The Effects of Elevation and Associated Environmental Conditions on the Roosting Behavior of Five Species of Myotis Bats & Continued Analysis of Bat Species Abundance and Reproduction at Heil Valley Ranch and Caribou Ranch

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Abstract: Habitat degradation and climate change are two critical factors predicted to negatively affect the size of regional bat populations in the future. In Colorado, habitat loss due to increasing human populations and development increases yearly, and with the addition of apparent rapid climate change (Adams and Hayes, 2008), we predict wildlife populations, including bats, could be negatively affected. Therefore, close monitoring of populations is critical to effective management. However, to understand how habitat loss and climate change will affect bat populations in the future, we first need to understand how species are utilizing habitat under current conditions. Although much research has been conducted on bats at elevations below 2250 m. in Boulder County, Colorado, almost nothing is known about bat populations residing at higher elevations under different seasonal climates. I hypothesize that as elevation increases, female abundance and species diversity will decrease. I also hypothesize that as elevation changes, habitat and roost characteristics will also change. During June, July, and August 2009, we netted 33 nights at 19 different locations in the Front Range of Colorado, ranging in elevation from 1800 meters to over 3300 meters. We captured 43 females, and 115 males. Of the 43 females, 23 were reproductive. No reproductive females were caught above 2500m, and only 6 reproductive females were captured above 2150m. Using preliminary capture data we saw a Simpson Index of 0.254 at low elevation (below 2285m), 0.511 at mid elevation (2286m to 2699m), and 0.431 at high elevation (above 2700m). Four reproductive females (2 *C. townsendii*, 1 *M. thysanodes* and 1 *M. volans*) were tagged and tracked, but never found. This data suggests that with cooler than average temperature and less than average precipitation in summer 2009, reproductive females tended to occur at lower elevations, and species diversity was higher at lower elevations. Bat reproduction in 2009 was the highest recorded since 2000.

Introduction and Literature Review: Elevation is known to influence the distribution and ranges of bat species in several regions (Cryan, 2000). Biologists have reported that abundance of reproductive female bats declines with increasing elevation and often only males are captured at higher elevations

(Cryan 2000). This may be because energetic demands of males and nonreproductive females are not as great as reproductive females and they can select cooler microclimates at higher elevations to facilitate torpor and conserve energy when prey resources are limited or conditions are unfavorable (Barclay 2006). While torpor can help reduce energetic costs in females, it can also delay gestation and reduce milk production (Barclay 2006), lowering female reproductive rates and increasing probability of early-winter mortality of young (Grindal et al. 1992). Warm roost temperatures may help reduce the high costs associated with long fetal development and lactation (Racey 1973) by reducing gestation time and increasing milk production (Wilde et al. 1999).

In Colorado much is known about bat populations residing at elevations below 2250 meters, but much less is known about bat populations residing at higher elevations where seasonal climates differ. Because reproductive females of many species are restricted by thermoregulatory needs, some may be confined to elevational limits, and thus, the number of suitable roost sites becomes increasingly important. Availability and quality of roost sites are critical factors influencing population size and distribution of some species of bats (Fenton 1997, Kunz and Lumsden 2003). The Colorado Front Range is experiencing increases in human population growth resulting in loss of natural habitats, including suitable natural roosts for bats. In addition, climate change in the West (Saunders et al. 2008) appears to be affecting bat reproduction and roost site microclimates (Adams and Hayes 2008). Because bats may be seeking out relief from these factors in the near future, populations of reproductive females may attempt to establish maternity roosts at higher elevations. If this is the case, knowledge of the foraging and roosting ecology of bats at higher elevations is needed to predict the potential outcomes of these factors on regional bat populations. During this study we focused on three specific hypotheses. First we tested the elevational gradient hypothesis, which predicts low species diversity at high elevations, and a negative relationship between reproductive females and increasing elevation. Second we hypothesized that as elevation changes, habitat use will also change. Finally we hypothesized as elevation changes, roost characteristics will also change.

Materials and Methods: Materials and Methods: During June, July, and August 2009 we surveyed bats at nineteen locations in the Front Range of Colorado varying in elevation from 1800m to over 3300m (Table 1). Each site was classified into three distinct elevational gradients, each based on vegetative ecology. Low elevation sites where those below 2285 meters, mid elevation were between 2286m and 2699m, and high elevation above 2700m. The foothills ecosystem (low elevation) is dominated by *Pinus ponderosa.* The montane (mid elevation) ecosystem, generally consist of *Psuedotsuga menziesii*, *Populous tremuloides*, and *Pinus contorta*. Subalpine (high elevation) ecosystems were dominated by *Pinus contorta*, and *Picea engelmannii*. Each site was surveyed several times during the study period. At each site we determined flight corridors and set mist nets (Avinet, P.O. Box 1103, Dryden, NY, USA 13053) there to capture bats. Mist nets were deployed 30 minutes before published sunset and closed several hours after sunset, or when bat activity diminished. In addition to mist nets we also used a Pettersson D240X to record echolocation calls and Sonobat analysis software to identify bats to species.

