LOCATION AND DISTRIBUTION OF DIURNAL ROOSTS, ROOST SITE PARAMETERS, AND THE USE OF WATER RESOURCES BY BOULDER COUNTY BATS (REPORT 2000)

(67 pages, 18 figures, 12 tables)

OVERSITE AGENCY

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CONTENTS

BULLETED HIGHLIGHTS

❶ Immediate protection is needed in the form of seasonal closure for a maternity colony of Townsend's Big-Eared bat (*Corynorhinus townsendii*) at Mallory Cave, and for a maternity colony of Fringed Myotis (*Myotis thysanodes*) located on the Second Flat Iron. Both species are listed as imperiled by the Colorado Natural Heritage Program, North American Bat Conservation Partnership, and the Western Bat Working Groups.

❷ Reproductive females and juveniles are captured in higher frequency at waterholes containing highest calcium levels in the water. More research is needed in this area to discern better this relationship and which sites are most important in providing this nutrient. Radio-telemetry data shows that reproductive females will travel more than two miles to visit waterholes with higher calcium levels, bypassing other waterholes in route.

❸ Other nutrients such as iron, potassium, and sodium tend to be higher at low calcium sites, and bats may visit different waterholes to help maintain overall mineral balance. This is the first study to show that waterholes provide a viable nutrient source for bats.

❹ Of the *Myotis* species so far tracked with radio-telemetry, most tend to prefer foraging in Douglas Fir habitat, this holds true also for *C. townsendii*, whereas other species such as the big brown bat (*Eptesicus fuscus*), the little brown bat *(Myotis lucifugus*), the Hoary (*Lasiurus cinereus*) and Silver-haired bats (*Lasionycteris noctivagans*) prefer open Ponderosa Pine habitat.

Abstract

In 2000, data were gathered on roost site locations, foraging patterns, home ranges, distances traveled and elevations profiles between roost sites and waterholes, temperature profiles of roost sites, temperature profiles of waterholes as well as, water hardness, turbidity and nine mineral levels of 11 waterholes. Seven new netting sites were added resulting in the location of five previously unknown roost sites, three of which were for species considered imperiled by the North American Bat Conservation Partnership (NABCP) and the Western Bat Working Groups (WBWG). previously unknown roost sites were located for six species. As in 1998 & 1999, all colonies documented were situated in rock crevices, two of which are located in areas of high human impact. One, a maternity colony of the fringed myotis (*Myotis thysanodes*) was found located next to an active climbing route on the Second Flatiron. The second is a maternity colony of Townsend's big-eared bat (*Corynorhinus townsendii*) that was found to occupy Mallory Cave. This colony represents one of only seven known maternity roost for this species in the state. These two sites are in immediate need of protection from human disturbance. In this report I strongly recommend seasonal closures at Mallory Cave and the Second Flat Iron. Both sites house maternity colonies of imperiled species that need immediate conservation protection from human disturbances. Within , I also provide data on minimum home range data and foraging patterns for several species and temperature profile data from several roost sites. Water quality data show support the initial hypothesis of 1999, that juveniles and reproductive females are attracted to waterholes containing the highest calcium content.

STATEMENT OF OBJECTIVES AND GOALS

The objective and goals of the 2000 bat project were to 1) add to the locality data base for maternity and bachelor diurnal roost sites of Boulder bats using radio telemetry, 2) document colony sizes by conducting visual counts during evening outflights, 3) document distance between water hole sites, 4) document home range and preferred foraging habitats per species, and 5) document the relationships between water quality and nutrient content with differential bat activity at waterholes.

METHODS

A. Capture--The study was conducted from 14 May to 24 September 2000 with the help of Jenna Jadin, who acted as field assistant. All bats were captured using American-made mist nets. Trapping was conducted over water and also at a single site in Ponderosa Pine Woodland. Captured bats were weighed, sexed, identified to species, and marked with color-coded, numbered, split-ring arm bands (*A.C. Hughes, London*).

B. Radio Telemetry–Seven individuals of six species were tagged with 0.45 g radio transmitters *(Holohil Systems, Ltd., Canada*) and tracked with two 48 channel receivers (*Wildlife Materials, Inc., Ill.*). Individuals were tracked until either the transmitter stopped transmitting, the transmitter fell from the animal, or the signal was not received over the 10 day life of the transmitter. General location of telemetry signals were first acquired by driving to high points overlooking the search area. After the signal was attained and relative position was documented, exact locations of roost sites were located by hiking and following transmitter signals from tagged individuals hanging in their day-roosts. In most cases, the exact crevice that housed the colony was located. To determine coordinates of tagged bats while they foraged, we used triangulation techniques from two distant landmarks, coordinating the timing of compass readings by walkie-talkie communications. Time intervals between readings were 3 minutes. Coordinates were mapped using TOPO Inc. (*San Francisco, CA*) computer software containing Front Range topographical maps. The point at which compass bearings intersect corresponds to the position of the foraging bat in space and time. Circumscribing of intersection points gives the minimum, approximate home range for that individual on that night. In order to gather roost site locality data, we used a Magellan 4000XL global positioning system to record coordinates at each roost site. We then used TOPO Inc, computer software to map the locations based upon our GPS readings. Once roosts were located, out-flight counts were made at dusk with unaided eyes until darkness, after which a MoonLight Night Vision scope (*Cabela's Inc., Ill*) was utilized.

C. Roost Temperature Recordings--Onset Computer Corporation 'Hobo' temperature-sensitive data-loggers equipped with six foot probes were placed at seven sites in 2000. With the help of Ranger and Naturalist Burton Stoner, data-loggers were placed in a *Myotis thysanodes* maternity roost discovered in 1998 on the climbing rock known as DerZerkle, and another was places in a *Eptesicus fuscus* maternity colony located in the Amphitheater climbing area near Gregory Canyon. Two loggers were placed in Harmon Cave, on in the *E. fuscus* bachelor roost and the other in the *C. townsendii* maternity chamber. One logger was placed in a house located on City of Boulder Open Space with the help of Boulder Wildlife Biologist, Cary Richardson. Another logger was placed in a newly found maternity roost of *Myotis evotis* located NNW of Artist Point on Flagstaff Mountain, and another was placed in Mallory Cave subsequent to the discovery of a maternity colony of *C. townsendii* using the site (see Table 5 for placement dates). Data were downloaded from the data loggers after they were removed from the sites using BoxCar Pro version 3.5+ for Windows software, and graphical results from these sites are presented in the results section.

D. pH--We measured pH of water at our six main waterholes in August using an Okidata digital pH meter (*Forestry Supplies, Ill.*).

E. Water Quality and Nutrient Testing.--Water was collected from 11 sites known to be visited by bats on 22 and 23 June and then again on 24 July. Surfaces water sampling was conducted using the dip sampling method involving filling containers held just below the surface of the water (National Handbook of Recommended Methods for Water-Data Acquisition). All samples were collected from the center of the waterhole where the highest numbers of bats visit to drink. All samples were kept cool on ice and delivered to the Boulder Water Treatment Plant for testing on the same day as collected.

RESULTS

A. DerZerkle Update and The Fringed Myotis.–In 1999, human disturbance of a maternity roost of the imperiled fringed myotis (*Myotis thysanodes*) took place, causing premature breakup and dispersal of this colony during the lactation period between females and young. The results of this disturbance at this time of year, could have been potentially devastating for this colony. Because of this, a seasonal closure was put in place on Der Zerkle, to prevent further disturbance and to hopefully facilitate recovery of this colony. On 22 May 2000, I returned to conduct an outflight of the colony. The outflight began at 2038h, and continued until 2055h. Twenty six adult female *M. thysanodes* exited the colony. On 29 July, the outflight was recounted and 17 bats exited the site, beginning at 2035h and ending at 2110h. On XXX September, Burton Stoner conducted an outflight count at Der Zerkle and counted five individuals exiting the site. Conclusions: Recovery of the nursery colony of *M. thysanodes* at Der Zerkle showed reestablishment of the site and successful reproduction in 2000, underscoring how protective measures can insure continued success of maternity sites of bats. In addition, the count conducted by Stoner in September showed that this colony typically stays in tact late in the season and warrants protection until 1 October in any given year.

B. Mallory Cave and Townsend's Big-Eared Bat.–In 1999, Stoner observed a colony of Townsend's Big-Eared bats (*Corynorhinus townsendii*) roosting in Mallory Cave. Subsequent visits by me showed to occupation by this colony. On 20 July 2000, I visited the site at 1000h and found a maternity colony of *C. townsendii* using the site roosting in the open at the north end of the cave. Upon entering the cave, the colony became highly aroused and began emitting audible calls associated with stress (Fenton 1985). I counted 19 individuals, some of which looked to be juveniles. It appears that this is the same colony the uses Harmon Cave, perhaps moving back and forth between the sites. In my opinion this colony prefers Mallory Cave over Harmon Cave because it meets the typical physiography os this species roost site, that is, a large open cavern (> 30 m, Pierson et al., 1991), having cool, relatively stable temperatures. Harmon Cave is much smaller that what is typically used by this species, and temperature profiles (see below) suggest that the temperature may be too high at some times of the season for a maternity site. With the finding in 2000, a voluntary closure what erected in an attempt to keep humans out of Mallory Cave. It was met with differential success, serving to cut back on the numbers of visitors, but many people ignored the signs and entered the cave. In fact a temperature data logger placed by me to gather a temperature profile of the cave to compare with data from Harmon was stolen from the site. I strongly encourage a seasonal closure of this site. This colony **1)** is in immediate danger of being extirpated by either direct or indirect human contact. Because the bats are roosting in the open on the cave ceiling, one act of violence would have devastating affects on this nursery colony, **2)** is only one of seven known maternity sites for this species in the entire state (K. Navo, CDOW, pers. comm.), **3)** is a species imperiled and in need of immediate conservation efforts (Natural Heritage Program, North American Bat Conservation Partnership, and Western Bat Working Groups), **4)** roosting in Mallory Cave is geologically unique and provides the only known traditional roost site for this species in the area. Observations at the entrance to Mallory Cave on the night of 8 August 2000, by field assistant Jenna Jadin, showed 73 outflights and 99 inflights over a one hour period. Pass data do not discern numbers of individuals clearly because bats are likely making multiple passes in and out of the cave. However, it does give some indication of activity at the site, and shows that bats other than *C. townsendii* are attempting to use the cave either for a day roost, or a night roost. Furthermore, human disturbances at this site at night, even when one might suspect that bats are out foraging and thereby not affected, may be significant because individuals are continuously traveling in and out throughout the night and the effects of this preferred behavior when humans are in the cave with lights is unknown, but predictable would cause stress. See further discussion in the **Conservation Needs** section below.

C. Capture Data.--Seven new sites were added to the census in 2000. A total of 192 bats was captured over 64 net nights between 15 May and 15 September. Four individuals were recaptures of individuals banded in previous years. One was a male *M. lucifugus* banded at Stockton Cabin in 1997 was recaptured at Abbey Pond on 18 July 2000 (Table 1). Locations of netting sites for 2000 can be found in Table 2. A male *M. thysanodes* captured at Bear Canyon

Table 1. *Capture data for 2000. p = pregnant, np = nonpregnant, l = lactating, nl = nonlactating, pl = postlactating, nlnp = nonreproductive, s = scrotal, ns = nonscrotal, SA = subadult.*

Eptesicus fuscus at Abbey Pond

Time of capture	**Sex**	**Repro. status**	**Weight (g)**	**Age**	**Band #**	**Date of capture**
2119	escaped					
2125	male	ns	18.2	Adult	none	31 May
2142	female	p,nl	22.3	Adult	none	31 May
2149	female	escaped				31 May
2208	male	ns	none	Adult	none	31 May
2208	male	ns	19.1			31 May
2110	male	ns	15.0	Adult	none	13 July
none	male	s	13.1	Adult	none	18 July
2140	male	s	21.0	Adult	none	18 July
2225	female	l	20.0	Adult	none	18 July
2237	male	ns	7.5	Juv.	none	18 July

Myotis ciliolabrum at Abbey Pond

Time of capture	**Sex**	**Repro. status**	**Weight (g)**	**Age**	**Band #**	**Date of capture**
2200	male	ns	6.1	Adult	none	18 July

Myotis lucifugus at Abbey Pond

Time of capture	**Sex**	**Repro. status**	**Weight (g)**	**Age**	**Band #**	**Date of capture**
2100	female	l.	6.5	Adult	none	13 July
2112	female	l	6.6	Adult	none	13 July
2113	female	l	6.3	Adult	none	13 July
2056	female	l	5.1	Adult	none	18 July

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2056	male	ns	6.0	Juvenile	none	18 July
none	male	ns	6.1	SA	none	18 July
none	male	ns	4.3	Juv.	None	18 July
none	male	ns	6.8	Juv.	None	18 July
none	female	nlnp	7.1	SA	none	18 July
none	male	ns	7.0	SA	none	18 July
none	male	ns	7.9	SA	none	18 July
none	male	ns	5.8	Adult	**RECAP. W860**	18 July
none	male	ns	7.0	Adult	none	18 July
none	male	ns	7.0	Adult	none	18 July
none	female	pl	6.4	Adult	none	18 July
none	female	l	7.1	Adult	none	18 July
none	female	l	8.1	Adult	none	18 July
2200	male	ns	6.4	Adult	none	18 July
2237	male	ns	7.1	Juv.	None	18 July

Lasiurus cinereus at Abbey Pond

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2200	male	ns	16.0	Juv.	none	18 July

Corynorhinus townsendii at Abbey Pond

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2224	male	ns	10.2	Adult	none	18 July

Myotis ciliolabrum at Dakota Ridge, Sanitas Valley

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2105	escaped					5 June
2112	female	1	4.0	Adult	BK274	5 June
2110	male	ns	3.5	Adult	none	29 June
2115	male	ns	4.0	Adult	none	29 June

Myotis volans at Dakota Ridge, Sanitas Valley

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2110	male	ns	5.5	Adult	BK273	5 June
2140	male	ns	6.1	Adult	none	29 June

Eptesicus fuscus at Dakota Ridge, Sanitas Valley

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2135	female	1	17.1	Adult	none	29 June
2135	female	1	17.5	Adult	**Radio-tagged**	29 June

Myotis ciliolabrum at Sanitas Valley Trailhead (Mapleton Dr.)

