
Bat Inventory of Grand Staircase-Escalante National Monument Using Mist Nets and Radio-telemetry.

Melissa S. Siders, Grand Staircase-Escalante National Monument

190 E. Center Street, Kanab, UT 84741

Abstract

Bats utilizing water sources within a variety of habitats were surveyed at 9 sites within or adjacent to Grand Staircase-Escalante National Monument in southern Utah over two field seasons (2003 and 2004). A total of 306 bats of 14 species were captured. Three of these are classified as sensitive species by Utah Division of Wildlife Resources. *Pipistrellus hesperus* was the most abundant bat species captured in 2003. *Antrozous pallidus* was the most abundant bat species captures in 2004. Radio transmitters were attached to seven bats of four species. Roost sites were found for *Idionycteris phyllotis*, *Corynorhinus townsendii*, and *Myotis lucifugus*.

Introduction

There are 986 species of bats in the world, inhabiting every continent except Antarctica. Of the 44 species of bats known to occur in North America, 18 have been reported in Utah (Oliver 2000). Rodents are the only order of mammals that exceed bats in number of species (Tidemann and Woodside, 1978); and yet much about bats remains poorly understood. Though general awareness and knowledge of bats has increased in recent years, more about the biology and ecology of bats needs to be determined if the management of bats is to be successful. Currently no species of bats have been classified as threatened or endangered in Utah; however, six species have been listed as sensitive due to declining populations and/or limited distribution (UDWR 2004).

Bats use a variety of habitat types for roosting and foraging, with certain species preferring specific habitats and roost sites (Table 1). Roost sites used by bats include caves, mines, rock crevices, trees, lava tubes, and man-made structures such as barns and eaves of buildings. At one time bat research was limited to the study of cave-dwelling bats or bats inhabiting roosts easily accessible to researchers (Tidemann and Woodside, 1978). With the advent of mist nets and traps, it became possible to capture bats away from roost sites, usually over open water or along foraging flyways. However, mist netting and other methods for bat capture are likely biased toward particular species and individuals within a species. Furthermore, a given location may not be used every night by the same species assemblage (O'Farrell, 1996).

Project Objectives

The primary objectives of this project were:

- 1) Capture bats at a various locations within or adjacent to Grand Staircase-Escalante National Monument.
- 2) Attached small radio transmitters to target species of suitable weight and health. Target species included Utah State Sensitive species (See Table 1). Little brown bats (*Myotis lucifugus* or *occultus*) were also targeted to assist in a USGS study.
- 3) Track radio tagged individuals to roost site locations and describe the roosting habitat.

This report describes the methods used to capture bats for this study and radio telemetry techniques to location roost sites during 2003 and 2004.

Acknowledgments

We wish to thank the following people for their contributions of time, energy, and humor: Wesely Jolly, Sue Goheen, Andy Goheen, Savannah Davenport, Terry Tolbert, Bill Falvey, Aaron Sinton, David Sinton, Mike O'Farrell, Chris Corbin, Carol Chambers, Ernie Valdez and friend. Funding for this project was provided by the Bureau of Land Management (BLM).

Methods

Trapping

Standard mist-netting techniques were used to capture bats at open water sources, including ponds, small creeks, wildlife catchments, springs, stock ponds, troughs, and stock tanks (Francis 1989, Thomas and West. 1989). Nets were typically stretched across open water, perpendicular to suspected bat flyways and also to the wind if possible. Whenever possible vegetation, rocky outcrops, or other natural features were utilized as cover for net sets to impede detection by bats, particularly on full moon nights. Mist-netting occurred from mid-June to early August in 2003 (six sessions) and late-May to mid-July in 2004 (9 sessions). Insect hoop nets were used to capture bats at a residential site in mid-June in 2004 (See Appendix B).

Whenever possible, mist-netting equipment was assembled 30 minutes before sunset. Usually the nets or traps would be opened between 20:15 hours and 21:00 hours and would typically remain open for a minimum of three hours, but usually would run until at least 01:00 hrs. Capture activities would be stopped if an hour lapsed without capturing a bat or in the event of inclement weather such as severe wind or rain. Nets and traps were periodically monitored for bats; however it was important to remain away from the trapping locations as much as possible to avoid discouraging bat activity. Captured bats were placed in mesh or fleece bags for processing. Processing included recording the time of capture, species, gender, reproductive status, ear length, tragus length, forearm length, and weight.

Fecal samples were collected from all little brown bats (*Myotis lucifugus* or *occultus*) by placing them in small zip-lock bags; closed only partially; and held for approx 10 minutes. Bags were labeled with capture information as recorded on the data sheet. These samples were given to Dr. Ernie Valdez, USGS BRD, for further genetic analysis to assist in the determination of species ranges for *Myotis lucifugus* and *M. occultus*.

Radio Telemetry

Radio transmitters (Holohil Systems Ltd., Model BD-2)¹ were attached to bats (priority given to lactating females) deemed healthy (by body weight²) and able to carry the extra weight of the transmitter (Table 2). Then each bat was released. Bats were followed while foraging and then to roost locations. Bats were tracked until the transmitter battery failed (about 10-14 days) or until the transmitter fell off.

Two methods of radio-tracking were used to find bat locations: ground tracking in vehicles and on foot (at fixed points and moving). A more detailed tracking technique was used to track Townsend's big-eared bat foraging movements (see Appendix B, pg 2). Once roost sites were located, evening exit counts were conducted to try to pin-point the roost location and the attempt to determine the size of the roost. Whenever possible, infra-red night vision goggles were used to aid in locating and counting bats during exit counts.