Table 1: GPS Locations and Elevation of 19 Netting Sites in Boulder and Larimer Counties.

Location	GPS Coordinates	Elevation
Geer Canyon, Boulder County	N 40'08.759, W 105'18.366	1,714
Gregory Canyon, Boulder County	N 39'59.848, W 105'17.719	1,783
Youngs Gulch, Larimer County	N 40'41.261, W 105'20.851	1,794
Shannon Pond, Boulder County	N 39'57.576, W 105'16.162	1,851
Lone Pine, Larimer County	N 40'46.214, W 105'21.468	1,888
Longs Canyon, Boulder County	N 39'59.782, W 105'17.756	2,000
Heil Ranch, Boulder County	N 40'10.931, W 105'17.822	2,043
Ingersol Quarry, Boulder County	N 40'10.583, W 105'18.299	2,073
Upper North Fork, Larimer County	N 40'27.339, W 105'25.961	2,171
Estes Park, Larimer County	N 40'22.433, W 105'32.153	2,330
Bennett Creek, Larimer County	N 40'39.401, W 105'34.236	2,507
Mud Lake Open Space, Boulder County	N 39'58.422, W 105'30.328	2,561

Peaceful Valley, Boulder County	N 40'07.483, W 105'31.288	2,568
Caribou Ranch, Boulder County	N 39'59.412, W 105'31.923	2,598
Caribou Ranch Homestead, Boulder County	N 39'59.388, W 105'31.895	2,603
Moffat Pass Rd, Boulder County	N 39'54.413, W 105'36.303	2,954
Red Rock Lake, Boulder County	N 40'04.964, W 105'32.484	3,110
Lefthand Reservoir, Boulder County	N 40'04.145, W 105'33.249	3,244
RM Research Station, Boulder County	N 40'02.529, W 105'34.528	3,371

With each capture we recorded species, sex, and reproductive condition (pregnant, lactation, post-lactating, or non-reproductive). Juveniles were distinguished from adults based on the lack of ossification in the joints of the phalanges of the third metacarpal (Racey, 1973). Pregnant females were determined by palpation of the abdomen, lactating females were distinguished by fur worn from enlarged nipples and expressed milk when pinched, and post-lactating females had fur worn from enlarged nipples but did not express milk. Those females with no discernable reproductive characteristics were classified as non-reproductive. Preliminary Capture data was used to determine the proportion of females across each elevational gradient. Female abundance will be calculated as bats per net per night and must be corrected for total effort across each gradient, by calculating number of nets used, size of nets used, and number of nights netted at each location. Once large enough samples are gathered from various elevations, I will use one-way ANOVA to test for female abundance across gradients. Capture data was also used to test species diversity across each gradient. Species diversity was calculated across each elevational gradient using a Simpson Index of Diversity.

During summer 2009, we also radio tagged 4 reproductive females with .39g temperature sensitive radio transmitters (model LB-2N Holohill Systems, Ltd.). Cotton swabs were used to part the fur between the scapulae where we attached the radio transmitters using a small amount of Skin Bond (Smith Nephew United). After each bat was tagged it was released. The following morning we used a Yagi 3 element directional antenna to try and locate a radio signal. We walked or drove transects several miles in each direction starting at the netting site. We continued this for several days or until the transmitter output stops (generally 7-14 days). In addition to tracking during the day we also went back to the netting location at night and attempted to locate the radio tagged bat as is it foraged. Although we were unable to find any of the 4 radio tagged bats this field season, we will continue to tag and track bats next season in an attempt to locate roosts. Once a roost site is found we will mark the exact location and elevation using GPS technology. To check roosts for activity we will count bats as they emerge from each roost. Once we find an active roost site we will assess the following: In order to assess ambient temperatures across the elevations, I will attach a Hobo data logger in to a nearby tree, in the shade at all times, as close to the roost site as possible. The data loggers will help us record daily mean high and lows at sites. I will also identify major vegetation types at each site. It has been noted that bats roost in close proximity to foraging areas which are usually similar in habitat and elevation (Arnett, 2007). Next, we will estimate percent canopy, and the height of at least five trees within a 20-m radius of the roost will be measured using a clinometer (Lacki, 2007). If the roost is in a clearing we will only measure the height of the roost. The number of live coniferous and deciduous trees within the plot will be counted. Percent rock, vegetation, and bare ground within the 20-m radius of the roost will also be estimated (Lacki, 2007). At each roost site we will also record percent slope, and slope aspect using a clinometer. Habitat characteristics will be compared across elevations and tested using a Chi square test. It is important to test habitat characteristics because habitat affects roost quality and availability, which are two critical factors influencing population size and distribution of some species of bats (Fenton 1997, Kunz and Lumsden 2003).