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2056	escaped					19 July

Lasiurus cinereus at NIST

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2108	female	escaped				

Myotis lucifugus at NIST

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2110	male	ns	5.5	Adult	none	8 June
2054	female	pl	10.1	Adult	BK291	24 July
2115	male	ns	4.2	Juv.	none	24 July

Myotis ciliolabrum at NIST

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2120	male	ns	5.1	Adult	none	8 June
2055	female	pl	5.0	Adult	BK292	24 July

Eptesicus fuscus at NIST

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2110	male	ns	13.1	Adult	none	8 June
2110	male	ns	20.4	Adult	none	8 June
2112	male	ns	17.2	Adult	none	8 June
2120	male	ns	18.3	Adult	none	8 June
2120	female	nlnp	12.2	Juvenile	none	8 June
2120	male	ns	none	Adult	none	8 June
2120	male	ns	none	Adult	none	8 June
2120	male	ns	none	Adult	none	8 June
2120	male	ns	none	Adult	none	8 June
2120	male	ns	none	Adult	none	8 June
2120	male	ns	none	Adult	none	8 June
2140	female	p	19.1	Adult	**Radio-Tagged**	8 June

Myotis evotis at Long Canyon

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2110	female	p	6.1	Adult	BK275	11 June
2111	female	p	6.2	Adult	BK276	11 June
2115	female	p	7.3	Adult	BK277	11 June
2120	female	l	9.0	Adult	BK278	11 June
2131	male	ns	8.1	Adult	none	11 June
2138	female	p	8.1	Adult	none	11 June
2143	female	l	6.5	Adult	none	11 June
2120	female	l	7.5	Adult	BK281	20 June
2135	male	ns	6.0	Adult	none	20 June
2136	male	ns	5.1	Adult	none	20 June
2137	male	ns	6.5	Adult	BK282	20 June
2155	female	nlnp	7.1	Adult	none	20 June
2158	female	l	7.5	Adult	none	20 June
2205	female	p	10.0	adult	none	20 June
2210	female	nlnp	7.2	Adult	none	20 June
2106	female	l	None	adult	**Radio-tagged**	2 July
2128	male	ns	5.1	Adult	BK285	2 July
2128	male	ns	5.3	Adult	BK286	2 July
2128	male	ns	5.1	Adult	none	2 July
2129	female	l	5.0	Adult	BK287	2 July
2129	male	ns	6.1	Adult	none	2 July
2129	female	l	6.0	Adult	none	2 July
2130	male	ns	7.1	Adult	none	2 July
2130	female	pl	7.0	Adult	BK288	20 July

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2145	male	ns	7.3	Adult	none	20 July
2145	male	ns	6.6	Adult	none	20 July
2145	female	l	6.5	Adult	none	20 July
2145	female	l	9.1	Adult	BK289	20 July
2145	female	l	7.1	Adult	BK290	20 July
2145	female	pl	8.1	Adult	none	20 July
2204	female	l	10.5	Adult	none	20 July
2204	female	l	8.5	Adult	none	20 July
2213	escaped					
2215	female	pl	10.5	Adult	none	20 July
2215	female	nlnp	5.8	Adult	none	20 July
2215	female	p	7.7	Adult	none	20 July
2222	female	l	7.5	Adult	none	20 July
2056	female	nlnp	5.5	Adult	none	3 Sept.
2106	female	nlnp	4.8	Adult	none	3 Sept.
2109	female	nlnp	4.9	Adult	none	3 Sept.
2115	male	ns	3.0	SA	none	3 Sept.

Myotis thysanodes at Long Canyon

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2125	female	l	None	adult	**Radio-Tagged**	20 June
2136	male	ns	9.1	Adult	none	20 June

Eptesicus fuscus at Red Rocks

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2125	female	l	16.1	Adult	none	28 June
2145	female	l	17.3	Adult	none	28 June
2145	female	l	21.2	Adult	none	28 June
2150	female	l	20.1	Adult	none	28 June
2150	female	l	19.4	Adult	none	28 June
2150	female	l	22.1	Adult	none	28 June
2154	escaped					
2145	escaped					
2145	escaped					
2235	female	l	21.1	Adult	none	28 June
2204	female	l	7.2	Adult	BK278	2 July
2046	male	s	20.9	Adult	none	19 Aug.
2050	female	nlnp	15.9	Adult	none	19 Aug.
2056	male	ns	21.4	Juvenile	none	19 Aug.
2056	male	s	21.4	Adult	none	19 Aug.
2110	male	ns	21.8	SA	none	19 Aug.
2113	male	s	21.8	Adult	none	19 Aug.
2118	female	nlnp	26.7	Adult	none	19 Aug.
2124	male	ns	18.2	SA	none	19 Aug.

Myotis volans at Long Canyon

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2159	female	nlnp	6.1	Adult	none	2 July

Myotis thysanodes at Lower Bear Creek, Mesa Trail

Time of capture	**Sex**	**Repro. status**	**Weight (g)**	**Age**	**Band #**	**Date of capture**
2058	female	l	7.0	Adult	none	19 July
2110	male	ns	7.1	Adult	**Radio-tagged**	19 July
2036	male	ns	5.1	Juvenile	none	7 Aug.
2039	male	ns	5.1	Juvenile	none	7 Aug.
2100	female	nlnp	5.2	Adult	none	7 Aug.
2106	male	s	5.4	Adult	**Recap. O136**	7 Aug.
2109	female	nlnp	6.4	Juvenile	none	7 Aug.
2136	male	ns	6.5	Juvenile	none	7 Aug.
2213	male	ns	5.8	SA	none	7 Aug.
1935	male	ns	3.9	SA	none	14 Sept.

Myotis lucifugus at Lower Bear Creek

Time of capture	**Sex**	**Repro. status**	**Weight (g)**	**Age**	**Band #**	**Date of capture**
2218	female	nlnp	10.0	Adult	none	19 July
2031	male	s	3.5	Adult	none	7 Aug.
2031	male	s	6.8	Adult	none	7 Aug.
2031	male	s	7.1	Adult	none	7 Aug.
2035	male	s	none	adult	none	7 Aug

Myotis ciliolabrum at Lower Bear Creek

Time of capture	**Sex**	**Repro. status**	**Weight (g)**	**Age**	**Band #**	**Date of capture**
2130	female	pl	4.0	Adult	BK283	19 July
2029	female	nlnp	2.9	Juvenile	none	7 Aug.
2229	male	ns	2.8	SA	none	7 Aug.

Myotis evotis at Lower Bear Creek

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2153	male	ns	10.1	Adult	none	19 July

Eptesicus fuscus at Lower Bear Creek

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2120	male	s	16.7	Adult	**RECAP. R824, R825, W790**	7 Aug.
2220	male	s	18.1	Adult	none	7 Aug.
2018	male	s	16.7	SA	none	14 Sept.

Myotis lucifugus at South Shanahan Pond

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
none	female	nlnp	adult	8.1	none	21 July
none	female	p	adult	7.2	none	21 July
none	female	nlnp	adult	8.2	none	21 July

Myotis thysanodes at South Shanahan

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
none	male	ns	10.3	Adult	none	21 July

Myotis evotis at Lower BlueBell Creek

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2331	female	l	None	adult	**Radio-tagged**	26 July

Corynorhinus townsendii at Mallory Cave

Time of capture	**Sex**	**Repro. status**	**Weight (g)**	**Age**	**Band #**	**Date of capture**
1000	Thirteen individuals	in cluster	Females and young	Mallory cave		20 July
2155	8 counted	in roost				29 July

Myotis lucifugus at North Shanahan Pond

Time of capture	**Sex**	**Repro. status**	**Weight (g)**	**Age**	**Band #**	**Date of capture**
2043	female	nlnp	none	Juv.	none	31 July
2045	female	pl	10.1	Adult	none	31 July
2045	male	ns	7.1	SA	none	31 July
2125	female	nlnp	6.0	SA	none	31 July

Myotis thysanodes at North Shanahan Pond

Time of capture	**Sex**	**Repro. status**	**Weight (g)**	**Age**	**Band #**	**Date of capture**
2053	male	ns	7.1	Adult	none	31 July
2115	female	pl	8.0	Adult	none	31 July
2125	male	ns	6.1	Adult	none	31 July
2137	male	s	7.8	Adult	none	31 July
2234	female	pl	9.9	Adult	**Recap. BK267**	31 July

Eptesicus fuscus at North Shanahan Pond

Time of capture	**Sex**	**Repro. status**	**Weight (g)**	**Age**	**Band #**	**Date of capture**
2125	male	s	21.8	Adult	none	31 July
2137	male	ns	13.7	Juv.	none	31 July
2234	female	l	27.0	Adult	none	31 July

Myotis lucifugus at Stockton Cabin

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2035	male	ns	6.1	Juv.	none	6 Aug
2035	male	ns	6.2	SA	none	6 Aug.
2035	male	ns	5.9	SA	none	6 Aug.
2052	male	ns	6.0	SA	none	6 Aug.
2052	male	s	7.1	Adult	none	6 Aug.
2052	male	ns	5.8	SA	none	6 Aug.
2052	male	s	6.5	Adult	none	6 Aug.
2052	male	s	7.8	Adult	none	6 Aug.
2052	female	nl	7.0	Adult	none	6 Aug.

Myotis thysanodes at Stockton Cabin

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2052	male	ns	7.9	SA	none	6 Aug.
2205	male	ns	7.1	Juv.	none	6 Aug.

Myotis ciliolabrum at Stockton Cabin

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2052	male	s	2.9	Adult	none	6 Aug.
2105	female	nlnp	2.9	Juv.	none	6 Aug.

Myotis evotis at Stockton Cabin

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2035	male	s	5.9	Adult	none	6 Aug.
2100	male	s	7.9	Adult	none	6 Aug.
2100	male	s	5.1	Adult	none	6 Aug.

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2110	male	s	5.8	Adult	none	6 Aug.
2035	male	s	5.5	Adult	none	11 Sept.
2108	male	s	5.2	Adult	none	11 Sept.

Myotis volans at Stockton Cabin

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2045	male	s	6.5	Adult	none	6 Aug.
1952	male	s	5.1	Adult	none	11 Sept.
2132	male	ns	none	Adult	none	11 Sept.
2132	male	ns	7.1	Adult	none	11 Sept.
2132	male	ns	7.2	Adult	none	11 Sept.

Corynorhinus townsendii at Stockton Cabin

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2150	male	s	9.9	Adult	none	6 Aug.

Eptesicus fuscus at Stockton Cabin

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
1955	male	s	17.3	Adult	none	11 Sept.
2025	male	s	18.0	Adult	none	11 Sept.
2052	male	s	20.1	Adult	none	11 Sept.

Myotis ciliolabrum at Gregory Canyon

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
1957	male	ns	3.0	SA	none	2 Sept.

Myotis thysanodes at Gregory Canyon

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2007	male	ns	6.5	SA	none	2 Sept.
2016	male	ns	8.8	SA	none	2 Sept.
2020	female	pl	7.7	Adult	none	2 Sept.

Myotis ciliolabrum at South Mesa Trailhead

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
1945	male	ns	4.8	SA	none	15 Sept.

Lasionycteris noctivagans at South Mesa Trailhead

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
1954	none	none	9.0	SA	none	15 Sept.
1954	female	nlnp	19.5	Adult	none	15 Sept.

Myotis thysanodes at Deer Canyon, Heil Ranch

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2143	male	ns	6.9	SA	none	1 Aug.

Lasiurus cinereus at Deer Canyon, Heil Ranch

Time of capture	Sex	Repro. status	Weight (g)	Age	Band #	Date of capture
2150	male	s	21.0	Adult	none	1 Aug.

Table 2. *Localities of net sites for 2000, all in Boulder County, Colorado*

NAME OF SITE	LOCATION	TOPOGRAPHIC COORDINATES
Stockton Cabin Pool (SC)	Intersection of Mesa Trail and Shadow Canyon Trail	T1S R71W sec. 24
Bear Creek Pool (BC)	Junction of Mesa Trail and Bear Creek, app. 1.2 miles from Wildwood Trailhead	T1S R71W sec. 12
Gregory Canyon Pool (GC)	approximately 0.5 miles N from Saddle Rock Trailhead from base of Gregory Canyon	T1S R71W sec. 1
Lindsay Pond (LP)	South end of Dowdy Draw Trail and just north of water diversion pipe	T1S R70W sec. 31
North Shanahan Trail Pond (NSH)	Intersection of the middle and north forks of Shanahan Ridge trail	T1S R70W sec. 18
South Shanahan Trail Pond (a.k.a. Pollywog Pond) (SSH)	Southwest of first right angle bend in south fork of Shanahan Ridge trail from Hardscrabble Drive access, approximately 0.5 mi.	T1S R70W sec. 18
Abbey Pond (ABB)	Casual path west from Hardscrabble Drive to Shanahan Ridge, app. 1/4 mi	T1S R70W sec. 18
NIST Pond (NIST)	National Bureau of Standards section of Skunk Canyon Creek, app. 50m from beginning of paved path, just north of Kohler Reservoir	T1S R71W sec. 6
Long Canyon (LOC)	At junction of Long Canyon and Ranger trails	T1S R71W sec. 2
Sanitas Valley Trail Head (SVTH)	Sunshine Canyon Creek, at foot bridge, just north of parking lot for SVTH at Mapleton Dr.	T1N R71W sec.36

NAME OF SITE	LOCATION	TOPOGRAPHIC COORDINATES
Dakota Ridge Sanitas Valley (DR)	Irrigation ditch 0.3 mi. north of Mapleton Trailhead	T1N R71W sec. 24
Red Rocks (RR)	Irrigation ditch 0.1 mi. south along Red Rocks Trail from Mapleton Trailhead.	T1N R71W sec.36
Upper Bear Canyon (UBC)	Flagstaff Road 0.1 mi. past Green Mtn. Trailhead, turn left onto private dirt road for 4 mi. to reach trailhead	T1N R71W sec. 11
Lower Blue Bell Canyon (LBB)	Blue Bell creek, 0.2 mi. SSW of Auditorium	T1S R71W sec. 1
South Mesa Trailhead (SMT)	Irrigation canal just east of South Boulder Creek, directly west of parking lot.	T1S R70W sec. 29

Creek on 4 June 1997 was recaptured on 7 August 2000 at Bear Canyon Creek, now designated as Lower BC (Table 2). A female *M. thysanodes* captured at Lower BC on 24 August 1999 was recaptured at North Shanahan Pond on 31 July 2000, she was postlactating. A male *E. fuscus* captured at Bear Canyon Creek on 30 May 1998 was recaptured at Lower Bear Canyon Creek on 7 August 2000 (Table 2).

Forest Netting.--Three nights of forest netting was conducted in 2000. Both lead to zero captures. On 18 June & 1 July, we attempted to relocates a foraging colony of female *C. townsendii* at the Douglas Fir 3 site located SW of the diversion canal near Eldorado Mountain. The Townsend's apparently were not foraging at this site in 2000, possibly because the area was exceedingly dry and therefore insect populations were perhaps too low at this site to warrant foraging activity. We will try again in 2001, as finding the location of this maternity is paramount for conservation of the species.

D. Temporal Spacing at Waterholes.–The assemblage continues to show significant species-specific temporal spacing at waterholes. Tables 3 and 4 show that at both open (flight access paths > 3m in diameter) and closed (flight access paths < 3m in diameter) sites ANOVA analysis finds significant differences among species in visitation times, and Bonferroni all-pairwise multiple comparison tests indicate that temporal spacing at closed sites is more significant allowing for statistical exclusion of species from one another in timing. At open sites, the powerful Bonferroni analysis could not distinguish between groups in a statistically significant manner, except between the big brown bat (*Eptesicus fuscus*) and the little brown bat *(Myotis lucifugus*).

Table 3. *Bonferroni (all-pairwise) multiple comparison test for high-use water holes. Degrees of Freedom = 909, Critical Value = 2.935.*

Group	Count	Mean	Different from Groups
M. ciliolabrum	55	61.109	*M. evotis, M. volans, E. fuscus*
M. evotis	108	82.944	*M. lucifugus, M. ciliolabrum, E. fuscus*
M. lucifugus	307	48.947	*M. thysanodes, M. evotis, M. volans, E. fuscus*
M. thysanodes	99	68.989	*M. lucifugus, M. ciliolabrum, E. fuscus*
M. volans	107	91.701	*M. lucifugus, M. ciliolabrum, M. thysanodes, E. fuscus*
E. fuscus	239	122.209	*M. lucifugus, M. ciliolabrum, M. thysanodes, M. evotis, M. volans*

Table 4. *Bonferroni (all-pairwise) multiple comparison test for low-use waterholes. Degrees of Freedom = 164, Critical Value = 2.978*

Group	Count	Mean	Different from Group
M. ciliolabrum	19	50.684	
M. evotis	1	41 .0	
M. lucifugus	54	56.796	*E. fuscus*
M. thysanodes	14	75.428	
M. volans	5	99.8	
E. fuscus	77	78.233	*M. lucifugus*

E. Radio Telemetry. ***Roost Site Locations.***--Most effort in 2000 was placed on radio-tracking to locate day-roost sites, as well as utilizing telemetry triangulation techniques to determine foraging patterns and home ranges of radio-tagged individuals. Of the seven transmitters placed on bats, two signals were never reacquired despite rigorous searches on foot and with vehicles, covering at least a six-mile radius of the tagging site for up to 10 days. For five individuals, telemetry signals were reacquired after release usually within 2 days, and roost sites were found usually within a day of reacquiring the signal. Table 5 gives locations of roost site locations for 2000.

