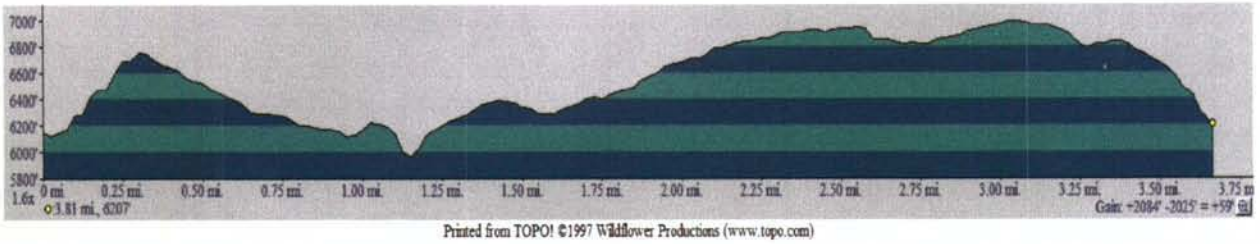

Figure 6. Profile of minimum range flight circuit flown by *M. ciliolabrum* tagged at Ingersol Quarry and roosting on rock cliff SSW of the Quarry. See text for further discussion.

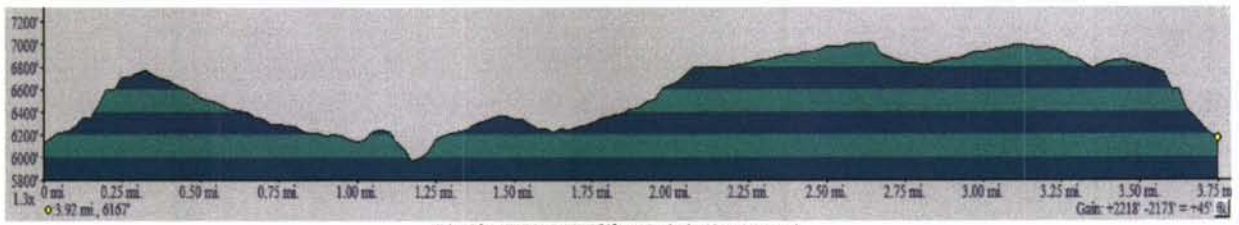

Figure 7. Profile of minimum range flight circuit of *M. thysanodes* tagged at Ingersol Quarry and roosting on rock cliff SSW of the Quarry. See text for further discussion.

along the foothills and valleys north of its roost site. Most foraging was observed to occur at about 1,800 m along the Dakota ridge NNW of its roost site. Figure 4 gives a flight profile for a lactating *M. evotis* radio-tagged at Upper Geer Canyon on 30 July. Some foraging was conducted at elevations approaching 2,100m, however, most of its activity was concentrated in the valley between higher elevations, between 1,800 and 1,900m. Figure 5 shows a terrain profile between Ingersol Quarry and the rock wall housing maternity colonies of *M. thysanodes, M. ciliolabrum*, and likely *M. lucifugus*. The roosting sites were located at an elevation of approximately 1,900m, and therefore bats leaving their roost had to traverse to an elevation of 2,100m to drink and forage at the Quarry. Flight profiles of foraging pathways for *M. ciliolabrum* (Fig. 6) and *M. thysanodes* (Fig. 7) indicate that these individuals traversed foothills in excess of 2,000m while foraging.

DISCUSSION

Data collected on bats at Heil Valley Ranch in summer 2002 has provided some preliminary insight in to species abundance and distribution at this location. In addition, radio-telemetry data yielded roost-site location data, minimum home range, and foraging behavior data for seven individuals among four species. Most importantly, maternity roost were located for the imperiled species, *M. thysanodes*. One of the roosts is located in Lower Geer Canyon within the closed area of the property. It is therefore likely protected from human disturbance by visitors. The other maternity site is located outside the Ranch boundary on National Forest lands and its protection status is unknown. In addition, the capture of a male Townsend's big-eared bat (*C. townsendii*) in Upper Geer Canyon, suggest that this imperiled species is present on site, however,

whether or not reproductive females are present is still uncertain. Further trapping may expose a maternity site for this highly imperiled species that tends to use larger caverns to set up maternity roosts. The City of Boulder Open Space and Mountain Parks has protected two such sites from human disturbance because of this species precarious existence in the Foothills. In fact, only eight maternity roost sites for this species are known in the state.