During summer 2010 we will also attempt to determine habitat characteristics across elevational gradients. Lacki and Baker (2007) found that day roosts of fringed myotis (*M. thysanodes*) vary throughout the distribution of the species. For Boulder County, natural roost sites for myotis species consists of cliff-face rock-crevices, rock-crevices within boulders, and under boulders at ground level (Adams, 2006). This is in contrast to Weller and Zabel (2001) who found that 100% of day roosts used by fringed myotis in California were tree snags. Here in Colorado little data exits for bats above 7,500 ft., and it is possible that tree-cavity roosts are also used, as this is more consistent with studies in other regions. In order to understand what types of roosts bats are choosing at different elevations, we will quantify the physical aspects of each roost site found. We will record roost site opening orientation (vertical or horizontal), which has been found to be a factor in roost selection. Chruszcz and Barclay (2002) found that pregnant females often chose horizontal oriented roosts that allowed for rapid re-warming. In contrast lactating females were found in vertical oriented roosts that exhibited a temperature gradient allowing bats to move up or down in the roost to thermoregulate. During this study we will also record roost aspect as it has also been suggested to play an important role in predator avoidance (Rancourt, 2005). In some cases roosts may be located in rocks well above the ground and will be inaccessible. If we are able to access roosts, we will measure width and length of each crevice and test these characteristics by orientation of the crevice and reproductive status of adult females. The width and length of the crevice has been suggested to be important in avoidance of predation (Rancourt, 2005). Maximum height and diameter of rocks used as roosts will be recorded. We will test for significant differences in characteristics of roosts across elevations using a principle component test. Although unlikely in this region, physical aspects of trees used as roosts will be quantified and compared at varying elevations. Diameter and height of each tree will be measured. If tree-cavity roosts are found, we will note species of tree and cavity type (natural hollow, abandoned primary cavity excavator hollow, loose bark, or crack). We will also record decay stage of the tree, which is a composite index based on the percent bark remaining, number of limbs present, condition of the top, and condition of the heartwood and sapwood, following Vonhof and Barclay (1996). Because we are using temperature sensitive radio transmitters we will get skin temperature data from each tagged bat. This data may help us predict roost temperature, and give us one more variable for comparing roost characteristics.

Preliminary Results: During June, July, and August 2009, we netted 33 nights at 19 different locations in the Front Range of Colorado, ranging in elevation from 1800 meters to over 3300 meters. In summer 2009, we captured 49 females, and 110 males. Of the 49 females, 26 were reproductive. No reproductive females were caught above 2500m, and only 6 reproductive females were captured above 2150m (Table 2). The proportion of reproductive females was highest at low elevations and least at high elevations (Chart 1). Abundance of females has not been calculated, but will be included in the results for 2010.

Table 2: Female Captures For 2009 Across Each Elevational Gradient

Species	Sex	Reproductive Status	Weight	Location	Elevation	Date
Myotis evotis	F	Pregnant	7.2g	Gregory Canyon	1,783	29-Jun
Eptesicus fuscus	F	Non-Reproductive	13.3g	Shannon Pond	1,851	7-Aug
Eptesicus fuscus	F	Non-Reproductive	20.2g	Shannon Pond	1,851	7-Aug
Myotis lucifugus	F	Pregnant	9.9g	Shannon Pond	1,851	7-Aug
Myotis lucifugus	F	Pregnant	6.2g	Shannon Pond	1,851	7-Aug
Myotis Thysanodes	F	Pregnant	8.6g	Shannon Pond	1,851	7-Aug
Myotis lucifugus	F	Non-Reproductive	NA	Shannon Pond	1,851	7-Aug
Myotis lucifugus	F	Lactating	7.7g	Ingersol	2,073	17-Jul
Myotis lucifugus	F	Lactating	7.8g	Ingersol	2,073	17-Jul
Corynorhinus townsendii	F	Lactating	NA	Ingersol	2,073	17-Jul
Corynorhinus townsendii	F	Lactating	NA	Ingersol	2,073	17-Jul
Myotis evotis	F	Lactating	6.5g	Ingersol	2,073	12-Aug
Myotis lucifugus	F	Lactating	7.7g	Ingersol	2,073	12-Aug
Myotis Thysanodes	F	Lactating	7.6g	Ingersol	2,073	12-Aug
Myotis evotis	F	Lactating	7.0g	Ingersol	2,073	12-Aug
Corynorhinus townsendii	F	Lactating	9.9g	Ingersol	2,073	12-Aug
Myotis evotis	F	Lactating	6.2g	Ingersol	2,073	12-Aug
Myotis ciliolabrum	F	Non-Reproductive	4.4g	Ingersol	2,073	17-Jul
Myotis ciliolabrum	F	Non-Reproductive	4.3g	Ingersol	2,073	17-Jul
Myotis lucifugus	F	Non-Reproductive	7.6g	Ingersol	2,073	17-Jul
Myotis evotis	F	Non-Reproductive	6.4g	Ingersol	2,073	17-Jul
Corynorhinus townsendii	F	Non-Reproductive	10.9g	Ingersol	2,073	17-Jul
Myotis evotis	F	Non-Reproductive	6.5g	Ingersol	2,073	12-Aug
Myotis evotis	F	Pregnant	7.2g	Ingersol	2,073	11-Jun
Myotis lucifugus	F	Pregnant	8.2g	Ingersol	2,073	11-Jun
Myotis lucifugus	F	Pregnant	6.6g	Ingersol	2,073	17-Jul
Myotis lucifugus	F	Pregnant	7.6g	Ingersol	2,073	17-Jul