Home Range Data.--Home range data were gathered on several species. Figure 1 shows radio-telemetry data for a lactating, female *M. evotis* whose roost was found located on Flagstaff Mtn., approximately 0.5 mi. NNW of Artist Point. This individual would leave the roost site at 2112h (2 July) and head down hill to Boulder Creek (Fig. 2) where it would fly back and forth for about 10 minutes, likely foraging, and possibly drinking, along the creek. It would then fly SE climbing back over Flagstaff Mtn. And dropping into the valley near the Long Canyon waterhole where it would drink and forage, heading SSE of the site foraging predominately in Douglas Fir habitat, before heading back towards its roost approximately one hour after leaving its roost. For individuals of the maternity colony of *M. thysanodes* located on the east face of the Second Flat Iron (Fig. 1), their primary drinking location appears to be the same small pool of water in an otherwise dry creek bed in Long Canyon, 0.92 miles from the roost requiring the traversing of 7100 foot peaks (Fig. 3). Once leaving the roost (2116, 20 June), this individual foraged for approximately 0.5 hours east of the 2nd Flat Iron predominately in Douglas Fir habitat. Subsequently, this individual would traverse westward into Long Canyon to drink, despite the fact that a similar pool of water located to the east of the roost site, and much closer, was present. The Long Canyon waterhole has the highest calcium levels in the water of all the sites tested this past summer (see Water Quality section below). Figure 4 shows the location of two maternity

Table 5.-- *Date, location, site where tagging occurred, roost location, colony type and size, and distance of roost site from tagging site for bats tracked with radio telemetry in 2000.*

SPECIES	DATE FOUND	SITE TAGGED	ROOST LOCATION	COLONY TYPE	COLONY SIZE	DISTANCE
M. ciliolabrum ♀	6 June	Dakota Ridge	Mount Sanitas	Maternity	2	
E. fuscus ♀	8 June	NIST	never reacquired			
E. fuscus	29 June	Dakota Ridge	Church building @ 4th and Mapleton	Maternity	35	
M. thysanodes ♀	20 June	Long Canyon	Second Flat Iron Lat. 39^0 59.31, N Long. 105^0 17.46 W	Maternity	17	
M. evotis ♀	2 July	Long Canyon	NNW of Artist Point, Flagstaff Mtn. Lat. 40^0 N 00.56, Long. 105^0 18.83 W	Maternity	Unknown	
M. thysanodes ♂	19 July	Lower BC	Spire Rock, 0.3 mi. NW of net site. Lat. 39^0 58.38N, Long. 105^0 17.19W	Bachelor	6	
M. evotis ♀	26 July	Lower BlueBell Canyon, Chautauqua	never reacquired			

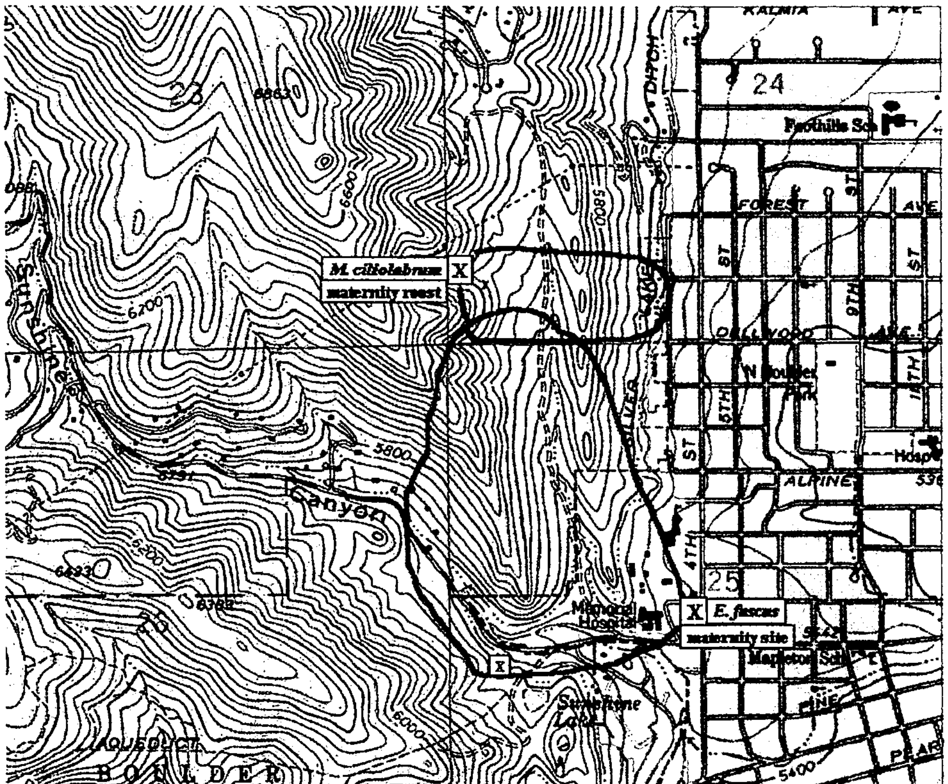

Figure 4. Roost site locations and minimum home ranges for a radio-tagged female *M. ciliolabrum* (blue line) followed for three nights (6,7, & 8 June). Its roost site was in a boulder rock crevice approximately 2 feet above the ground on Mount Sanitas. A female *E. fuscus*, also tagged at Dakota Ridge but on 29 June was tracked to the church building located on the NW corner of 4th Street and Mapleton Ave. Green line depicts minimum home range, most of the time this individual was foraging out of range of our telemetry gear.

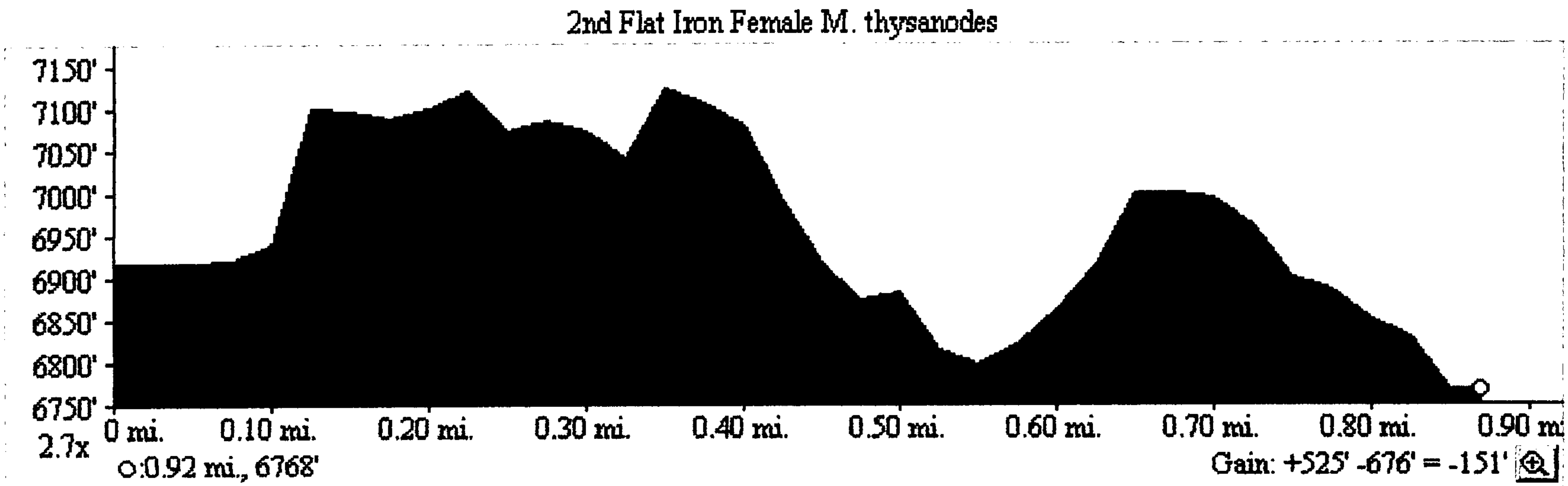

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Figure 3. Elevational profile of flight path estimated using radio-telemetry for a lactating, female *M. evotis* on the nights of 19 & 20 July. This profile depicts the changes in landscape between the roost site and the waterhole of capture estimated to be encountered by this individual.

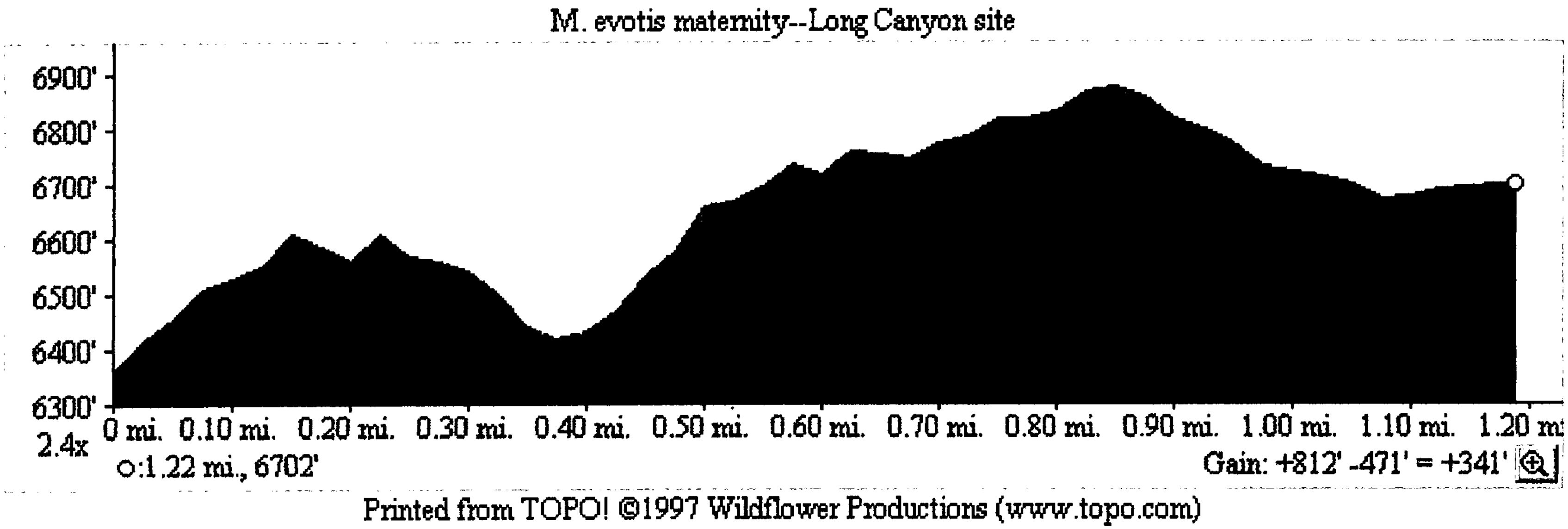

Figure 2. Elevational profile of flight path estimated using radio-telemetry for a lactating, female *M. thysanodes* on the nights of 2 & 3 July. This profile depicts the changes in landscape between the roost site and the waterhole of capture estimated to be encountered by this individual.

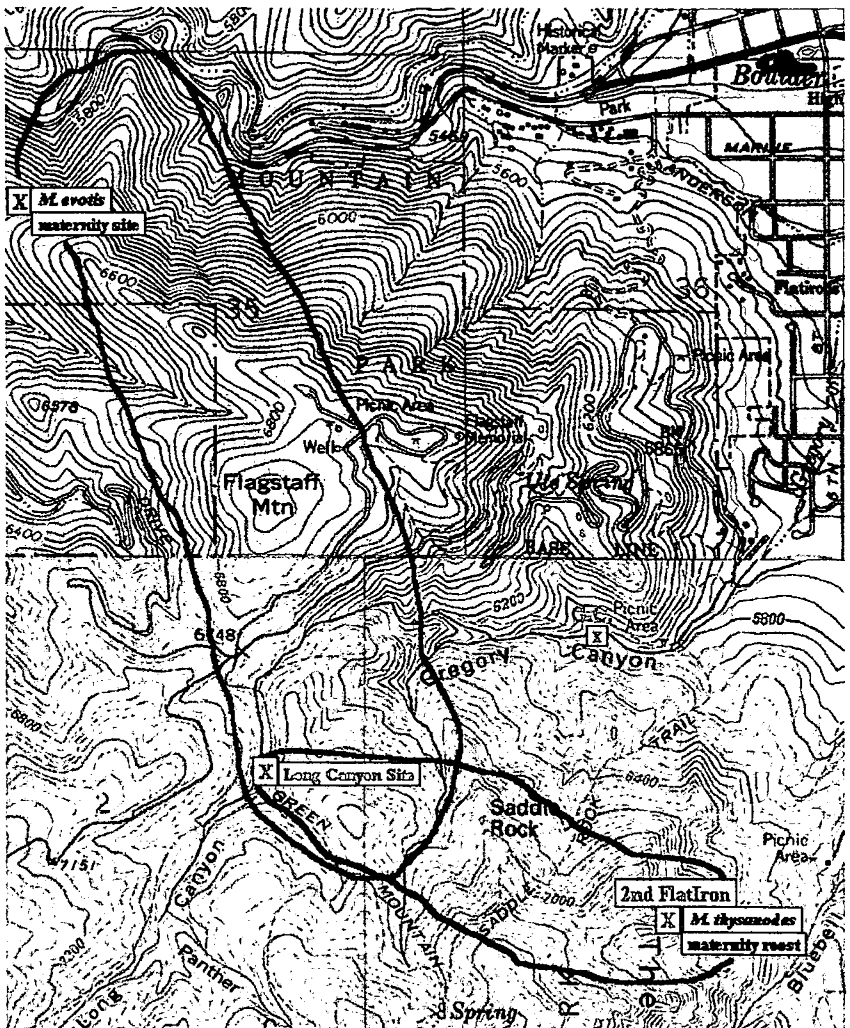

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Figure 1. Locations of maternity roosts for the long-eared myotis (Myotis evotis) and fringed myotis (*M. thysanodes*) both individuals radio-tagged at the same waterhole in Long Canyon. Although Long Canyon stream dried up in May, a small, deeply imbedded pool of water remained throughout the summer. Water quality analysis showed that this waterhole contained the highest level of dissolved calcium (see text for further discussion) of the 11 sites tested.

colonies, one for *M. ciliolabrum* located on Mount Sanitas in a rock crevice of a boulder, the other for *E. fuscus*, located in the Church at 4th Street and Mapleton Ave. For *M. ciliolabrum*, who left the roost at 2056h (6 June) this individual spent most of its time foraging near and around 3rd and 4th streets and in a parking lot lite with street lamps that attract insects. It's foraging is quite small and is depicted quite accurately by the blue line on the provided map. For the Church colony of *E. fuscus* who left its roost at 2051h (30 June), the line represents minimal foraging range, and, in fact, this individual spent much of its time out of range of our telemetry equipment even though we attempted to follow it on several occasions. This colony would leave the roost and fly to the Red Rocks area, foraging on the saddle area to the west and also along the irrigation ditch, were we caught as many as 15 individuals on another occasion. Figure 5 & 6 show elevational profiles for the flight patterns of these individuals. Figure 7 shows the location of a bachelor roost on the Spire in Bear Canyon and the minimum foraging area for this male that was captured and tagged at our Bear Creek site. The colony size was estimated between 6 and 10 individuals. Figure 8 shows the elevational profile of the foraging forays for this individual.