Results

Trapping

A total of 14 bat species were captured during the course of the study. Individuals from three of the six species listed as sensitive by the Utah DWR were captured: *Corynorhinus townsendii*, *Idionycteris phyllotis*, and *Tadarida brasiliensis*. Bat species known to occur in Utah that were not captured or detected during the study were *Euderma maculatum*, *Lasiurus blossevilli*, *Lasiurus cinereus*, and *Nyctinomops macrotis*. As with previous work in the area, *Eumops perotis* was also not detected using mist netting techniques (Jackson and Herder 1997).

Trapping effort in 2003 captured 133 individuals from 9 species (Table 3), and 173 individuals from 14 species in 2004 (Table 4). Over the two seasons, a total of 306 bats were captured from 9 different locations in three habitats throughout the south eastern portion of the Monument, and one residential location in the town of Kanab, UT (Fig. 1-3; Appendix A). Fourteen different species were captured, including *Antrozous pallidus*, *Corynorhinus townsendii*, *Eptesicus fuscus*, *Idionycteris phyllotis*, *Lasionycteris noctivagans*, *Myotis californicus*, *M. ciliolabrum*, *M. evotis*, *M. occultis (lucifugis)*, *M. thysanodes*, *M. volans*, *M. yumanensis*, *Pipistrellus hesperus*, and *Tadarida brasiliensis*. A total of 52.0 hrs netting and trapping hours were expended during the 2003 and 2004 field seasons.

Appendix A provides a summary of the number of bats captured at each site by species. Information regarding each site's location, elevation, and habitat type is also provided.

Radio Telemetry Results

Radio transmitters were attached to 7 bats during the 2004 season (Table 5).

Corynorhinus townsendii

A single male Townsend's big-eared bat was captured at a night roost location in the town of Kanab Utah on June 15, 2004 using an insect hoop net. A radio transmitter was attached and the animal was released. Three general night-roosting locations were determined for the tagged male over six nights (15-20 June 2004). All three roosts were in the same general location,

¹ Weights of transmitters were: 0.41 g for *Idionycteris phyllotis* and *Corynorhinus townsendii*; 0.35 g for *Myotis sp.*

² Transmitter weight was less than 5% of animals body weight. Minimum weight for the 0.41g transmitter was 8.2 g; minimum weight for the 0.35g transmitter was 7.0g.

approximately 2.1 to 2.9 km from the capture (night-roost) location. Roost sites appeared to be high on rocky cliffs, and the male seemed to move roosts every day or two. Roost sites were difficult to pinpoint due to the inaccessibility of the sites, and at times radio transmitter bounce. This portion of the study received additional acoustic and foraging monitoring and analysis. See Appendix B for more details.

Idionycterus phyllotis

Three adult female Allen's lappet-browed bats were captured over water and fitted with radio transmitters from one location in early July 2004 (Table 5). It should be noted that captures of Allen's lappet-browed bats in this area are at the far northern reach of its range, if not outside of the current range map for the species (BCI 2002). All three females were located in the same day-roost cliff, but three separate cracks (Photos 1, 1A, 1B, 1C). An exit count was conducted on 16 July using infra-red night vision goggles and two observers. At least 15 individuals were counted and audible echolocation calls detected exiting the roost sites. The roost cliff was a large northwest-facing cliff, located in the eastern side of a small side box canyon. Pinyon-juniper habitat was found in the canyon bottoms and ridge tops. The drainage bottom appeared to be mature to old-growth woodland habitat. Cliffs were tall, highly fractured, vertical cliffs, with a large talus slope at the base. Roosts were generally in the top 1/3 to 1/2 of the cliff face. Roost sites were approximately 4.8 km from the capture site.

Myotis thysanodes

One adult female fringed myotis was captured over water and fitted with a radio transmitter (Table 5). After being released from the capture site, the bat was tracked for a few minutes, then the signal was lost. No additional locations were detected for this bat during the remainder of the study. No roost location was found.

Myotis lucifuguslocultis

Two adult little brown bats (one male; one female) were captured over water and fitted with radio transmitters (Table 5). Roost sites were found for both individuals (Photos 2-4). Exit counts were conducted on the little brown bat female on 10 July (Wes Jolley) and 14 July (Ernie Valdez). Both times 5-6 bats were seen exiting the roost. No exit count was conducted on the male roost due to the inaccessibility of the roost. The female roost was located on a southfacing cliff at the confluence of two drainages. The male roost cliff was located in the main canyon on a west-facing cliff. Both roost sites were surrounded by pinyon-juniper woodland habitat. Roost site to capture site distances were 2.8 km (female) and 4.2 km (male).

Discussion

The most abundant species of bats captured during the 2003 and 2004 field seasons were *Antrozous pallidus*, *Myotis evotis*, and *Pipistrellus hesperus*.

While limited time was available for bat capture and radio tracking during the 2004 field season, we captured and documented very interesting species for the area. Allen's lappet-browed bats were captured and a fairly large maternity roosts found outside of the current range map for the species. Townsend's big-eared bats were documented using a garage as a spring-time night roost; foraging activity in an "urban" setting; and roost sites located. Little brown bats roosts were located, and data collected to help Dr. Ernie Valdez in clarifying the ranges of *Myotis lucifugus* and

Myotis occultis in the four-corners area. All three of these aspects are important beginnings for bat research on the Monument.

Additional netting and radio telemetry should be conducted at additional locations within the Monument. A review of past (UDWR and others) mist-netting and acoustic efforts should help to pinpoint important locations for further work. Acoustic detections of *Eumops perotis* by Jackson and Herder (1997) on the Monument, and the verification of foraging on the Kaibab Plateau and roost sites in the Grand Canyon to the south had already resulted in a range expansion of the species (Castner et al. 1996, Siders and Steffensen 1998). Netting at larger water sources, and additional acoustic monitoring may help to verify this species on the Monument.