Myotis evotis	F	Pregnant	7.0g	Upper North Fork	2,171	17-Jun
Myotis lucifugus	F	Pregnant	7.8g	Upper North Fork	2,171	17-Jun
Myotis evotis	F	Lactating	7.8g	Bennett Creek	2,507	4-Aug
Myotis volans	F	Lactating	7.6g	Bennett Creek	2,507	4-Aug
Myotis volans	F	Lactating	8.2g	Bennett Creek	2,507	4-Aug
Myotis volans	F	Lactating	NA	Bennett Creek	2,507	17-Aug
Myotis volans	F	Non-Reproductive	7.8g	Bennett Creek	2,507	4-Aug
Myotis volans	F	Non-Reproductive	NA	Bennett Creek	2,507	4-Aug
Myotis volans	F	Non-Reproductive	NA	Bennett Creek	2,507	4-Aug
Myotis volans	F	Non-Reproductive	NA	Bennett Creek	2,507	4-Aug
Myotis volans	F	Non-Reproductive	7.6g	Bennett Creek	2,507	4-Aug
Myotis volans	F	Non-Reproductive	8.3g	Bennett Creek	2,507	17-Aug
Myotis volans	F	Pregnant	7.7g	Bennett Creek	2,507	4-Aug
Myotis volans	F	Pregnant	7.7g	Bennett Creek	2,507	4-Aug
Myotis volans	F	Non-Reproductive	7.0g	Moffat Pass Rd	2,954	23-Jul
Myotis volans	F	Non-Reproductive	7.4g	Moffat Pass Rd	2,954	23-Jul
Myotis lucifugus	F	Non-Reproductive	NA	Red Rock Lake	3,110	19-Jun
Myotis lucifugus	F	Non-Reproductive	NA	Red Rock Lake	3,110	19-Jun
Myotis lucifugus	F	Non-Reproductive	NA	Red Rock Lake	3,110	19-Jun
Myotis lucifugus	F	Non-Reproductive	NA	Red Rock Lake	3,110	19-Jun
Myotis lucifugus	F	Non-Reproductive	NA	Red Rock Lake	3,110	19-Jun
Myotis volans	F	Non-Reproductive	NA	Red Rock Lake	3,110	19-Jun

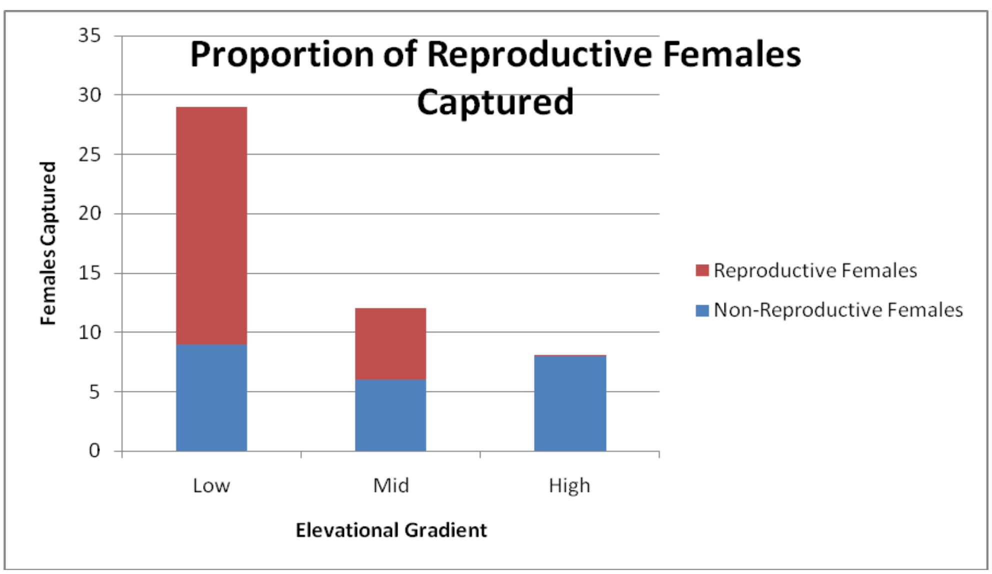

Figure 1: Proportion of Reproductive Females Across Each Elevational Gradient

Using preliminary capture data we saw a Simpson Index of Diversity of 0.746 at low elevation, 0.489 at mid elevation, and 0.569 at high elevation (Chart 2). Four reproductive females were tagged and tracked, but never found.