F. Roost Site Temperature Profiles.--Of the seven temperature data loggers deployed in 2000, one failed, one was stolen, and the other five provide temperature profiles for roost sites for several species of bats. Figure 9a shows data gathered via an inserted temperature probe into a maternity roost of long-eared myotis (*Myotis evotis*) located on Flagstaff Mountain NNW of Artist Point (see Table 1), 9b shows data gathered from outside the roost by the logger sensor. The logger was placed at the roost on 11 July and removed on 30 August. Unfortunately, the logger was found on 30 August removed from the roost and heavily chewed upon by rodents. The logger probe was severed and the waterproof bag was chewed through in several places.

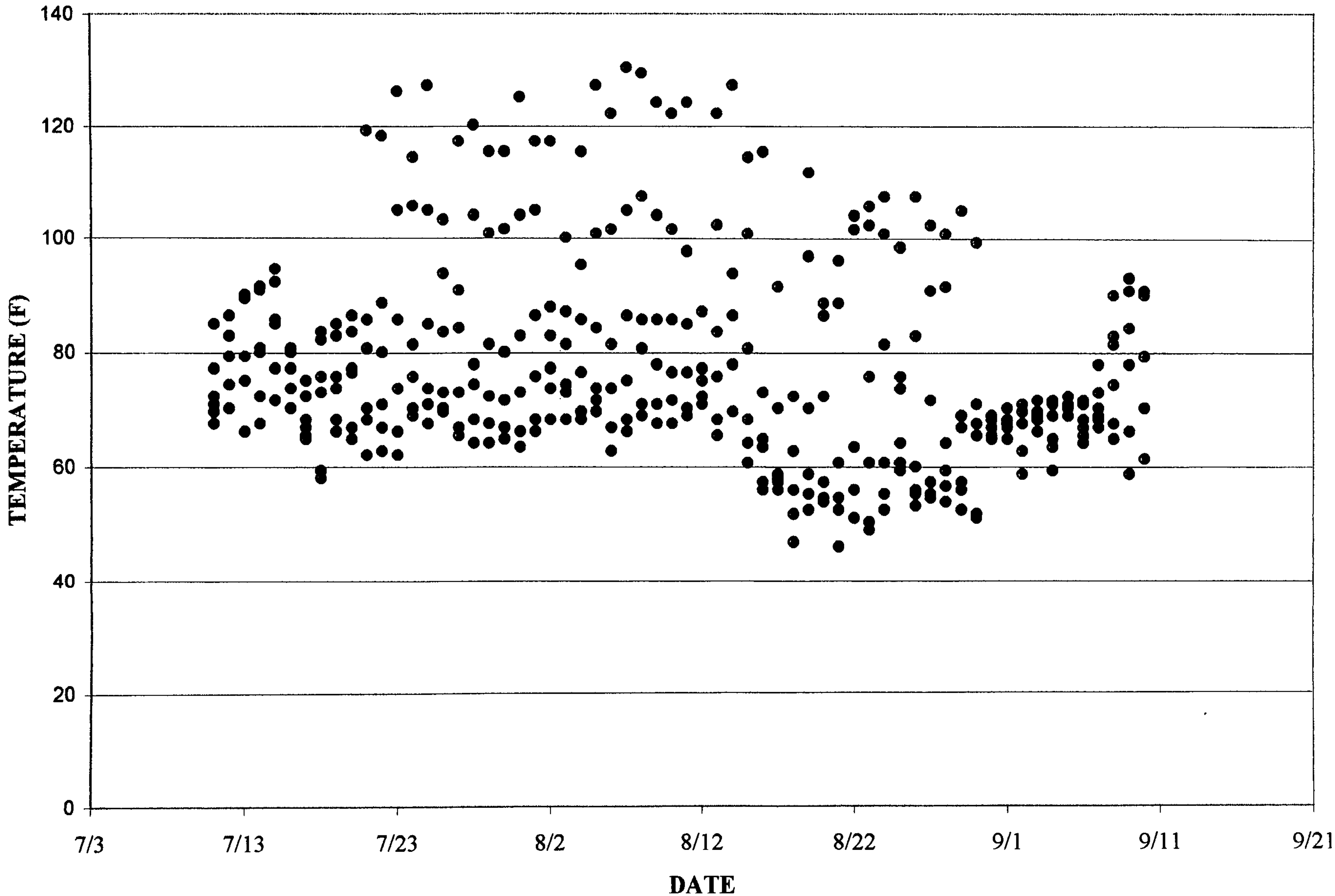

Figure 9b. Temperature data gathered from outside a maternity roost of *Myotis evotis* (11 July-10 Aug.) on Flagstaff Mtn.

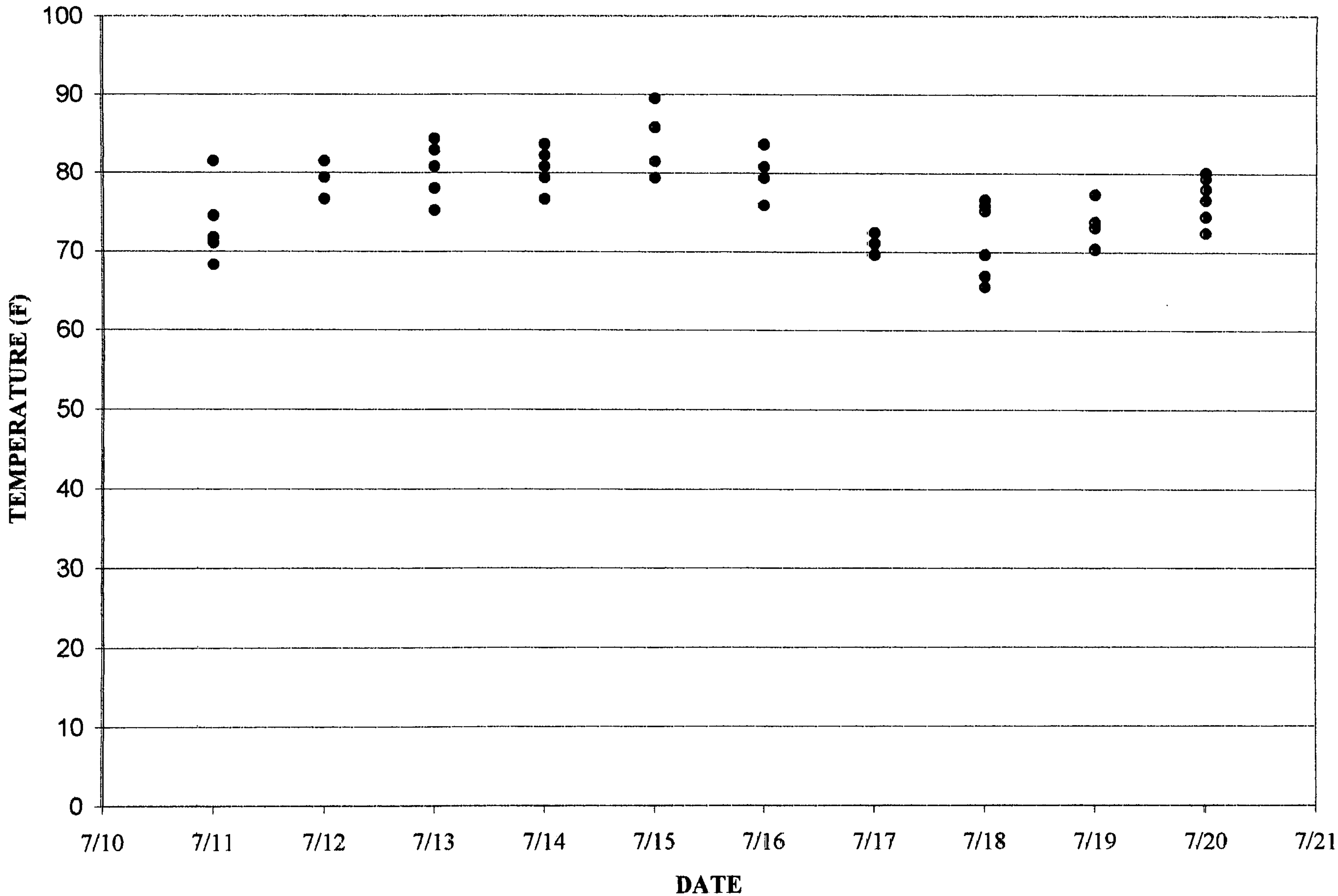

Figure 9a. Temperature data gathered from within a maternity roost of *Myotis evotis* (11 July-10 Aug.) on Flagstaff Mtn.

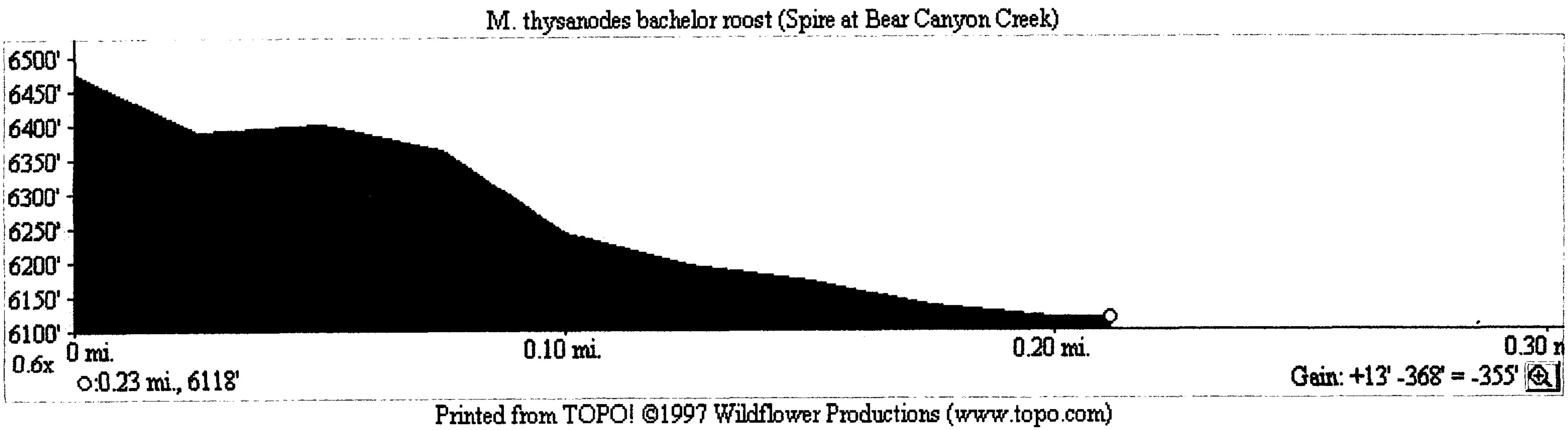

Figure 8.–Elevational profile of flight paths used between the Bear Canton Creek Spire bachelor roost of *M. thysanodes* and the BC waterhole where it was tagged. Data on distance and elevational changes between the two are given at the bottom of the figure.

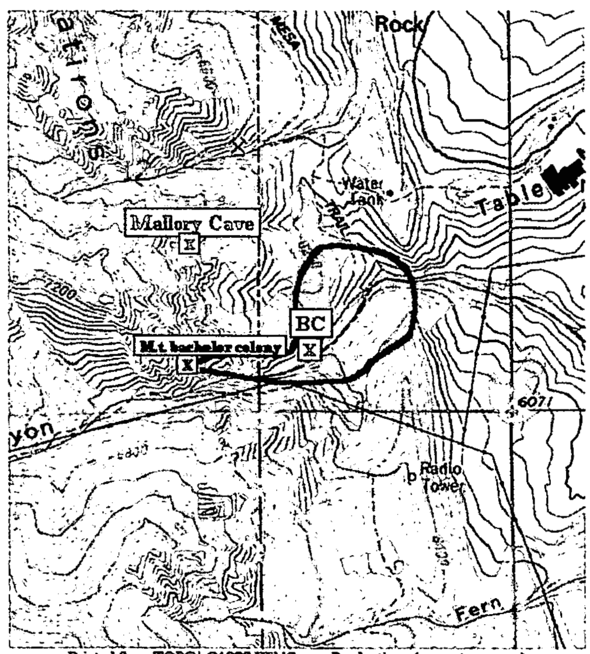

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Figure 7. Roost site location of a bachelor colony of *M. thysanodes* located on the Spire in Bear Canyon. Blue line indicates minimum foraging range for this individual.

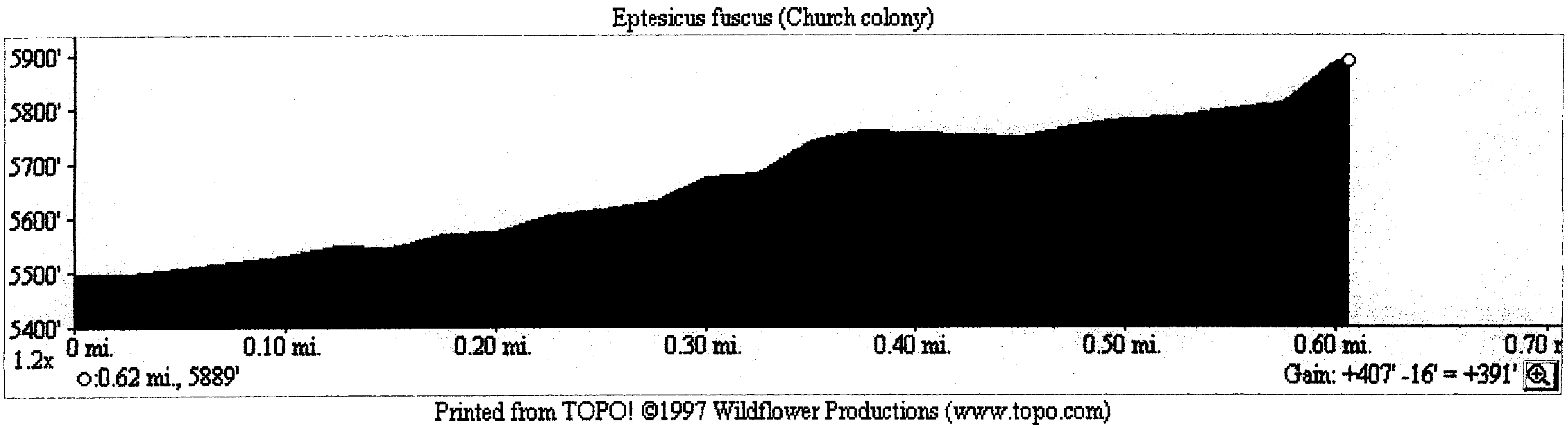

Figure 6.–Elevational profile of flight paths used between the Church roost site colony of *E. fuscus* and the Dakota Ridge waterhole where it was tagged. Data on distance and elevational changes between the two are given at the bottom of the figure.