Of the four sites netted in 2002, Ingersol Quarry is the most active. It is a relatively large water hole that can accommodate open aerial foragers such as big brown bats (*Eptesicus fuscus*) and hoary bats (*Lasiurus cinereus*). In addition, four species of myotis were captured at the site including *M. thysanodes* which is imperiled. The single capture of a small footed myotis *(M. ciliolabrum*) at Ingersol Quarry was significant because this species has thus far not been captured elsewhere on the property.

RECOMMENDATIONS

Further trapping at more sites and at the same sites at Heil Valley Ranch will give greater information into the bat species composition and abundance. In my opinion, it is probable that Heil Valley Ranch supports more maternity colonies than thus far located. The only species in the Foothills assemblage unaccounted is the long-legged myotis (*M. volans*). Predictably this species will be captured on-site if netting is continued. Continued collection of telemetry data will give greater insight, not only into the number of roost sites present, but also population numbers and foraging behaviors.

RELEVANT LITERATURE

Adams, R. A. 1988. Trends in the reproductive biology of some bats in Colorado. *Bat Research News*, 39:21-25.

Adams, R. A. 1990. Biogeography of bats in Colorado: ecological implications of species tolerances. *Bat Research News*, 31:17-21.

Adams, R. A. 1995. Boulder County bats: a one year census.*City of Boulder Open Space Technical Report, Boulder*.

Adams, R. A. 1996. Patterns of water resource use and continued census of bats in Boulder County. *City of Boulder Open Space Technical Report*, 34 pp.

Adams, R. A. and K. M. Thibault. 1998. Survey of Boulder County bats: A study of roost site distribution and community ecology *City of Boulder Open Space Technical Report, Boulder*.

Adams, R. A. and K. M. Thibault. 1999. Records of the Brazilian free-tailed bat (Chiroptera: Molossidae), *Tadarida brasiliensis*, in Colorado. The Southwestern Naturalist, 44: 542-543.

Adams, R. A., and J. A. Simmons. In press. Directionality of drinking passes by bats at water holes: is there cooperation? Acta Chiropterologica.

Adams, R. A., S. C. Pedersen, K. M. Thibault, J. Jadin, and B. Petru. Revised. Calcium as a limiting resource to insectivorous bats: can water holes provide a supplemental calcium source. Journal of Zoology, London.

Armstrong, D. M. 1972. Distribution of mammals in Colorado. *Mus. of Nat. Hist., Univ. Kansas*, 3:1-415.

Armstrong, D. M., R. A. Adams, and J. Freeman. 1994. *Distribution and ecology of bats of Colorado*. Univ. Colorado Nat. Hist. Inventory., 15:1-83.

Armstrong, D. M., R. A. Adams, K. Navo, J. Freeman, and S. Bissell. 1995. *Bats of Colorado: shadows in the night*. Colo. Div. Wildlife Publ., Denver.

Findley, J. S. 1993. *Bats: a community perspective*. Cambridge Univ. Press, 167 pp.

University of Tennessee

Kunz, T H. 1988. *Ecological and behavioral methods in the study of bats. Smithsonian Press*, Washington, D.C..

Thibault, K. M., and R. A. Adams. 1996. Patterns of water usage by a Coloradan bat assemblage. *Bat Research News*, 37:153.

Thibault, K. M. and R. A. Adams.1998. Use of rock crevices as day roosts by the bat of Boulder. *Bat Research News*, 39:160.