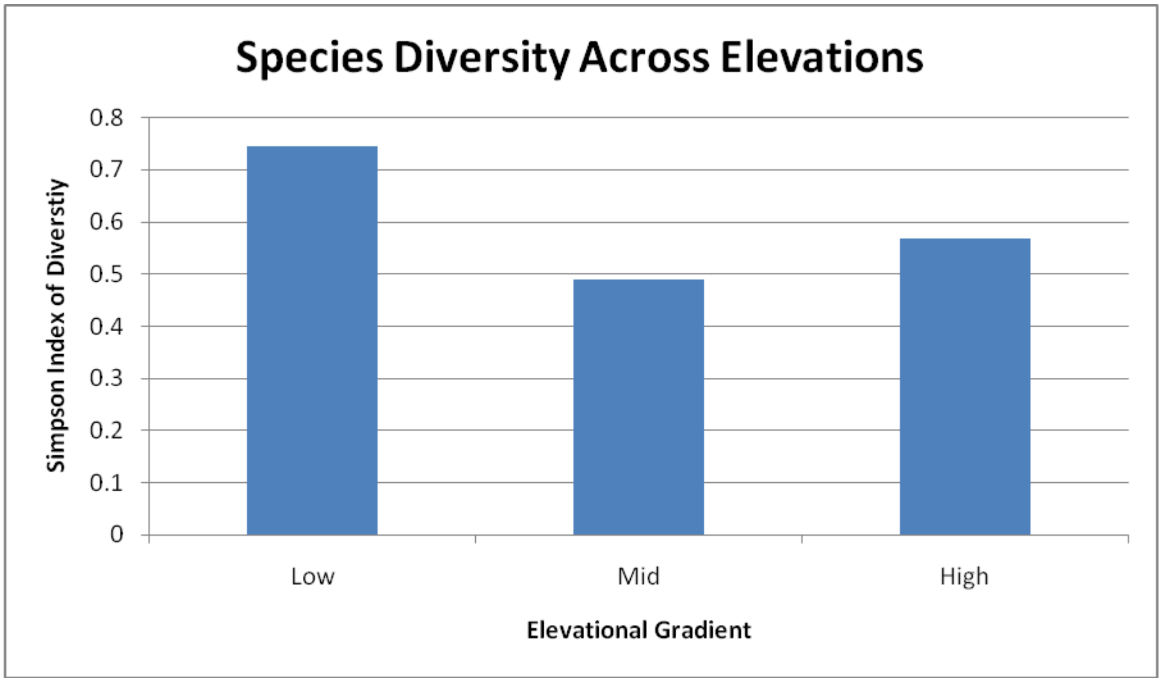

Figure 2: Species Diversity Across the Elevational Gradient Using and Simpson Index of Diversity

Mist Net Captures at Heil Valley Ranch

A total of 119 bats was captured at Heil Valley Ranch (Table 3). Of these 55 were *Myotis evotis*, 21 were *M. lucifugus*, 18 were *M. thysanodes*, 8 were *Eptesicus fuscus*, 7 were *M. ciliolabrum*, 6 were *Corynorhinus townsendii*, 3 were *M. volans*, and 1 was *Lasionycteris noctivagans*.

Table 3. All HVR capture data from 2009.

YEAR	DATE	MONTH	LOCALITY	SPP	WGT	SEX	REPRO	AGE
2009	12-Jun	June	UGC	MYVO	7.6	F	P	A
2009	12-June	June	UGC	LANO	10.5	M	NS	A
2009	12-Jun	June	UGC	MYVO	7.8	M	NS	A
2009	12-Jun	June	UGC	MYVO	8.8	M	NS	A
2009	12-Jun	June	IQ	MYLU	8.2	F	P	A
2009	12-Jun	June	IQ	MYEV	7.2	F	P	A