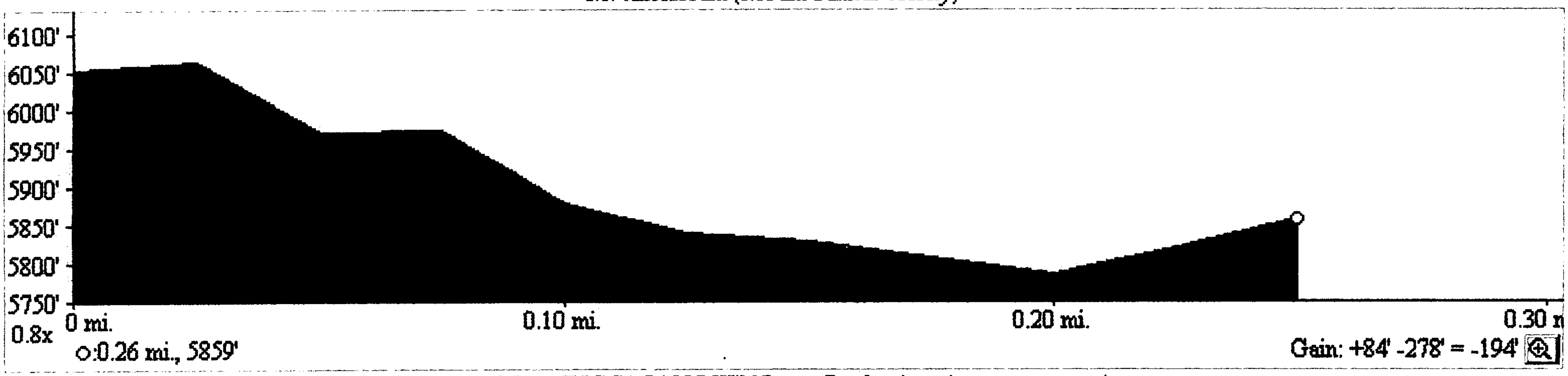

Figure 5.–Elevational profile of flight paths used between the Mount Sanitas roost site colony of *M. ciliolabrum* and the Dakota Ridge waterhole where it was tagged. Data on distance and elevational changes between the two are given at the bottom of the figure.

Date concerning this event are unknown. However, in reviewing Figure 9a, it appears that there is a steady and consistent pattern between 11 July and 10 August and then a spike of activity that suggest a change in position of the probe. During the period between 11 July and 10 August, the patterns of fluctuations is consistent, with daytime temperatures approaching 90° F and nighttime temperatures hovering around 50° F. Outside roost temperature during this time interval fluctuated between 61° F and 128° F. Figure 10 shows temperature data for the Harmon Cave chamber that houses the *C. townsendii* maternity colony for part of the year. The logger was placed at the site on 23 March and set to launch on 1 May. The logger was removed by Burton Stoner 12 October. Bats are believed to begin using the site in early May. Temperatures increased in the chamber throughout the summer reaching a peak of 78° F in early to midAugust. It is likely that these high temperatures are not tolerated by *C. townsendii*, and hence the colony moves apparently to Mallory Cave which predictable maintains a more steady and lower temperature regime (unfortunately, a data logger placed in Mallory Cave was stolen) (Humphrey and Kunz, 1976; Kunz and Martin,1982). Temperature is a limiting to this species (Twenty, 1955), and this species prefers temperatures below 30° C (85° F) in the summer roost (Pierson, 1991).

Figure 11 shows data gathered from a maternity colony of big brown bats (*E. fuscus*) located at the Amphitheater near Gregory Canyon (see Table 1). Figure 11a are data from the probe that was inserted into the colony by Burton Stoner on 1 August and removed on 13 October. Temperatures in the roost site in early August ranged from about 75° F at night to about 88° F during the day (Fig. 11a), where as temperatures outside the roost (Fig. 11b) fluctuated at lower and higher temperatures than recorded inside the roost. Although the roost temperatures

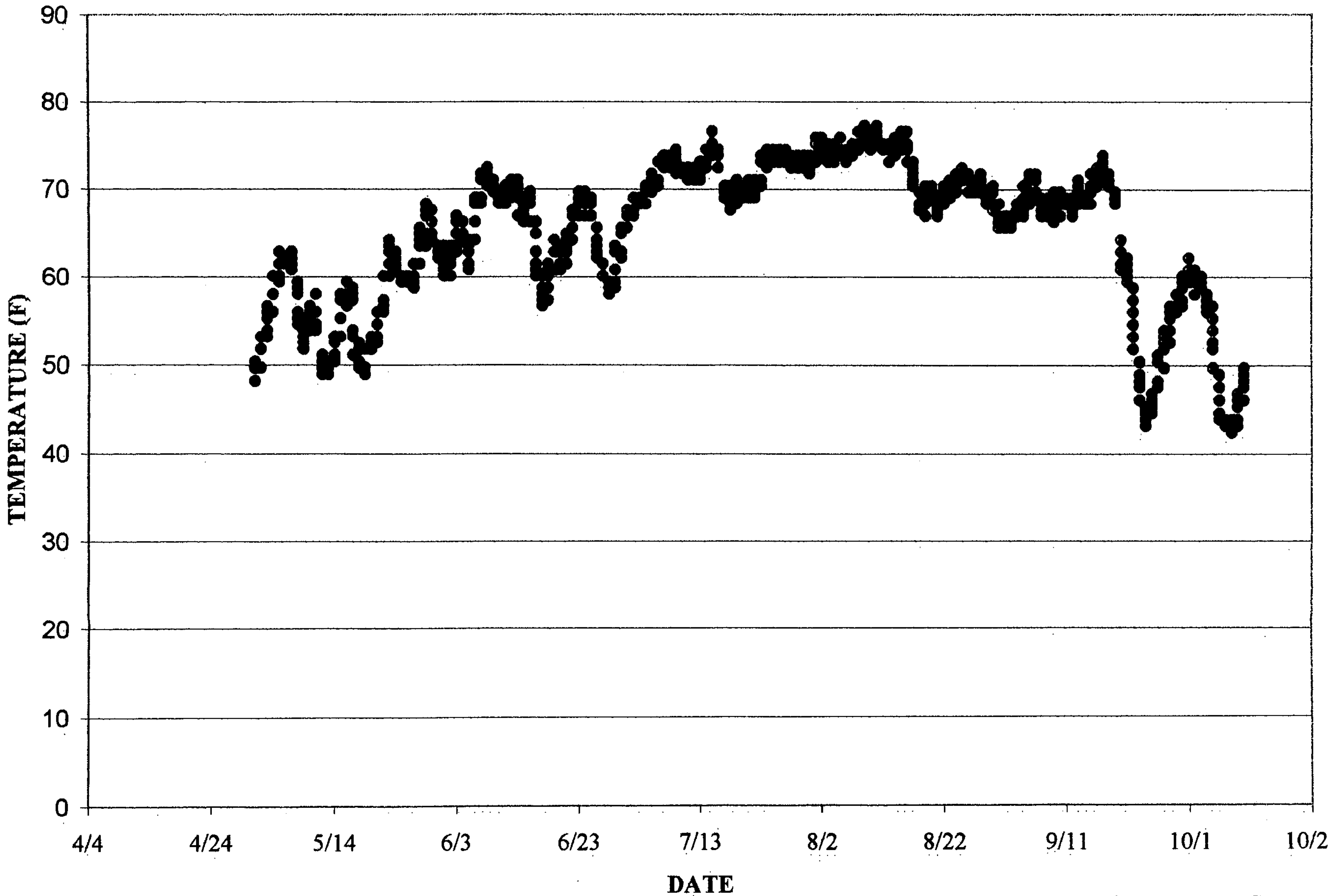

Fig. 10. Temperature data gathered from 1 May to 10 October from a maternity roost of *Corynorhinus townsendii* at Harmon Cave.

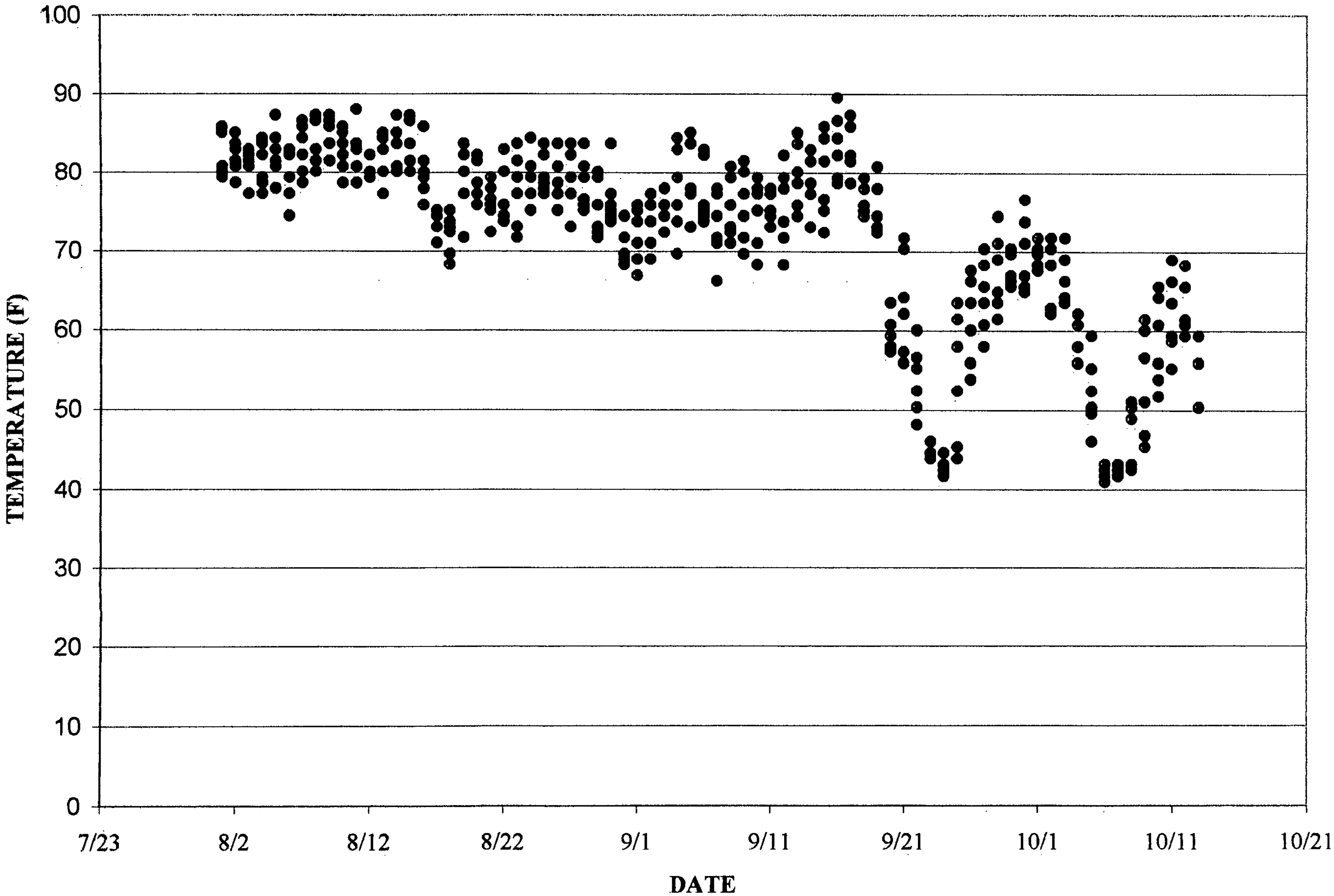

Figure 11a. Temperature data gathered from within the Amphitheater maternity roost of *Eptesicus fuscus* (1 Aug.-13 Oct.).

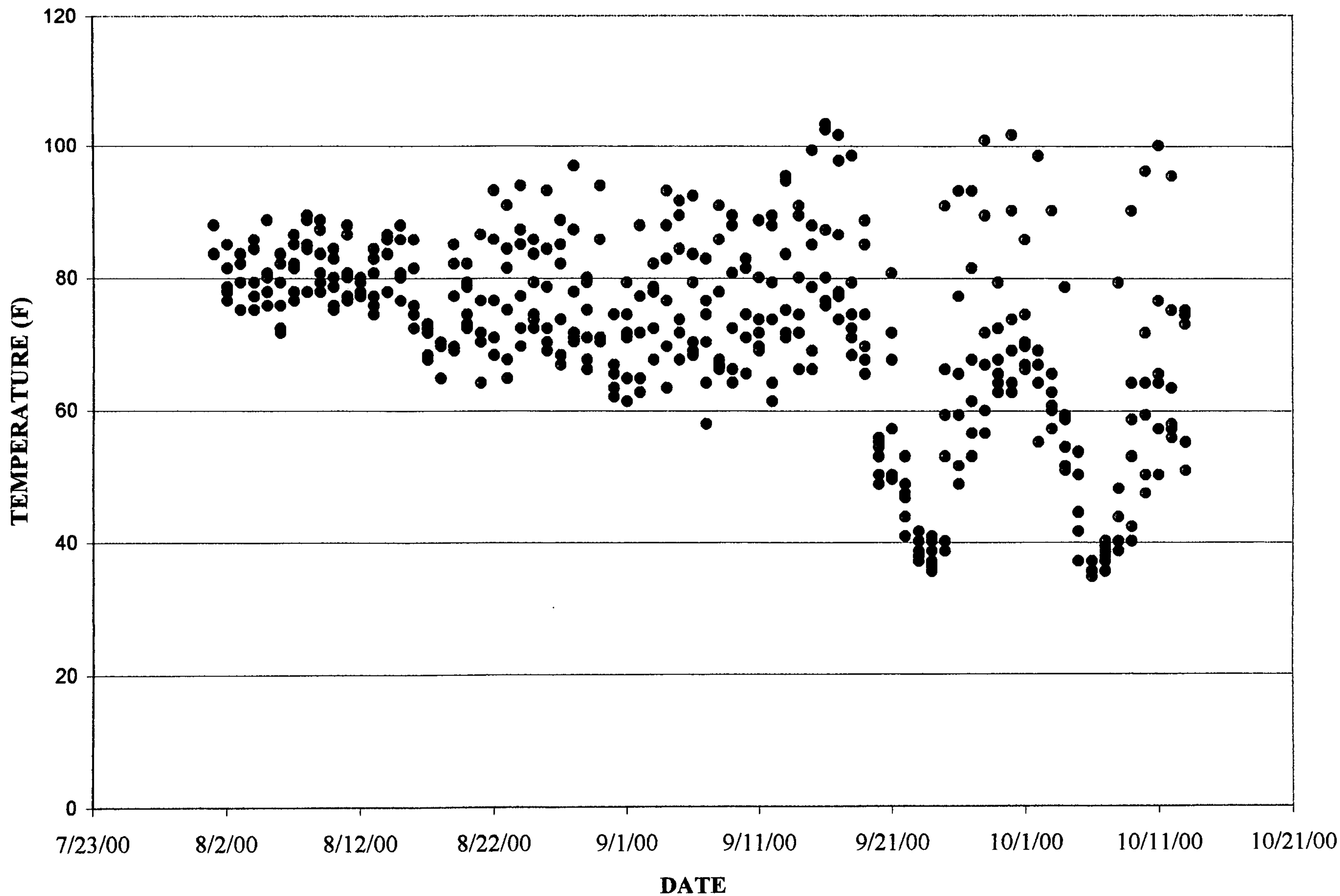

Figure 11b. Temperature data gathered from outside the Amphitheater maternity roost of *Eptesicus fuscus* (1 Aug.-13 Oct.).

declined some in late August, less variation in temperature was recorded from inside the roost than from the sensor located outside. Figure 12 shows temperature data recorded between 16 July and 16 November from a maternity colony of *E. fuscus* located in a house on Open Space property near Boulder Reservoir. As compared to temperature recording from the Amphitheater site, temperatures were typically 8-10° F higher in the house than in the rock crevice maternity site. Highest temperatures in the house neared 100° F, whereas in the rock crevice remained mostly in the low 90°'s. Figure 13 shows temperature data from a bachelor colony of *E. fuscus* located in a rock crevice inside of Harmon Cave. Data began being collected on 1May, and the logger was retrieved by Christina Allen (local biologist and bat enthusiast with Classroom Connect) and me on 19 December. Figure13a shows data collected outside of the bachelor roost, but inside of the cave chamber, and Figure 13b shows data from the probe inserted into the colony in March by Burton Stoner. Although there are some subtle differences discernable between the temperature profiles taken from inside and outside the roost, the differences are a matter of a few degrees only. Generally speaking, temperatures are on the order of 10-20° F lower than those recorded in the rock crevice and house maternity roost for this species.