Additional work is needed on the night roosting of *Corynorhinus townsendii*; roosting and foraging habitat for *Idionycteris phyllotis* at the northern extent of their range; and coordination with Dr. Ernie Valdez on the identification of little brown bats in the area.

Literature Cited

- BCI. 2002. Bat Species: U.S. Bats: *Idionycteris phyllotis*. Available: <http://batcon.org/discover/species/iphyllo.html>.
- Castner, S.V., T.K. Snow, D.C. Noel, M.J. Rabe, M.S. Siders, D. Garcia de la Cadena. 1996. Redefining the range of the greater western mastiff bat in Arizona. *Bat Research News* 37(1): 23.
- Francis, C. M. 1989. A comparison of mist nets and two designs of harp traps for capturing bats. *J. Mamm.* 70(4):865-870.
- Jackson, J.G. and M.J. Herder. 1997. Baseline bat inventory of southern Utah using nets and ultrasonic detectors. Utah Division of Wildlife Resources Publication No. 97-10, Utah Division of Wildlife Resources, Cedar City, UT.
- Kunz, T.H. and A. Kurta, 1988. Capture methods and holding devices. *In* Ecological and behavioral methods for the study of bats. T.H. Kunz (editor). Smithsonian Institution Press, Washington D.C., pp. 1-29.
- O'Farrell, M.J. 1996. Development of vocal signatures as a method for accurate identification of free-flying bats in northern Arizona. Arizona Game and Fish Department Heritage Report I94005. Unpublished. 25 pp.
- Oliver, G.V. 2000. The Bats of Utah: a literature Review. Utah Division of Wildlife Resources Publication Number 00-14. Utah Division of Wildlife Resources, Salt Lake City, UT.
- Siders, M.S., Rabe, M. J., T. K. Snow and K. Yasuda. 1999. Long foraging distance for two uncommon bat species (*Euderma maculatum* and *Eumops perotis*) in northern Arizona. Proceedings of 4th Biennial Conference of Research on the Colorado Plateau.
- Simmons, J.A., D.J. Howell, and N. Sugo. 1975. Information content of bat sonar echoes. *Journal of Comparative Physiology*. pp. 204-215.
- Thomas, D.W. and S.D. West. 1989. Sampling methods for bats. U.S. Forest Service PNW-GTR-243. 21 pp.
- Tidemann, C.R. and D.P. Woodside. 1978. A collapsible bat-trap and a comparison of results obtained with the trap and with mist-nets. *Australian Wildlife Research* 5:355-362.
- UDWR. 2004. The Utah state sensitive species list. Utah Division of Wildlife Resources Salt Lake City Office. Available: <http://dwrcdc.nr.utah.gov/ucdc/ViewReports/SSL092204.pdf>

Tables

Table 1. Bat Species Known or Suspected to Occur in Utah With Habitat and Roosting Preferences.

<i>Scientific Name</i>	<i>Common Name</i>	<i>Sensitive Status</i>	<i>Habitat</i> ³	<i>Preferred Roosting Area</i> ⁴
<i>Antrozous pallidus</i>	Pallid Bat		DESH, GRAS, PIJU, RIPA	R, C/M, B, F
<i>Corynorhinus townsendii</i>	Townsend's Big-eared Bat	X	DESH, GRAS, PIJU, RIPA, MXCO	C/M, B
<i>Eptesicus fuscus</i>	Big Brown Bat		DESH, GRAS, PIJU, RIPA, MXCO	C/M, B, R, F
<i>Euderma maculatum</i>	Spotted Bat	X	DESH, GRAS, RIPA, MXCO	R, C/M
<i>Eumops perotis</i> *	Greater Western Mastiff		DESH, GRAS, RIPA	R, B
<i>Idionycteris phyllotis</i>	Allen's Lappet Browed Bat	X	DESH, GRAS, PIJU, RIPA, MXCO	F, R, C/M
<i>Lasionycteris noctivagans</i>	Silver-haired Bat		PIJU, RIPA, MXCO	F, R, C/M, B
<i>Lasiurus blossevilli</i>	Western Red Bat	X	PIJU, RIPA, MXCO	F
<i>Lasiurus cinereus</i>	Hoary Bat		PIJU, RIPA, MXCO	F
<i>Myotis californicus</i>	California Myotis		DESH, GRAS, PIJU, RIPA	C/M, B, R, F
<i>Myotis ciliolabrum</i>	Small-footed Myotis		GRAS, PIJU, MXCO, RIPA	C/M, B, R, F
<i>Myotis evotis</i>	Long-eared Myotis		PIJU, MXCO, RIPA	F, R, C/M
<i>Myotis lucifugus</i> [†]	Little Brown Bat		MXCO, RIPA	F, R, B, C/M
<i>Myotis thysanodes</i>	Fringed Myotis		DESH, GRAS, PIJU, RIPA, MXCO	C/M, B
<i>Myotis volans</i>	Long-legged Myotis		PIJU, MXCO, RIPA	F, R, B, C/M
<i>Myotis yumanensis</i>	Yuma Myotis		DESH, GRAS, PIJU, RIPA	B, C/M, R
<i>Nyctinomops macrotis</i>	Big Free-tailed Bat	X	DESH, GRAS, PIJU, RIPA, MXCO	C/M, R, B
<i>Pipistrellus hesperus</i>	Western Pipistrelle		DESH, GRAS, PIJU, RIPA	R, C/M, B
<i>Tadarida brasiliensis</i>	Mexican Free-tailed Bat	X	DESH, GRAS, PIJU, RIPA, MXCO	C/M, B, F

* This species has not previously been reported in the State of Utah

[†] This species may be *Myotis lucifugus* or *Myotis occultis*

³ Habitat Codes: DESH - desert shrub; GRAS – grassland; PIJU - pinyon-juniper; RIPA - riparian (cottonwood, willow); MXCO - mixed conifer (ponderosa pine, Gambel oak)

⁴ Roosting Codes: R - rocks (crevices, cliff faces, and ground rocks); B - building or other manmade structures; F - forest trees or snags (foliage, cavity, and under bark roosts); C/M - Cave and/or mines

Table 2. Average bat weights and minimum bat weights for radio transmitter attachment for this study.