2009	12-Jun	June	LGC	MYTH	6.6	M	NS	A
2009	17-Jul	July	IQ	MYEV	6.4	M	NS	A
2009	17-Jul	July	IQ	MYLU	7.7	F	L	A
2009	17-Jul	July	IQ	MYCI	4.4	F	NLNP	A
2009	17-Jul	July	IQ	MYCI	4.8	M	NS	A
2009	17-Jul	July	IQ	MULU	6.6	F	P	A
2009	17-Jul	July	IQ	MYLU	7.8	M	NS	A
2009	17-Jul	July	IQ	MYLU	7.7		NS	A
2009	17-Jul	July	IQ	MYLU	7.6	F	P	A
2009	17-Jul	July	IQ	MYLU	7.8	F	L	A
2009	17-Jul	July	IQ	MYCI	4.3	F	NLNP	A
2009	17-Jul	July	IQ	MYEV	6.2	M	NS	A
2009	17-Jul	July	IQ	MYTH	7.7	M	NS	A
2009	17-Jul	July	IQ	MYTH	7.4	M	NS	A
2009	17-Jul	July	IQ	MYTH	7.5	M	NS	A
2009	17-Jul	July	IQ	MYLU	6.6	M	NS	A
2009	17-Jul	July	IQ	MYTH	7.7	M	NS	A
2009	17-Jul	July	IQ	MYEV	6.5	F	L	A
2009	17-Jul	July	IQ	MYEV	5.7	M	NS	A
2009	17-Jul	July	IQ	MYLU	7.3	M	NS	A
2009	17-Jul	July	IQ	MULU	7.6	M	NS	A
2009	17-Jul	July	IQ	EPFU	14.4	M	NS	A
2009	17-Jul	July	IQ	MYLU	6.9	M	NS	A
2009	17-Jul	July	IQ	MYEV	6.6	M	NS	A
2009	17-Jul	July	IQ	MYLU	7.7	F	L	A
2009	17-Jul	July	IQ	MYLU	6.9	M	NS	A
2009	17-Jul	July	IQ	MYEV	6.3	M	NS	A
2009	17-Jul	July	IQ	MYEV	6	M	NS	A
2009	17-Jul	July	IQ	MYEV	6.4	M	NS	A
2009	17-Jul	July	IQ	EPFU	13.6	M	NS	A
2009	17-Jul	July	IQ	MYEV	6.5	M	NS	A
2009	17-Jul	July	IQ	MYTH	7.5	M	NS	A
2009	17-Jul	July	IQ	MYTH	7.6	F	L	A
2009	17-Jul	July	IQ	EPFU	NW	M	S	A
2009	17-Jul	July	IQ	MYEV	7	F	L	A
2009	17-Jul	July	IQ	COTO	9.9	F	L	A
2009	17-Jul	July	IQ	COTO	NW	F	L	A
2009	17-Jul	July	IQ	MYTH	NW	F	L	A
2009	17-Jul	July	IQ	EPFU	NW	M	NS	A
2009	17-Jul	July	IQ	MYEV	6.2	F	L	A
2009	12-Aug	Aug	IQ	MULU	7	M	I	A
2009	12-Aug	Aug	IQ	MYEV	7.5	M	NS	A
2009	12-Aug	Aug	IQ	MYEV	5.9	M	NS	SA
2009	12-Aug	Aug	IQ	MYEV	6.2	M	NS	A
2009	12-Aug	Aug	IQ	MYEV	6.5	F	NLNP	SA
2009	12-Aug	Aug	IQ	MYEV	6.1	M	NS	A
2009	12-Aug	Aug	IQ	MYEV	5.4	M	NS	SA
2009	12-Aug	Aug	IQ	EPFU	NW	M	S	A

2009	12-Aug	Aug	IQ			M	I	A
2009	12-Aug	Aug	IQ	MYLU	7.6	F	NLNP	SA
2009	12-Aug	Aug	IQ	MYEV	6.3	M	NS	A
2009	12-Aug	Aug	IQ	MYEV	6.7	M	I	I
2009	12-Aug	Aug	IQ	MYEV	6.1	M	I	I
2009	12-Aug	Aug	IQ	MYEV	5.8	M	NS	A
2009	12-Aug	Aug	IQ	MYEV	6.6	M	I	I
2009	12-Aug	Aug	IQ	MYEV	6.4	F	NLNP	A
2009	12-Aug	Aug	IQ	COTO	10.9	F	NLNP	A
2009	12-Aug	Aug	IQ	COTO	NW	F	L	A
2009	12-Aug	Aug	IQ	COTO	NW	F	L	A
2009	12-Aug	Aug	IQ	EPFU	NW	M	NS	A
2009	12-Aug	Aug	IQ	MYEV	NW	M	NS	A
2009	13-Aug	Aug	IQ	MYEV	6.2	M	I	A
2009	13-Aug	Aug	IQ	MYEV	6.2	M	I	A
2009	13-Aug	Aug	IQ	MYTH	7.8	M	NS	A
2009	13-Aug	Aug	IQ	MYTH	7.3	M	NS	A
2009	18-Aug	Aug	IQ	MYEV	6.4	F	L	A
2009	18-Aug	Aug	IQ	MYEV		M	I	A
2009	18-Aug	Aug	IQ	MYEV		M	NS	A
2009	18-Aug	Aug	IQ	COTO	10.4	F	NLNP	A
2009	18-Aug	Aug	IQ	MYEV	7.2	M	NS	SA
2009	18-Aug	Aug	IQ	MYEV	6.8	M	NS	I
2009	20-Aug	Aug	IQ	MYEV	6.5	F	L	A
2009	20-Aug	Aug	IQ	MYCI	4.5	F	PL	A
2009	20-Aug	Aug	IQ	MYLU	6.6	M	NS	A
2009	20-Aug	Aug	IQ	MYLU	7.4	M	NS	A
2009	20-Aug	Aug	IQ	MYLU	6.8	F	NLNP	SA
2009	20-Aug	Aug	IQ	MYLU	6.5	M	I	A
2009	20-Aug	Aug	IQ	MYTH	6.6	M	I	A
2009	20-Aug	Aug	IQ	MYLU	6.6	M	NS	SA
2009	20-Aug	Aug	IQ	MYEV	4.8	M	NS	SA
2009	20-Aug	Aug	IQ	MYEV	5.4	M	NS	SA
2009	20-Aug	Aug	IQ	MYCI	4.2	F	NLNP	J
2009	20-Aug	Aug	IQ	MYEV	7.1	F	PL	A
2009	20-Aug	Aug	IQ	EPFU	21.2	M	S	A
2009	20-Aug	Aug	IQ	MYEV	7.7	M	NS	A
2009	20-Aug	Aug	IQ	MYEV	8	M	NS	A
2009	20-Aug	Aug	IQ	MYLU	8.2	F	NLNP	J
2009	20-Aug	Aug	IQ	MYEV	9.2	F	NLNP	A
2009	4-Sep	Sept	IQ	EPFU	19	M	NS	A
2009	4-Sep	Sept	IQ	MYEV	NW	F	NLNP	J
2009	4-Sep	Sept	IQ	MYTH	7.6	M	NS	A
2009	4-Sep	Sept	IQ	MYTH	7.9	F	NLNP	SA
2009	4-Sep	Sept	IQ	MYEV	5.7	M	NS	J
2009	4-Sep	Sept	IQ	MYCI	4.7	M	NS	SA
2009	9-Sep	Sept	IQ	MYEV	NW	M	NS	SA
2009	9-Sep	Sept	IQ	MYTH	NW	M	S	A