G. Water Temperatures and pH.--Average water temperature for 13 waterholes documented in 2000 are shown in Figure 14. Stream sites had much lower average water temperatures (Range 50°-62° F), whereas ponds were much higher in average temperature (72°-78° F). Average pH levels of 11 waterholes are given in Figure 15 and show some variation between June and July per site. For most sites, pH was higher in June than July. Generally, all sites registered pH's that were basic (Range 7.1-8.8).

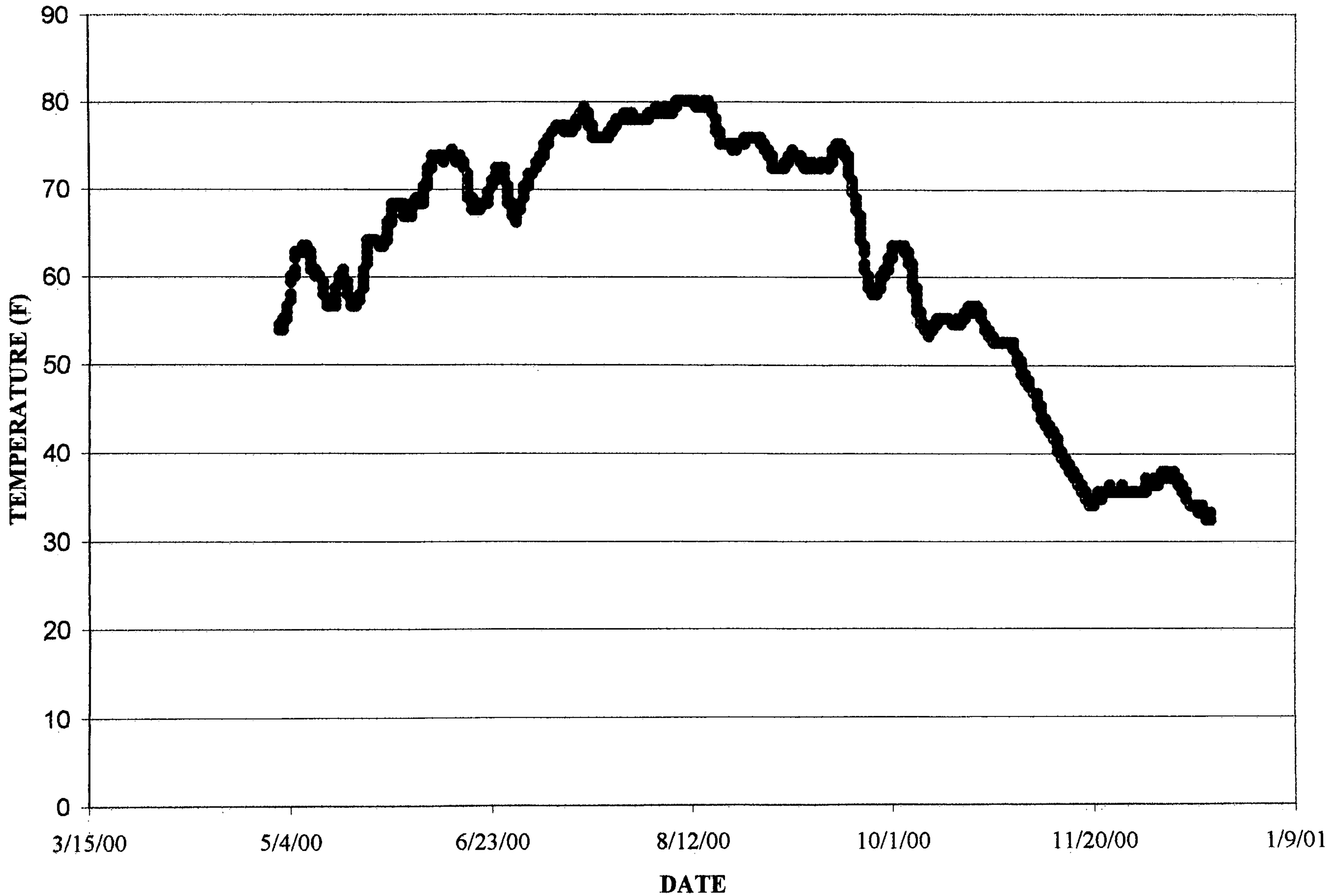

Figure 13b. Temperature data gathered from inside a bachelor roost of *Eptesicus fuscus* at Harmon Cave (1 May-19 Dec.).

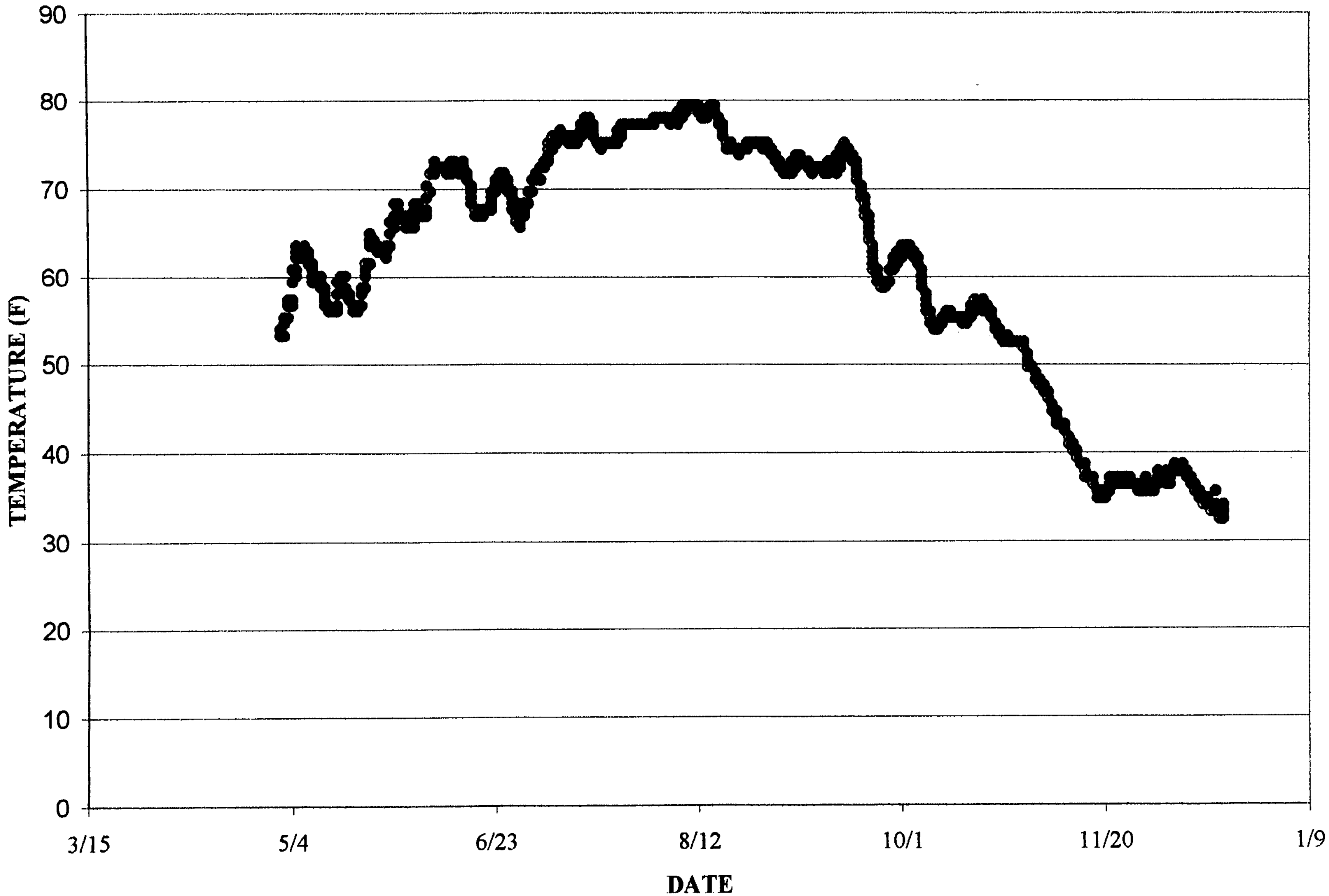

Figure 13a. Temperature data gathered from outside a bachelor roost of *Eptesicus fuscus* at Harmon Cave (1 May-19 Dec.).

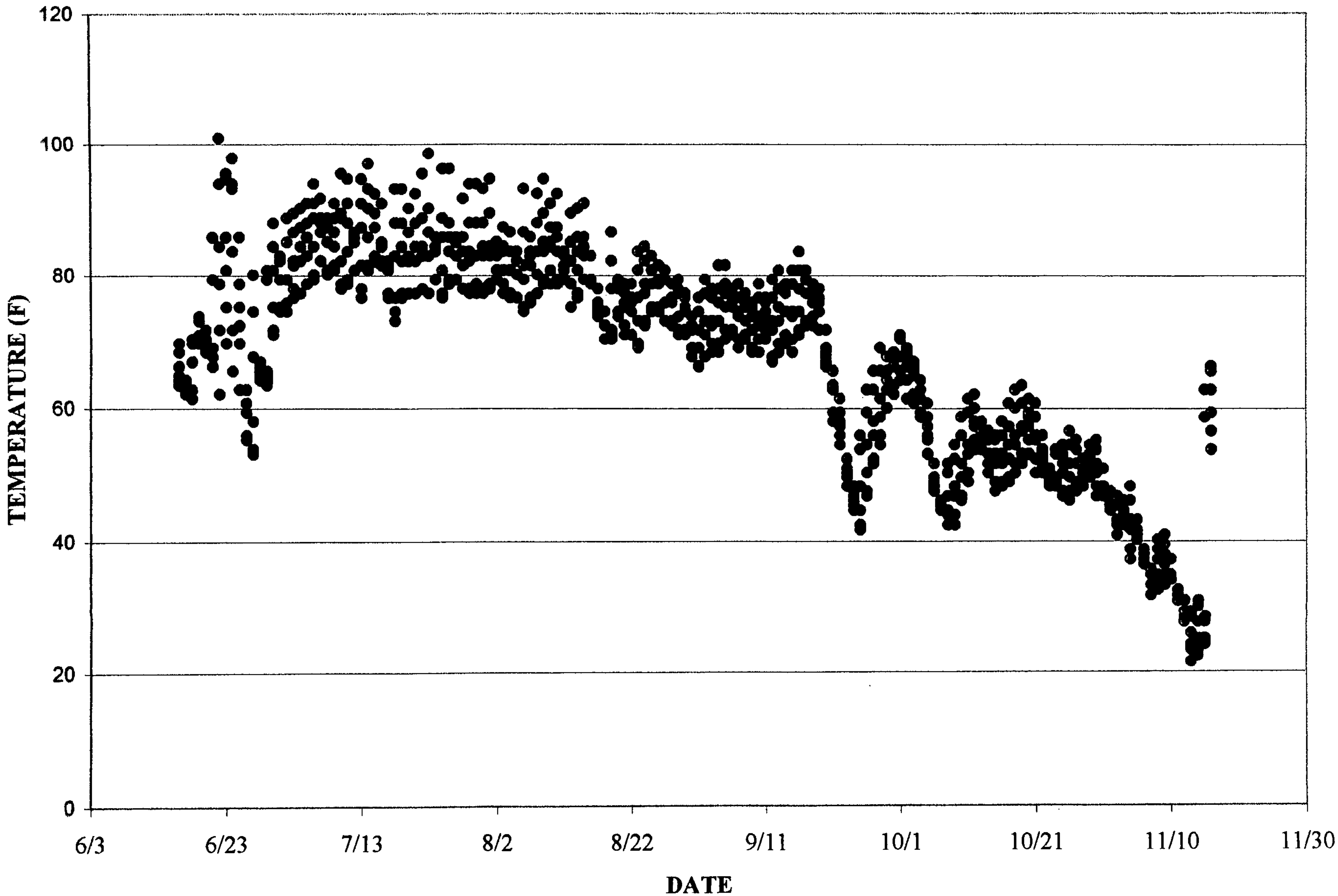

Figure 12. Temperature data gathered from inside the maternity house roost of *Eptesicus fuscus* (16 July-16 Nov.).

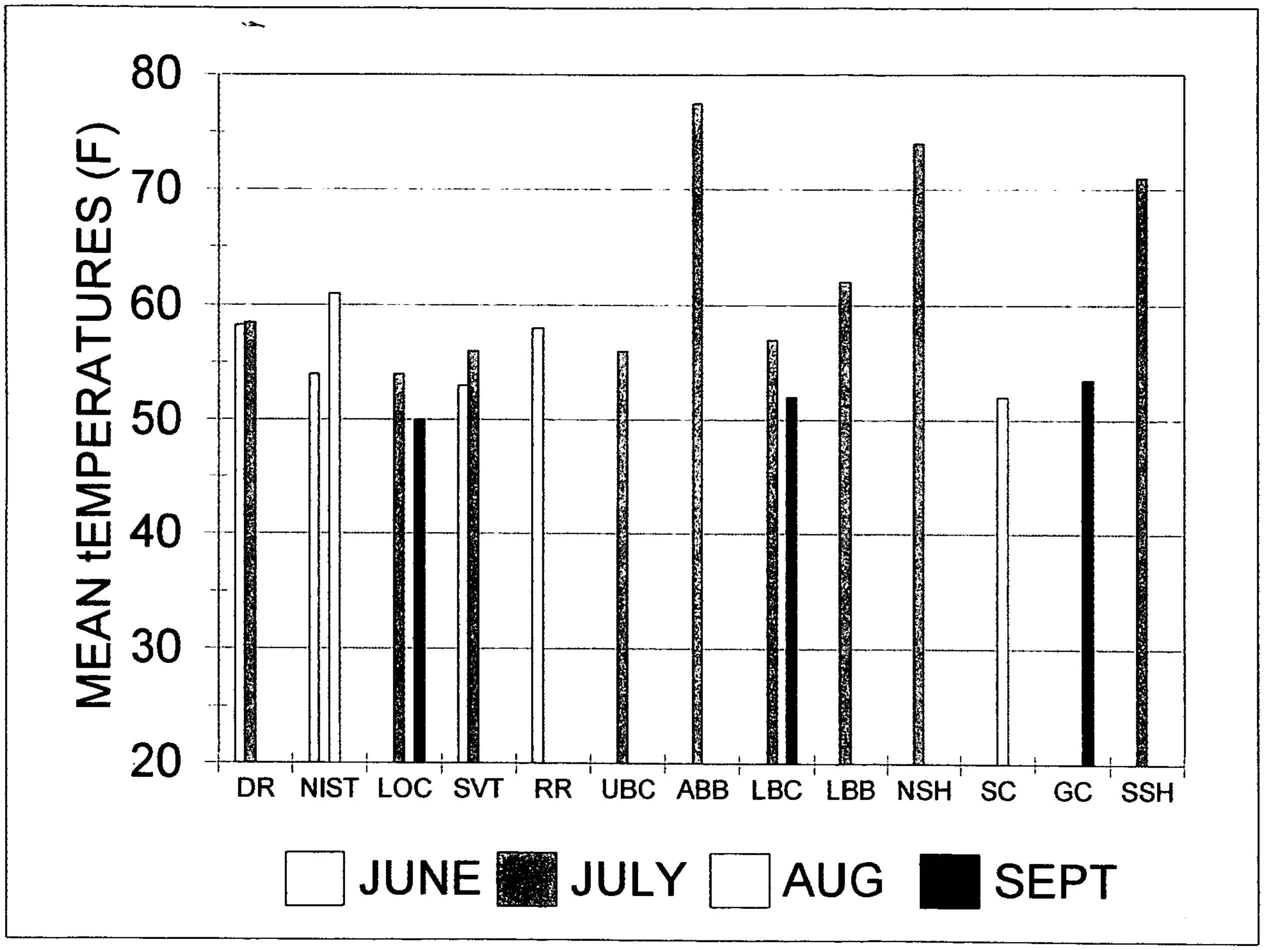

Figure 14. Mean temperatures calculated for June, July, August, and September for 13 waterholes netted for bats in 2000. See Table 2 for abbreviations.