Species	Bat Weight (g) ⁵			Radio Transmitter Weight (g)	Minimum Bat Weight (g)
	Minimum	Maximum	Average		
<i>Idionycteris phyllotis</i>	8	16		0.41	8.2
<i>Corynorhinus townsendii</i>	9	12		0.41	8.2
<i>Myotis thysanodes</i>	6	11.8	8.8	0.35	7.0
<i>Myotis lucifugus</i>	7	13	10	0.35	7.0

Table 3. Trapping results from 2003 trapping efforts (23.1 trapping hrs) on Grand Staircase-Escalante National Monument in Southern Utah.

Species	Habitat Type			TOTAL
	DESH	JUNI	S-AMX	
<i>Antrozous pallidus</i>	8	9	2	19
<i>Eptesicus fuscus</i>		13		13
<i>Myotis ciliolabrum</i>		3		3
<i>Myotis evotis</i>		4		4
<i>Myotis occultis</i>		24		24
<i>Myotis sp.</i>	3	4		7
<i>Myotis thysanodes</i>	1	5		6
<i>Myotis volans</i>		12		12
<i>Myotis yumanensis</i>	5	2	1	8
<i>Pipistrellus hesperus</i>	36	1		37
TOTAL	53	77	3	133

⁵ Wilson, D.E. and S. Ruff. 1999. Pgs. 95, 100, 123 and 125 in *The Smithsonian Book of North American Mammals*. Smithsonian Institution Press, Washington DC.

Table 4. Trapping results from 2004 trapping efforts (28.9 trapping hrs) on Grand Staircase-Escalante National Monument in Southern Utah.

Species	Habitat Type			TOTAL
	<i>JUNI</i>	<i>RESI</i>	<i>S-AMX</i>	
Antrozous pallidus	44		11	55
Corynorhinus townsendii		1		1
Eptesicus fuscus	13		5	18
Idionycteris phyllotis			3	3
Lasionycteris noctivagans	1		7	8
Myotis californicus			1	1
Myotis ciliolabrum	1		5	6
Myotis evotis	12		33	45
Myotis occultus	2		4	6
Myotis thysanodes	1		1	2
Myotis volans	3		8	11
Myotis yumanesis	2		9	11
Pipistrellus Hesperus	2		2	4
Tadarida brasiliensis			1	1
Unknown			1	1
TOTAL	81	1	91	173

Table 5. Bats fitted with radio transmitters in Kane County, Utah from 15 June through 13 July in 2004.

<i>Date of Activity</i>	<i>Specific Location</i>		<i>Elevation</i> (m)	<i>Common Name</i>	<i>Scientific Name</i>	<i>No. of Animals</i>	<i>Age</i>	<i>Sex</i>	<i>Breeding Condition</i>	<i>Day Roost Fount</i>	<i>Activity at Capture</i>	<i>Habitat Index</i>	<i>Disposition of Specimen</i>
6/15/2004	364904	4100467	1504	Townsend's Big-eared Bat	<i>Corynorhinus townsendii</i>	1	Adult	Male	No	Yes ^a	Perched/Sitting	RESI	Released ^b
6/28/2004	374793	4124563	1905	Occult Little Brown Bat	<i>Myotis occultus</i>	1	Adult	Male	No	Yes ^c	Flying	SAMX	Released ^d
7/1/2004	374793	4124563	1905	Allen's Big-eared Bat	<i>Idionycterus phyllotis</i>	1	Adult	Female	Yes	Yes ^e	Flying	SAMX	Released ^f
7/1/2004	374793	4124563	1905	Occult Little Brown Bat	<i>Myotis occultus</i>	1	Adult	Female	Yes	Yes ^g	Flying	SAMX	Released ^h
7/12/2004	378600	4117040	1704	Fringed Myotis	<i>Myotis thysanodes</i>	1	Adult	Female	Yes	No	Flying	JUNI	Released ⁱ
7/13/2004	374793	4124563	1905	Allen's Lappet-browed Bat	<i>Idionycterus phyllotis</i>	1	Adult	Female	No	Yes ^j	Flying	SAMX	Released ^k
7/13/2004	374793	4124563	1905	Allen's Lappet-browed Bat	<i>Idionycterus phyllotis</i>	1	Adult	Female	Yes	Yes ^l	Flying	SAMX	Released ^m

^a Approx. day-roost locations 367040E 4100705N and 367919E 4100822N

^b Radio tagged, Holohil LB-2N (0.41g), 150.659, Serial No. 86782; Captured at night-roost location

^c Approx. day-roost location 376050 E 4120500N

^d Radio tagged, Holohil LB-2N (0.35g), 150.842, Serial No. 86569

^e Approx. day-roost location (All three IDPH) 376544 E 4120286 N

^f Radio tagged, Holohil LB-2N (0.41g), 150.700 kHz, Serial No. 86783

^g Approx. day-roost location 375600E 4121980 N

^h Radio tagged, Holohil LB-2N (0.35g), 150.861 kHz, Serial No. 84570

ⁱ Radio tagged, Holohil LB-2N (0.35g), 150.890 kHz, Serial No. 84571

^j Radio tagged, Holohil LB-2N (0.41g), 150.741 kHz, Serial No. 86784

^k Radio tagged, Holohil LB-2N (0.41g), 150.741 kHz, Serial No. 86784

^l Radio tagged, Holohil LB-2N (0.41g), 150.781 kHz, Serial No. 86785

^m Radio tagged, Holohil LB-2N (0.41g), 150.781 kHz, Serial No. 86785

Figures

Fig. 1. Bat captures for 2003 field season for the Grand Staircase-Escalante National Monument, by Species and Habitat. 9 total species detected; 133 individuals captured.