2009	29-Sep	Sept	IQ	MYTH		M	NS	SA
2009	29-Sep	Sept	IQ	MYTH		M	NS	A
2009	29-Sep	Sept	IQ	MYEV		M	NS	A
2009	29-Sep	Sept	IQ	MYEV		M	NS	SA
2009	29-Sep	Sept	IQ	MYEV		M	NS	SA
2009	29-Sep	Sept	IQ	MYEV		M	NS	A
2009	29-Sep	Sept	IQ	MYEV		M	NS	A
2009	29-Sep	Sept	IQ	MYEV		M	NS	A
2009	29-Sep	Sept	IQ	MYEV		M	NS	A
2009	29-Sep	Sept	IQ	MYEV		F	NLNP	A
2009	29-Sep	Sept	IQ	MYEV		M	NS	A
2009	29-Sep	Sept	IQ	MYTH		F	NLNP	A
2009	29-Sep	Sept	IQ	MYEV		F	NLNP	A
2009	3-Oct	Oct	IQ	MYEV		M	S	A
2009	3-Oct	Oct	IQ	MYEV		M	NS	SA

Sonar Analysis

Sixty two new hand release calls were added to the Colorado Call Library. Sonar analysis at Caribou Ranch indicated conducted on 18 May, 7 July, 16 July, 24 July and 12 August totaled 50 calls with most recorded on 18 May and 24 June. Species recorded were: *Eptesicus fuscus, Lasiurus cinereus, Lasionycteris noctivagans, Myotis evotis, M. lucifugus, M. thysanodes* and *M. volans*.

PIT-tag Reader Data

The submersible antennae placed in the artificial water source in Geer Canyon, ran the third week in May and then from 6 July till 30m August. Unfortunately, the recoding unit was misbehaving and thus individuals may have been missed throughout this time window, The unit is back at BioMark, Inc. being repaired for next season. Table 3 shows data gathered in 2007-2009.

Table 4. PIT-tag reader data for 2006-2009.

SITE	NUMBER	TAGYR	REACYR	REACYR	REACYR	REACYR	SPP	REPRO
GEER	579	2006	2006				MYLU	NS
GEER	FEB	2006					MYTH	L

GEER	AD5	2006					MYTH	L
GEER	AF0B	2006					MYLU	NS
GEER	C746	2006	2006	2007			MYEV	L
GEER	D460	2006					MYLU	NS
GEER	C8CE	2006		2007			MYTH	L
GEER	F018	2006	2006				MYTH	L
GEER	B8FB	2006		2007	2008		MYTH	L
GEER	EDAF	2006					MYEV	NS
GEER	3FB3	2006					MYEV	NS
GEER	821	2006					MYEV	NLNP
GEER	F1C9	2006	2006				MYTH	NS
GEER	D63C	2006					MYTH	NS
GEER	2B9E	2006					MYTH	L
GEER	CEF4	2006					MYTH	NS
GEER	DIE1	2006	2006	2007	2008	2009	MYTH	NLNP
GEER	A3FD	2006	2006				MYTH	L
GEER	BF62	2006	2006				MYEV	NS
GEER	48F6	2006	2006				MYTH	L
GEER	BF06	2006	2006				MYTH	L
GEER	A778	2006	2006				MYTH	NLNP
GEER	CDE6	2006			2008		MYEV	L
GEER	386A	2006					MYTH	L
GEER	3237	2006	2006				MYTH	L
GEER	8E8C	2006					MYLU	NS
GEER	0FE5	2006					MYEV	NLNP
GEER	45E0	2006					MYTH	L
GEER	802D	2006	2006				MYTH	L
GEER	7767	2006	2006				MYTH	L
GEER	42C4	2006					COTO	NS