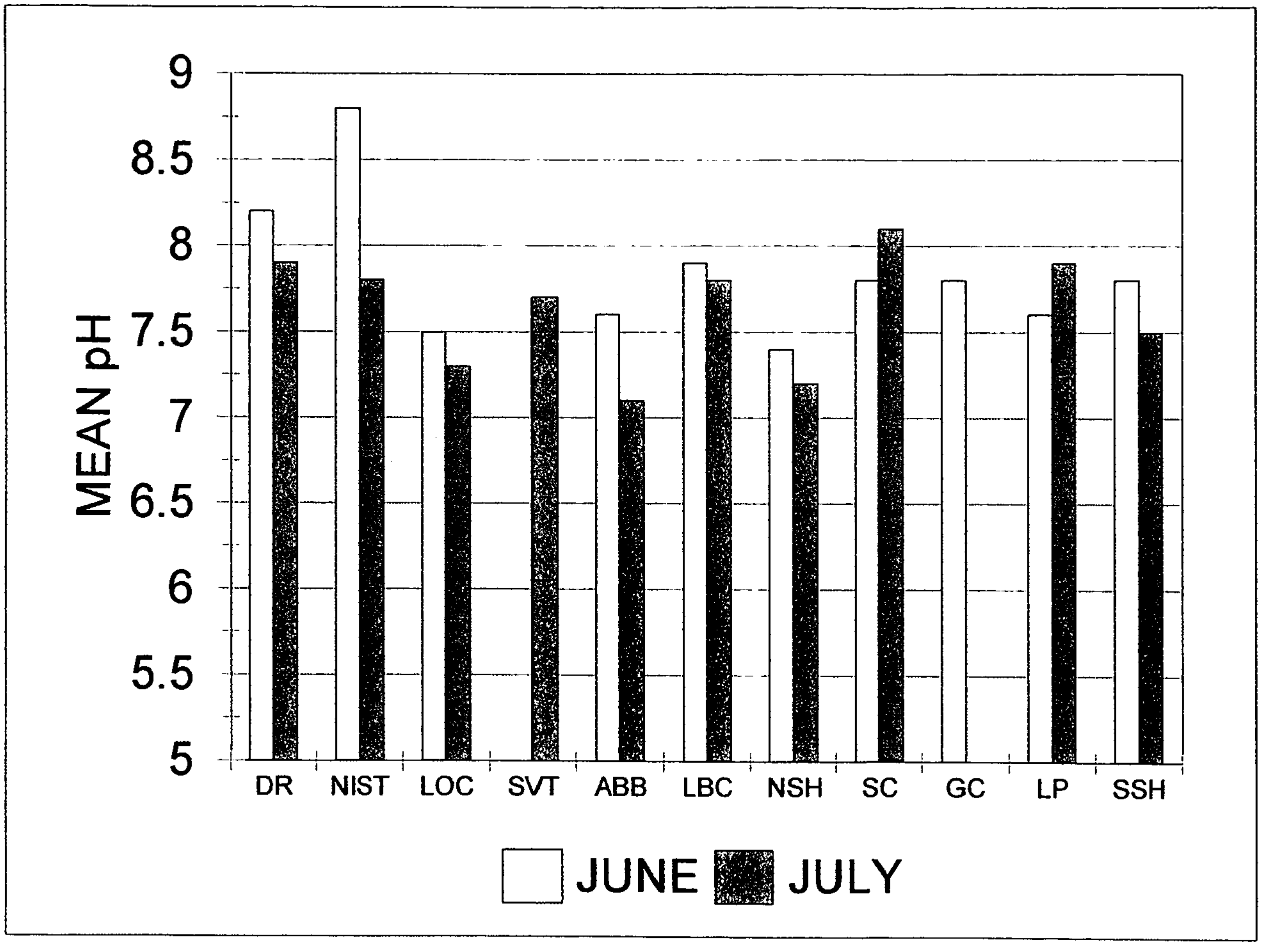

Figure 14. Mean pH calculated during June & July at 11 waterholes tested for water quality and mineral content in 2000. PH was taken at the time of water quality testing as well as during netting at these sites. See Table 2 for site abbreviations.

H. Water Quality and Nutrient Content of Waterholes.--In 2000, samples were gathered on 22 (six sites) & 23 June (four sites), and again on 24 July. Ten sites were sampled each time with the June sampling including Gregory Canyon stream, and the July sample replacing Gregory Canyon stream with Sunshine Canyon stream (SVTH) because Gregory Canyon had become dry. Tables 6 & 7 show analyses of specific conductance, turbidity, alkalinity, hardness, nitrogen, sulfate, total and dissolved phosphate levels at each site in June and July. There was high variability among sites, however, variability across months was small. Turbidity was highest at the pond sites and ranged from 0.58 ntu at Stockton Cabin to 438 ntu at North Shanahan Pond (NSH) in June. In July, Lower Bear Canyon Creek was lowest in turbidity at 0.50 ntu and NSH was highest and increased to 1279 ntu in July. Specific Conductance, Alkalinity, and Hardness are intricately related and in June hardness readings were lowest Dakota Ridge (16 mg/l) and highest at Gregory Canyon (111.5 mg/l). In July, lowest hardness was at Abbey Pond (15.3 mg/l), and highest levels were recorded for Long Canyon (110.9 mg/l), however, it should be noted that Gregory Canyon was not tested in July because it stop flowing.

Water hardness is highly correlated ($r = 0.91, p = 0.000$) with calcium levels of the water which is highly correlated with visitation of reproductive females and juvenile bats calculated as an index of total number of bats captured at the site to adjust for differential sampling among sites (Fig.16).

Table 6.--*Measured water attributes for 10 water hole sites sampled on June 22nd and 23rd. Time stated is time sampled was taken on the respective day. SP.CO. = Specific Conductivity (umhos/cm), followed by Turbidity (ntu), Alkalinity (mg/L), Hardness (mg/L),* NO_3 *(mg/L),* SO_4 *(mg/L), Total Phosphate* (ug/L), *and Dissolved Phosphate* (ug/L).

SITE	TIME	SP. CO.	TURB.	ALK.	HARD.	NO3	SO4	TOT-P	DIS-P
SC	1110	57.0	0.83	12.0	19.7	1.240	7.0	67.6	59.5
BC	1130	115.3	1.02	47.3	47.5	0.161	3.0	24.2	24.9
NIST	1210	188.2	1.40	65.2	77.8	0.259	15.0	63.4	18.9
LP	1020	208.0	12.00	69.9	91.2	0.000	28.0	42.9	10.5
DR	1110	40.5	3.33	14.3	16.0	0.018	0.0	12.9	5.2
ABB	0905	111.7	437.00	28.2	23.3	0.000	6.0	328.3	18.9
SSH	0940	116.2	29.00	38.0	30.5	0.000	1.0	134.7	47.5
GC	1000	352.0	0.58	98.4	111.5	0.008	49.0	22.8	18.6
NSH	0920	172.6	438.00	49.4	51.5	0.011	13.0	226.6	10.5
LOC	1030	265.0	12.00	89.6	109.1	0.015	8.0	76.5	21.4

Table 7.--*Measured water attributes for 10 water hole sites sampled on July 24th. Time stated is time sampled was taken on the respective day. SP.CO. = Specific Conductivity (umhos/cm), followed by Turbidity (ntu), Alkalinity (mg/L), Hardness (mg/L), NO_3 (mg/L), SO_4 (mg/L), Total Phosphate* (ug/L), *and Dissolved Phosphate* (ug/L).

SITE	TIME	SP. CO.	TURB.	ALK.	HARD.	NO3	SO4	TOT-P	DIS-P
SC	0835	57.1	1.1	12.1	19.6	1.230	7.0	111.76	54.59
BC	0920	115.6	0.5	47.6	47.6	0.242	1.0	29.87	29.52
NIST	1030	165.9	2.4	62.2	68.2	0.259	9.0	30.22	NA
LP	0800	239.0	55.7	89.7	105.2	0.000	28.0	101.91	16.10
DR	1100	46.6	3.8	16.3	17.8	0.023	0.0	17.51	4.45
ABB	0955	111.3	482.0	18.7	15.3	0.000	12.0	508.76	20.69
SSH	1010	133.0	101.0	41.2	33.9	0.000	3.0	344.71	41.52
SVTH	1109	196.6	4.4	82.1	80.0	0.000	5.0	52.70	10.10
NSH	0945	153.7	1279.0	26.8	33.0	0.001	19.0	377.52	10.45
LOC	0710	247.0	2.5	101.1	110.9	0.006	8.0	62.54	28.81

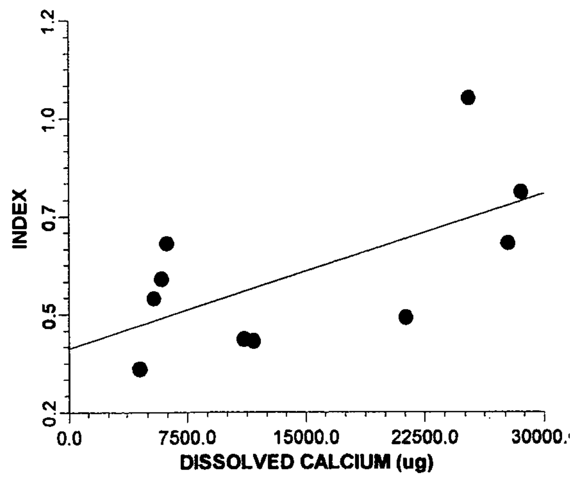

Figure 16. Plot of index (reproductive females and juveniles/total captures) versus levels of dissolved calcium per site
$r = 0.623, p = 0.007, r^2 = 0.401$

These data suggest that the importance of waterholes to Boulder bats resides not only in the water itself, badly needed to replenish reserves lost during diurnal roosting in Colorado's highly xeric environment, but also as nutrient source for replenishing minerals for daily minimum requirements.

Tables 8 and 9 show data concerning dissolved and total mineral deposits in 11 waterholes tested in 2000. Amount of dissolved calcium found per site was highly variable, but within site calcium levels varied little between June (Table 8) and July (Table 9). Highest calcium loads were consistently found Gregory Canyon, Long Canyon, NIST, and Lindsay Pond . And these sites were visited predominately by reproductive females and juveniles that are calcium deficient and cannot gain sufficient amounts to maintain daily minimum requirement from food only (Barclay 1995). In addition, as shown in Tables 8 & 9, some waterholes hold significant amounts of sodium, iron, potassium, and manganese that also may be important nutrient sources for bats and other wildlife. Table 10 shows Principal Component Analysis of the mineral content of the 11

Table 8.--*Mineral analysis of water collected from 10 sites on 22 & 23 June 2000. All measurements are in ug. DR = Dakota Ridge-Sanitas Valley, SC = Stockton Cabin, GC = Gregory Canyon, LC = Long Canyon, NIST = NIST site, ABB = Abbey Pond, LP = Lindsay Pond, LBC = Lower Bear Creek, SSH = South Shanahan Pond, and NSH = North Shanahan Pond.*

SITE	CALCIUM		IRON		POTASSIUM		MAGNESIUM		SODIUM	
	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total
DR	4548	4488	60	293	515	517	1061	1083	2635	2672
SC	5941	5822	10	28	1451	1439	1462	1317	2866	2682
GC	28572	27528	151	278	2894	2765	10468	9633	36964	35031
LC	27749	27476	77	833	2366	2634	10280	10364	9757	15851
NIST	21319	21573	52	128	1677	1873	5885	6015	7664	7835
ABB	5462	9403	1005	28083	7291	9953	1623	4396	8589	8389
LP	25298	21808	73	1053	2253	2221	7331	6815	6875	6781
LBC	11709	11736	6	131	2228	2128	4131	3992	4309	5038
SSH	6259	6247	1550	2692	8149	8004	3000	2786	8923	7375
NSH	11086	15962	210	12574	6902	9467	3679	5967	9783	9977

Table 9.--*Mineral analysis of water collected from 10 sites on 24 July 2000. All measurements are in ug. DR = Dakota Ridge-Sanitas Valley, SC = Stockton Cabin, SVTH = Sanitas Valley Trail Head at Mapleton, LC = Long Canyon, NIST = NIST site, ABB = Abbey Pond, LP = Lindsay Pond, LBC = Lower Bear Creek, SSH = South Shanahan Pond, and NSH = North Shanahan Pond. NA = not available.*

SITE	CALCIUM		IRON		POTASSIUM		MAGNESIUM		SODIUM	
	Dissolved	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**
DR	5201	NA	35	NA	515	NA	1223	NA	3281	NA
SVTH	19621	20170	81	287	1366	1411	9004	8918	10865	21717
SC	5652	5751	10	123	1514	1588	1400	1428	3129	2716
LC	29975	29292	369	1354	2574	2613	10373	10041	21322	10608
NIST	20418	21290	32	127	1523	1569	4943	4841	6540	6475
ABB	3786	7547	753	29363	7845	12556	1212	4061	9373	8777
LP	24443	29053	79	1848	2847	3041	7925	7540	6656	7044
BC	12724	10863	9	65	2232	2172	3917	4206	3796	4209
SSH	6330	7316	1110	4692	8280	9541	2719	3261	9023	8297
NSH	8089	15253	325	30592	6801	13676	2537	7146	9946	10984

Table. 10.--*PC Analysis of mineral attributes of 10 waterholes showing highest eigenvalue for Factor 1 of which calcium loads very highly as a significant factor. Other minerals, with the exception of sulfate, tend to be inversely proportional to calcium levels.*

FACTOR	EIGENVALUE	INDIVIDUAL PERCENTAGE	CUMULATIVE PERCENTAGE
1	2.442	40.71	40.71
2	1.559	26.00	66.71
3	1.343	22.38	89.09

FACTOR LOADINGS

Variable	Factor 1	Factor 2	Factor 3
Diss. Calcium	0.7853	0.0904	-0.3167
Sulfate	0.6430	0.4877	-0.5575
Phosphate	-0.2886	0.6215	0.6475
Diss. Iron	-0.8156	0.3532	-0.3527
Diss. Potassium	-0.7050	0.3580	-0.5606
Diss. Sodium	0.4081	0.8212	0.2721

sites tested in 2000. This multivariate analysis shows that Factor 1 contains the majority of variation in the sample and the Factor Loadings indicate that calcium is one of the major distinguishing variables among sites and that other elements, with the exception of sulfate, are inversely proportional to calcium at most waterholes.

I. Diversity of Species Utilizing Waterholes.--Figure 17 shows the relationship among the nine predominant species of regional bats utilizing waterholes in City of Boulder Open Space. Data on total numbers of individuals (*n* = 1462) indicate that some waterholes are used more frequently than others (Fig. 17, NSH, SC, BC), however overall numbers of species utilizing a waterhole may be high without having high numbers of visiting bats (Fig. 17, SSH, ABB, GC). Other sites simply are not high in use or diversity. There are likely many variables involved with the "choice" of waterholes by bats, and in the next section I discuss patterns of use in relation to the variable so far measured.