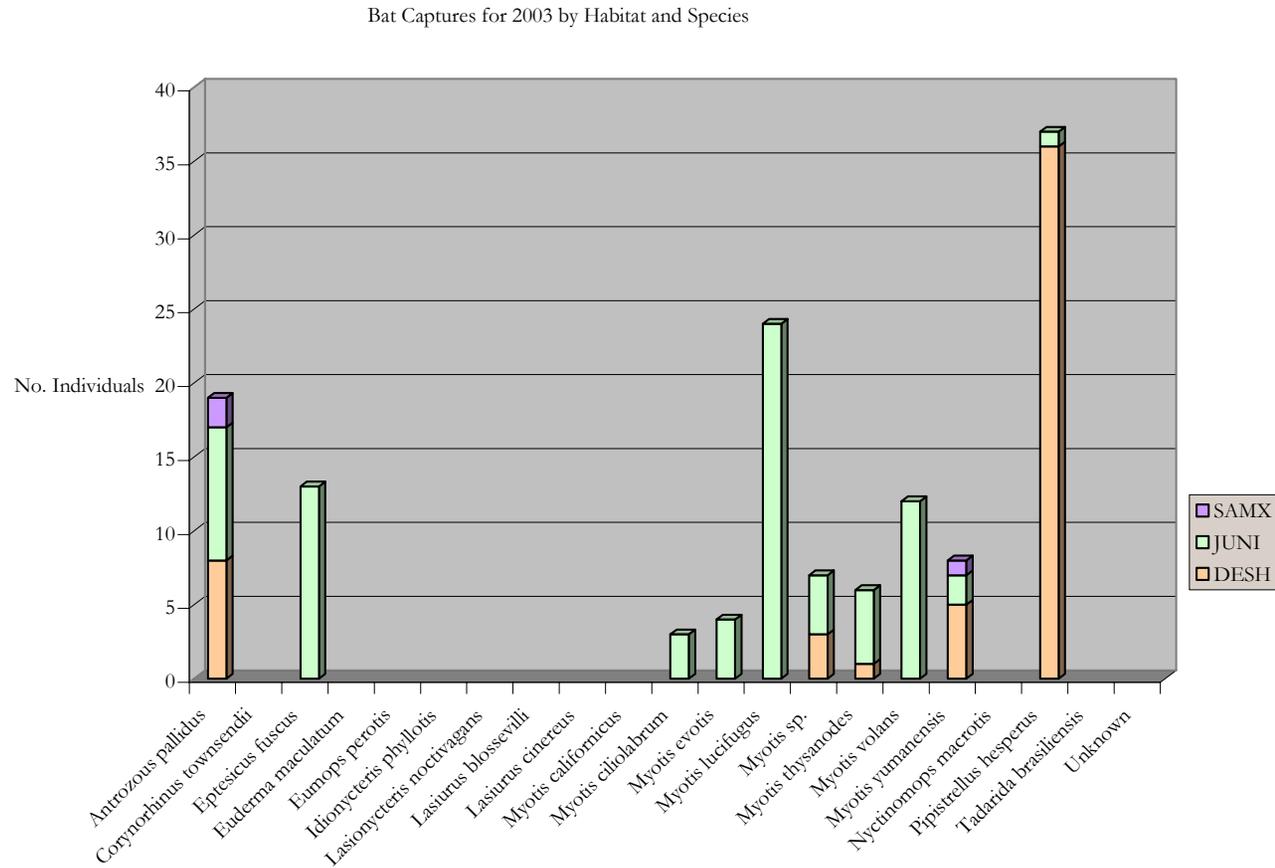


Fig. 2. Bat captures for 2004 field season for the Grand Staircase-Escalante National Monument, by Species and Habitat. 14 total species detected; 173 individuals captured.