GEER	DCE0	2006					COTO	NS
GEER	E06E	2006					MYTH	L
GEER	783B	2006					MYTH	L
GEER	C2BC	2006	2006				MYTH	NS
GEER	948C	2006					MYTH	L
GEER	494C	2006					MYTH	L
GEER	BC7D	2006		2007			MYTH	NLNP
GEER	15E3	2006					MYTH	L
GEER	3890	2006	2006	2007	2008		MYTH	L
GEER	094F	2006	2006				MYTH	NLNP
GEER	DED7	2007					MYTH	P
GEER	453C	2007					LACI	NS
GEER	3821	2007		2007	2008	2009	MYTH	NLNP
GEER	352A	2007					MYEV	NS
GEER	DC0D	2007					MYTH	P
GEER	BD85	2007		2007	2008		MYTH	P
GEER	1F17	2007					MYTH	S
GEER	D959	2007		2007			MYLU	P
QUARRY	5CD4	2007					MYEV	P
QUARRY	35EA	2007					EPFU	NS
QUARRY	60B5	2007					MYEV	NS
QUARRY	530E	2007					MYEV	P
QUARRY	8ED7	2007					MYEV	NS
QUARRY	D245	2007					MYLU	NS
QUARRY	42AC	2007					MYLU	NS
QUARRY	B6E2	2007					MYTH	P
QUARRY	3510	2007					COTO	P
QUARRY	519B	2007					MYTH	NS
QUARRY	C608	2007					MYEV	NS

QUARRY	1579	2007					MYCI	NS
QUARRY	F6EF	2007					EPFU	S
QUARRY	DEE7	2007					MYLU	P
QUARRY	CBC4	2007					MYTH	S
QUARRY	CE4F	2007					MYEV	S
QUARRY	44FF	2007					MYEV	S
QUARRY	8933	2007					MYEV	S
QUARRY	740E	2007					EPFU	S
QUARRY	42DB	2007					MYLU	NS
QUARRY	D491	2007					COTO	P

Discussion: Although this is the first year of a two year study we are starting to see some interesting patterns. As we predicted we did see a higher proportion of reproductive females at lower elevations. Because reproductive females are under greater thermoregulatory pressure during reproduction, they may be restricted to certain elevational limits. Selecting a warmer microclimate can help reduce the need to enter torpor, which has been suggested to increase gestation and reduce milk production. A warmer climate can also help facilitate a greater passive warming and help to reduce the costs associated with re-warming after a torpor bout. It is important to understand where reproductive females may be roosting in order to incorporate management plans. Although we were unsuccessful finding any roosts in 2009, we can predict that a higher proportion of females are roosting in the lower elevations and only a small proportion are roosting at higher elevations. Protecting these roosts becomes even more important because it is likely that reproductive females may be restricted to the lower elevations where temperatures are warmer. If habitat begins to disappear in the lower elevations roost sites will also disappear and reproductive females may be hardest hit. It is important for resource managers to know and understand where bats are roosting in order to reduce potential disturbance. For Boulder County, natural roost sites for myotis species consists of cliff-face rock-crevices, rock-crevices within boulders, and under boulders at ground level (Adams, 2006). In areas where roosts are likely it may be important for managers to reduce foot travel, in order to reduce disturbance. However, little is still known, and future research may need to focus more on the impacts of disturbance and degradation on reproductive females and roost sites.

During summer 2009 we also saw that the greatest diversity of bats was at the lowest elevations. Again this is important for managers to know in order to protect populations. It is even more important because several species are of special concern to Colorado. As climate change and habitat degradation continue to destroy suitable habitat for these species, they may be forced to move and some populations may see decline. Loosing suitable roosts and habitat may also increase competition and may have a negative effect on populations. With the increase in habitat degradation and climate change it becomes even more important to continually monitor these populations for any changes, and management practices should be implemented based on population trends.

Capture data trends showed more reproductive output in 2009 than in the 3 years previous. Throughout Boulder County, about 73% (34 of 47) adult females captured were reproductive. In addition, 22 juveniles were captured in 2009, the highest number since 2000 in which 28 juveniles were captured. This is likely due to a cooler/wetter spring/summer than in previous years (Adams, in press).

Goals for 2010: During summer 2010 we will continue to survey and monitor local populations and continue to look at species diversity and female abundance across each gradient. In addition we will attempt to locate roosts of reproductive females and quantify the physical aspects in order to compare them across elevations. In 2010 we will also monitor insect abundance and determine how elevation may affect prey availability, another factor known to affect distribution of bats. Once the project is completed all information will be given to Boulder County Parks and Open Spaces and recommendations will be made based on our findings.

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