SYNTHESIS

Relationship of Roost Site Locations and Calcium to Waterhole Visitation Patterns of Bats

As reported in previous years, location of roost sites and relative abundance of bats utilizing a site are significantly correlated ($r = -0.783$, $P = 0.006$). However, data gathered in 2000 utilizing radio telemetry suggest that females and juvenile will travel significant distances in order to visit specific waterholes, and even passing up apparent waterholes along the way. In particular, the Long Canyon pool, deeply imbedded in an otherwise dry drainage, was utilized by significant numbers of reproductive females and juveniles of the long-eared myotis (*Myotis evotis*) and the fringed myotis (*M. thysanodes*), both of which traveled one or miles to, bypassing several waterholes along the way, to visit this site. As shown in Fig. 16, calcium content of water and

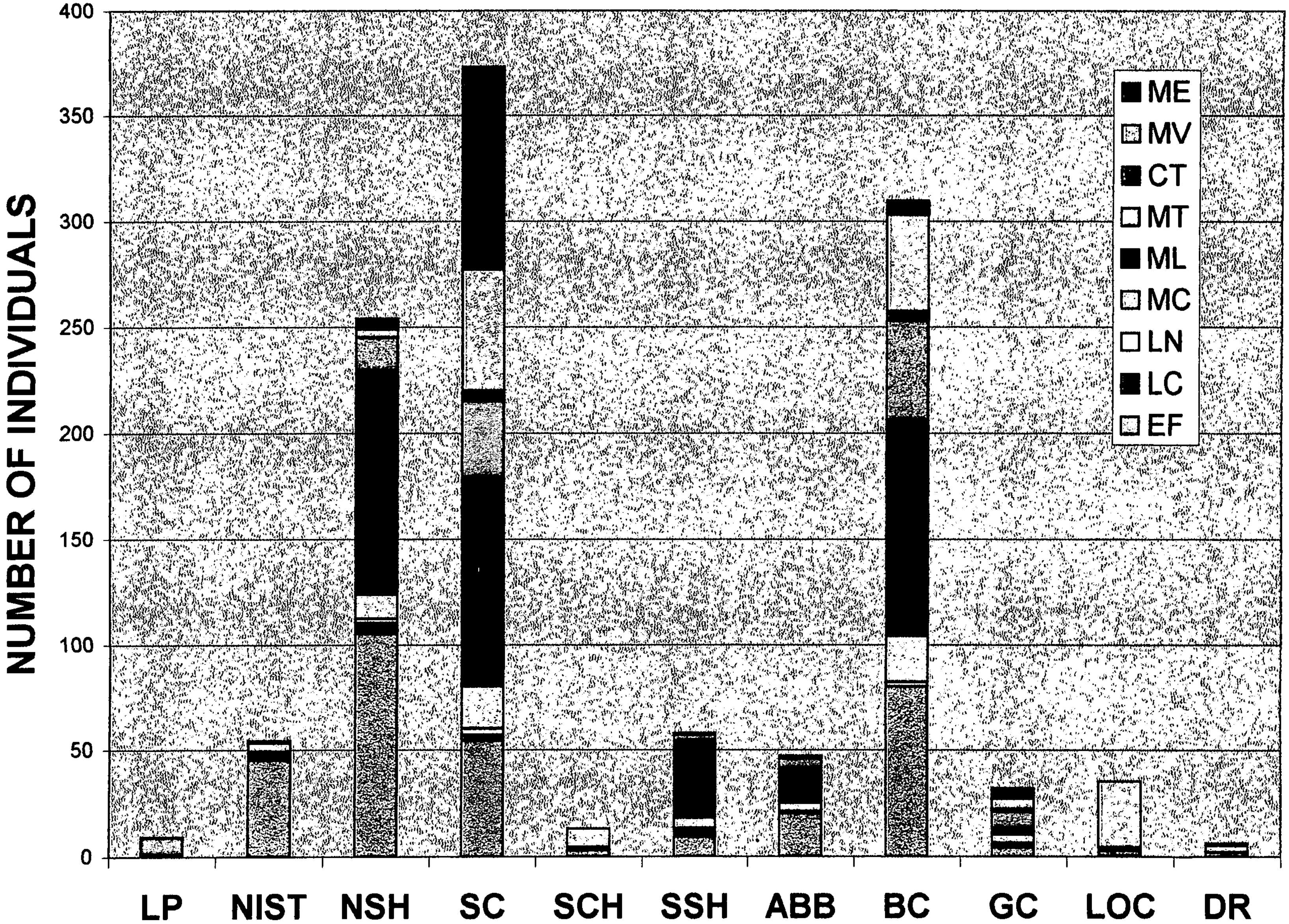

Figure 17. Stacked-bar graphs of numbers of individuals captured at various waterholes sites since 1996.

visitation by females and juveniles is significantly correlated. Curiously, Long Canyon has the highest dissolved calcium content of any of the sites tested (29 mg/l) and, apparently females and juveniles of these species are attracted to this approachability difficult site. In fact, access is so limited by the depression itself, and vegetative clutter that only these two species, which have a high-maneuverability index, can utilize this site.

This begs the question that: if reproductive females and young visit sites to help maintain body calcium, then which sites carry the highest loads and how accessible are these sites all bats in the community? In particular, how does body size affect accessibility to higher calcium sites? By categorizing sites as either closed (< 3m either in waterhole size, or in flight path diameter to the waterhole) or open (> 3 m in accessability), we can see that for the most part bats prefer to visit sites that are closed (Fig. 18). However, the patterns for females and males differ, likely in part, to the fact that females gain weight throughout the summer, and therefore experience increased wing loading which apparently makes access to closed sites too energetically expensive (Fig. 18). In fact, Table 11 shows that there are significant intraspecific differences among sites in terms of the body sizes that were captured. Therefore, for gravid females, waterholes with highest calcium levels may not be accessible until juveniles are weaned, and for juveniles, not until they develop adequate flight ability. Exceptions to this pattern are *Myotis lucifugus*, *M. ciliolabrum* (the smallest body sizes in the assemblage and, therefore, unconstrained) and *M. evotis* which is a clutter-specialist, adapted for hovering flight and gleaning insects from vegetation.

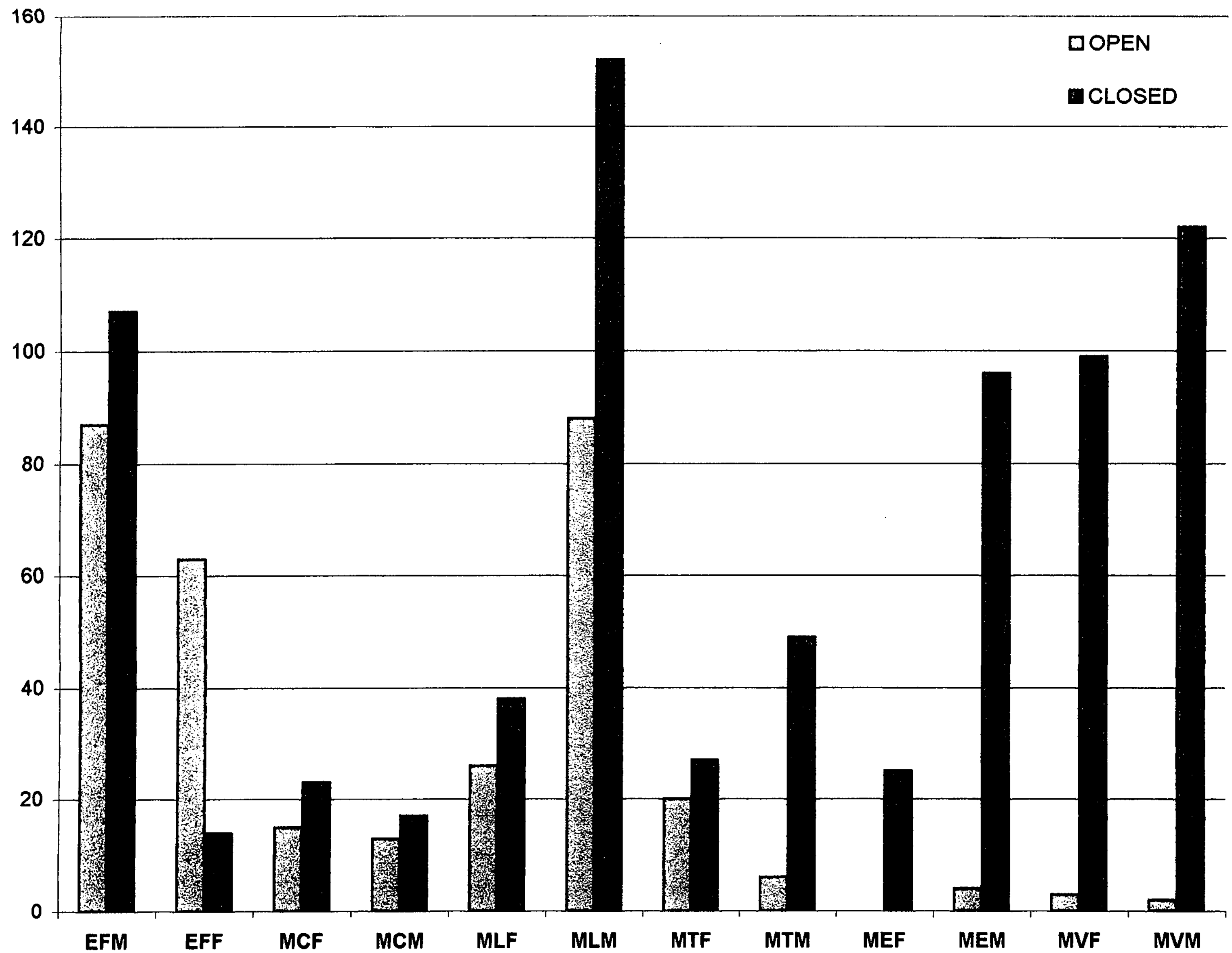

Figure 18. Bar graph of numbers of females versus males per species captured at open versus closed waterholes.

Table 11. *Results of Kruskal-Wallis One-Way Analysis on Ranks to test for significant differences associated with body wgt. differences between open and closed waterholes. H_o = all medians are equal.*

SPECIES	N	SQUARE	P	DECISION
M. ciliolabrum	71	0.749	0.386	Accept H_o
M. lucifugus	252	2.836	0.092	Accept H_o
M. thysanodes	105	43.175	0.000	Reject H_o
M. evotis	98	2.402	0.121	Accept H_o
M. volans	109	5.363	0.020	Reject H_o
E. fuscus	256	17.095	0.000	Reject H_o

Table 12 (below) illustrates that some high calcium sites are more limiting in terms of access of both some species of bats, as well as those that are most calcium deficient such as reproductive females and juveniles. The majority of sites so far examined can be classified as closed, and Fig. 18 shows clearly that bats, in general prefer closed sites. However, closed sites tend to be those containing the highest calcium loads, and therefore, for at part of the season, these sites are not available to the subgroup of bats are calcium deficient. Of course, these sites to become available to reproductive females, soon after parturition, and to juveniles that survive long enough to develop competent flight skills in cluttered habitats. Mist netting in late September at Long Canyon and Gregory Canyon (which regained water flow late in the season), produced captured of females and young only (i.e. no adult males were captured), suggesting that the calcium deficient groups continues to visit these sites late in the season, possible because of their high calcium content. It is also possible that males leave the area to locally migrate to their hibernation sites before females and, but there is currently no evidence supporting this.

Table 12. *Dissolved calcium by site relative to the 'approachability' of the site and the percentage of calcium deficient (i.e. reproductive females and juveniles) captured at these sites.*

SITE	DISSOLVED CALCIUM	TOTAL CAPTURES	% CALCIUM DEFICIENT	CLOSED/ OPEN
DR	4548 *ug*/l	7	57%	Closed
SC	5941	391	31%	Closed
GC*	28572	35	54%	Closed
LOC*	27749	35	63%	Closed
NIST*	21319	58	48%	Closed
BC*	11709	390	39%	Closed
LP*	25298	30	100%	Open
ABB	5426	45	49%	Open
SSH	6259	61	64%	Open
NSH*	11086	291	39%	Open

IMMEDIATE CONSERVATION NEEDS

Mallory Cave: I am strongly recommending the seasonal closure of Mallory Cave from April through October. This site was found to contain a maternity colony of Townsend's big-eared bat, *Corynorhinus townsendii*, a species considered imperiled and in need of immediate conservation efforts by the Colorado Natural Heritage Program (CNHP), The Colorado Bat Society (CBS), North American Bat Conservation Partnership (NABCP) and the Western Bat Working Groups (WBWG). It is highly concerning that in five years not a single juvenile of this species has been captured although there are at least two maternity colonies in the area (Mallory/Harmon cave, and the Eldorado Mtn. Colony of unknown location). **There are only seven known maternity colonies of this species in the state** (Navo, CDOW, pers. comm.).

Furthermore, it is important that the closure area be large enough to buffer the cave from noise disturbance and to allow for a monitoring buffer for rangers. I would strongly recommend that the closure begin at the base of the rock-face leading up to the cave, and a sign be posted as to the reasons and fines for breaching the buffer zone.

In 1995, I documented several bat species that use Mallory Cave as a night roost. From my temperature data from Harmon Cave, it appears that this site may be too hot at some points of the season for use by *C. townsendii*, whereas Mallory Cave, being much more open, with greater airflow, would predictably maintain a lower and more constant temperature (a temperature data logger placed in Mallory Cave was stolen this year). **Although this year provides the strongest evidence yet that a nursery colony of *C. townsendii* is attempting to use the site, and resulted in the implementation of a voluntary-closure, much more protection is required beginning in 2001, the fact that the temperature data logger that was placed in proximity of the colony was stolen after the voluntary closure underscores the need for mandatory protection.** Mallory Cave is one of the very few sites locally, and perhaps in the state, that provides the physiographic parameters known to be important to this species. *Corynorhinus townsendii* is known to inhabit cooler roosting sites (Lacki et al, 1994) and **they require large, spacious roosts (> 30m usually) for setting up maternity roosts** (Pierson et al., 1991) and Mallory, unlike Harmon, provides such a roost site. **These behaviors, unlike any other bat species in the state, makes this species highly vulnerable to lack of appropriate roost sites in an area and opens them up to human and other types of disturbances.** The important and expensive grating of Harmon Cave in 1998 by the City of Boulder was a great step in preservation of one of this species' roost sites. This great effort (both monetary and physical) by the city to protect this site from disturbance will only be overshadowed by ignoring another site that is being used either by members of the Harmon Cave colony (most likely) or perhaps a separate colony of this imperiled species. The open-cavern atmosphere of Mallory Cave provides perfect roost site physiography for this species. Because of the lack of 'true' caves in the area, Mallory Cave is one of the few sites that provides a large natural open, but protected, area for members of this species to establish a maternity colony. In fact, if not impacted by humans such as it is today, this site would perhaps house one of the largest colonies of this species in the area. It should be noted that the popularity of this area is understood, but I feel that the majority of the public will support a closure to protect sensitive wildlife, as they have for the species of falcons in the area. **In fact there were two articles in Daily Camera this summer featuring both Townsend's Big-eared bat and the Mallory Cave conservation effort, in efforts to educate the public and prepare them for a seasonal closure this coming year.**

The Second Flat Iron: In 2000, we located a maternity colony of the fringed myotis (*Myotis thysanodes*) on the Second Flat Iron. This species is considered imperiled by the CNHP, CBS, NABCP, and WBWG. I am suggesting a seasonal closure on the route nearest this roost site to avoid human disturbance (either direct or via high levels of noise), to this colony. Thus far we have documented only three maternity roosts for this species in the area, and one of these was apparently a small temporary rock-crevice site in Gregory Canyon and was recently apparently made unavailable to bats due to a tree falling over the site. If future research locates more roost sites for this species that are not being influenced by humans, we may consider removing the seasonal closure on the Second Flat Iron. However, at the moment protection of this site is prudent as a conservation measure for this imperiled species.

FUTURE RESEARCH: Several tasks await the 2001 season. I have submitted a proposal for funding outlining a 2001 research program, and in an effort to save trees and your time I will direct you to that document.

ACKNOWLEDGMENTS

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