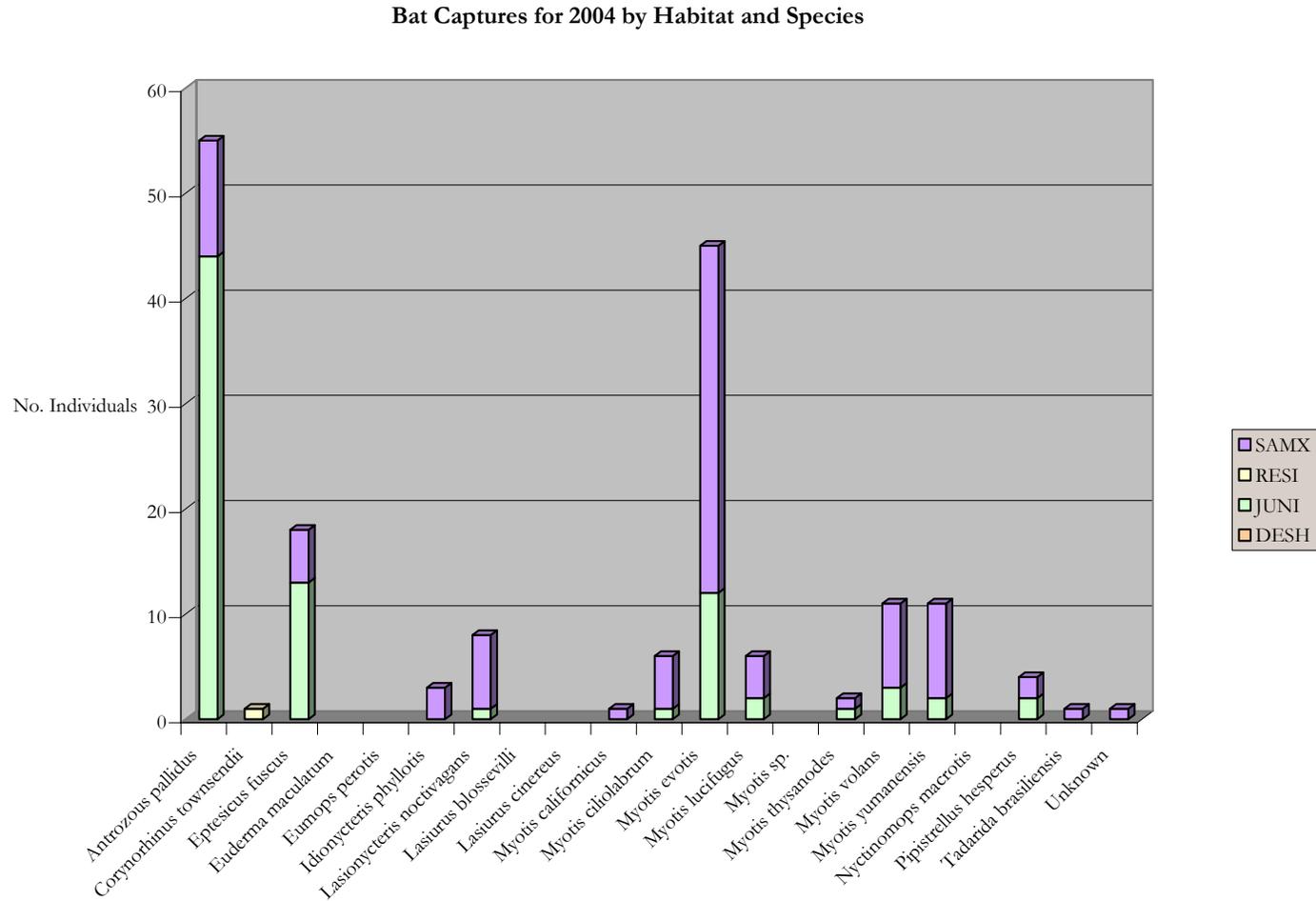
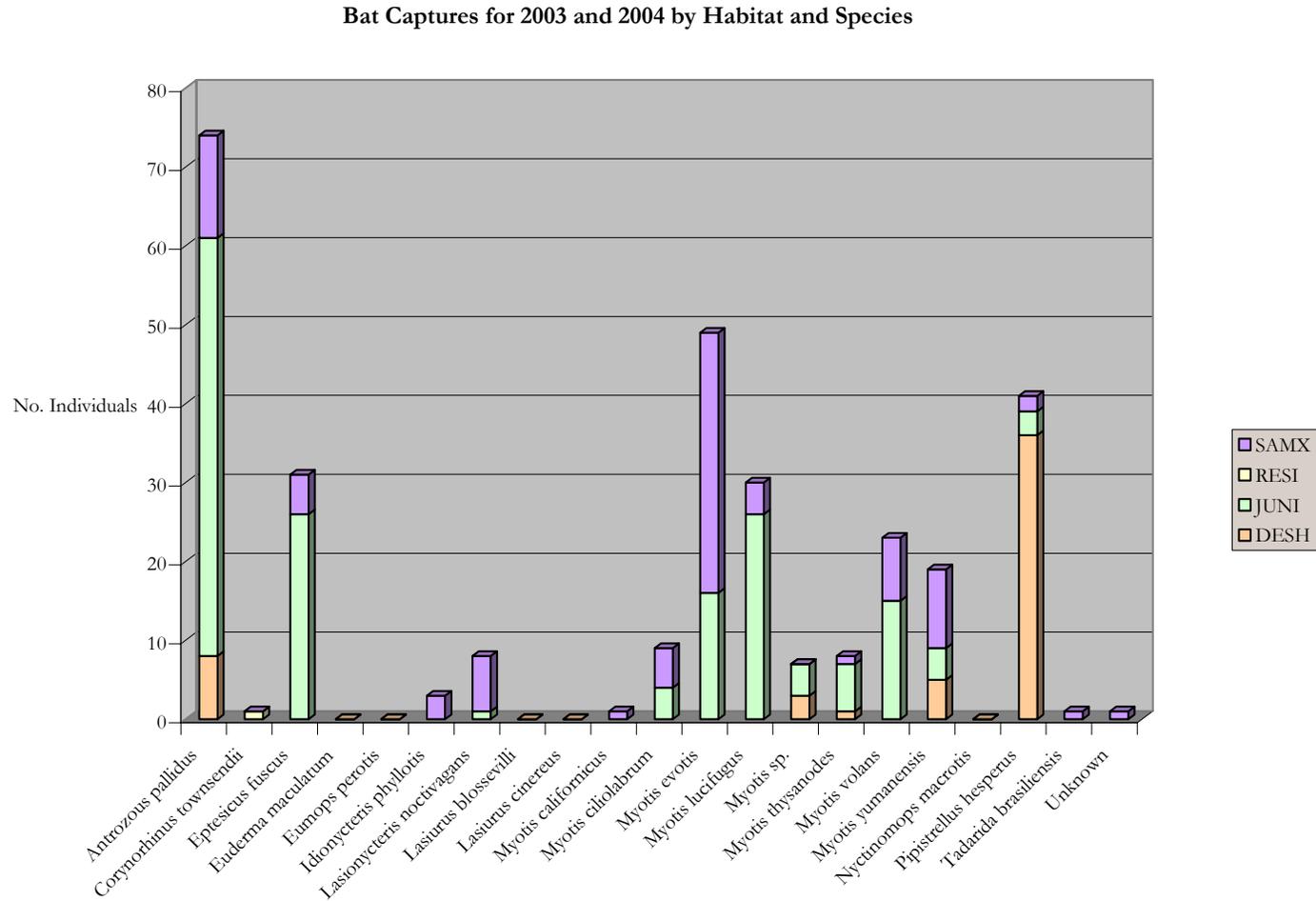


Fig. 3. Bat captures for both 2003 and 2004 field season for the Grand Staircase-Escalante National Monument, by Species and Habitat. 14 total species detected; 306 individuals captured.



Photos

Photo 1. Allen's Lappet-brow bat roost cliff, Swapp Canyon, Kane County, Utah. Taken from 376511E 4120286 N.



Photo 1A. Allen's Lappet-brow bat roost for bat 150.700, Swapp Canyon, Kane County, Utah. Taken from 376511E 4120286 N. Roost was 29 degrees from location.



Photo 1B. Allen's Lappet-brow bat roost for bat 150.781, Swapp Canyon, Kane County, Utah. Taken from 376511E 4120286 N. Roost was 101 degrees from location.



Photo 1C. Allen's Lappet-brow bat roost for bat 150.741, Swapp Canyon, Kane County, Utah. Taken from 376511E 4120286 N. Roost was 59 degrees from location.



Photo 2. Roost site for male Little Brown Bat (376050E 4120500N). Swapp Canyon, Kane County, Utah



Photo 3. Closer view of roost site for male little brown bat. Swapp canyon, Kane County, Utah

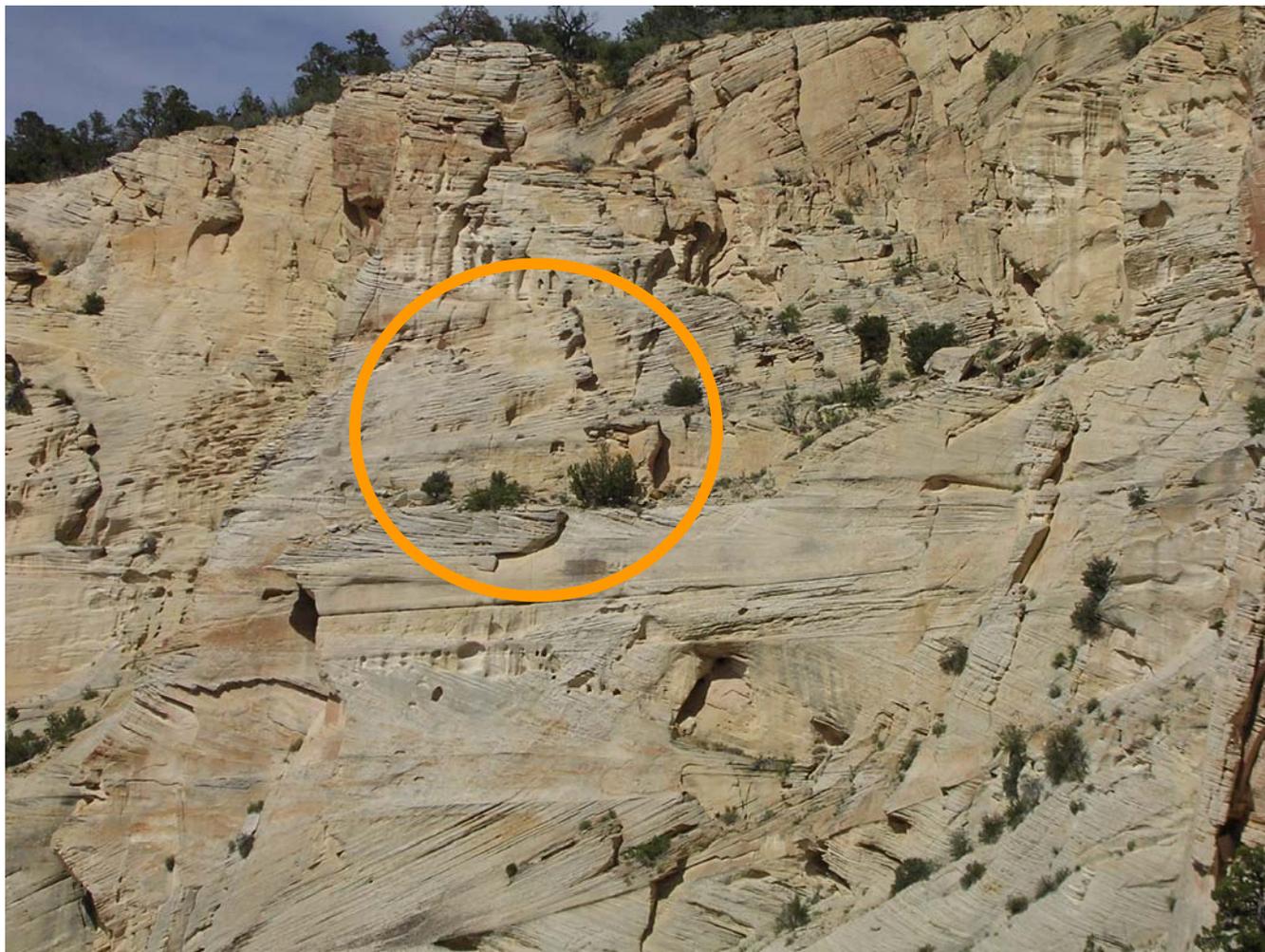


Photo 4. Female Little Brown Bat roost site (375600 E, 4121980 N), Swapp Canyon, Kane County Utah.



Appendix A.

Locations of Bat Capture Sites With Habitat Types and Bat Species Captured on the Grand Staircase-Escalante National Monument in 2003 and 2004 Field Seasons.

2003 Field Season																	
Elev (m)	Habitat	Location	UTM E	UTM N	Common Name	Scientific Name	Date	Sex	Age	Reproductive Status							
1941	Pinyon-juniper	Pink Cove	385690	4115500	Fringed Myotis	<i>Myotis thysanodes</i>	6/26/2003	Female	Adult	Lactating							
							6/26/2003	Male	Adult	Non-scrotal							
							6/26/2003	Male	Adult	Non-scrotal							
							6/26/2003	Male	Adult	Non-scrotal							
							6/26/2003	Male	Adult	Non-scrotal							
							6/26/2003	Male	Adult	Non-scrotal							
					Occult Little Brown Bat	<i>Myotis occultus</i>	6/26/2003	Female	Adult	Lactating							
							6/26/2003	Female	Adult	Lactating							
							6/26/2003	Female	Adult	Non-reproductive							
							6/26/2003	Female	Adult	Pregnant							
							6/26/2003	Male	Adult	Non-scrotal							
							1704	Pinyon-juniper	Montezuma Tank	378600	4117040	Big Brown Bat	<i>Eptesicus fuscus</i>	6/25/2003	Female	Adult	Lactating
														6/25/2003	Female	Adult	Lactating
														6/25/2003	Female	Adult	Lactating
6/25/2003	Female	Adult	Lactating														
6/25/2003	Female	Adult	Lactating														
6/25/2003	Female	Adult	Lactating														
6/25/2003	Female	Adult	Lactating														
6/25/2003	Female	Adult	Lactating														
6/25/2003	Female	Adult	Unknown														
6/25/2003	Male	Adult	Scrotal														
6/25/2003	Male	Adult	Unknown														
6/25/2003	Unknown	Unknown	Unknown														
Long-eared Myotis	<i>Myotis evotis</i>	6/25/2003	Female	Adult	Lactating												
		6/25/2003	Female	Adult	Pregnant												
		6/25/2003	Male	Adult	Unknown												
		6/25/2003	Male	Adult	Unknown												
Long-legged Myotis	<i>Myotis volans</i>	6/25/2003	Female	Adult	Lactating												
		6/25/2003	Female	Adult	Lactating												
		6/25/2003	Female	Adult	Pregnant												
		6/25/2003	Male	Adult	Unknown												
Occult Little Brown Bat	<i>Myotis occultus</i>																

						5/27/2004	Male	Adult	Scrotal	
1653	Sagebrush	720 Road Tank	394059	4099885	Long-legged Myotis	<i>Myotis volans</i>	6/14/2004	Female	Adult	Non-reproductive
					Mexican Free-tailed Bat	<i>Tadarida brasiliensis</i>	6/14/2004	Male	Adult	Non-scrotal
					Pallid Bat	<i>Antrozous pallidus</i>	6/14/2004	Female		Pregnant
							6/14/2004	Female	Adult	Lactating
							6/14/2004	Female	Adult	Non-reproductive
							6/14/2004	Female	Adult	Non-reproductive
							6/14/2004	Female	Adult	Pregnant
							6/14/2004	Female	Adult	Pregnant
							6/14/2004	Female	Adult	Pregnant
							6/14/2004	Female	Adult	Pregnant
					Silver-haired Bat	<i>Lasiomycteris noctivagans</i>	6/14/2004	Male	Adult	Non-scrotal
					Western Pipistrelle	<i>Pipistrellus hesperus</i>	6/14/2004	Female	Adult	Pregnant
							6/14/2004	Male	Adult	Non-scrotal
					Western Small-footed Myotis	<i>Myotis ciliolabrum</i>	6/14/2004	Male	Adult	Non-scrotal
1742	Sagebrush	571 Tank	395835	4104205	Long-eared Myotis	<i>Myotis evotis</i>	6/15/2004	Female	Adult	Non-reproductive
					Western Small-footed Myotis	<i>Myotis ciliolabrum</i>	6/15/2004	Female	Adult	Non-reproductive
					Yuma Myotis	<i>Myotis yumanensis</i>	6/15/2004	Female	Adult	Non-reproductive
							6/15/2004	Female	Adult	Pregnant
1905	Sagebrush	Glendale Bench Pond	374793	4124563	Occult Little Brown Bat	<i>Myotis occultus</i>	6/28/2004	Male	Adult	Non-scrotal
					Silver-haired Bat	<i>Lasiomycteris noctivagans</i>	6/28/2004	Male	Adult	Non-scrotal
1704	Pinyon-juniper	Montezuma Tank	378600	4117040	Big Brown Bat	<i>Eptesicus fuscus</i>	7/12/2004	Female		Lactating
							7/12/2004	Female	Adult	Lactating
							7/12/2004	Female	Adult	Lactating
							7/12/2004	Female	Adult	Lactating
							7/12/2004	Female	Adult	Lactating
							7/12/2004	Female	Adult	Lactating
							7/12/2004	Female	Adult	Lactating
							7/12/2004	Female	Adult	Lactating
							7/12/2004	Female	Adult	Lactating
							7/12/2004	Female	Adult	Lactating

Fringed Myotis	<i>Myotis thysanodes</i>	7/13/2004	Male	Adult	Non-scrotal
Long-eared Myotis	<i>Myotis evotis</i>	7/13/2004	Female		Lactating
		7/13/2004	Female		Lactating
		7/13/2004	Female	Adult	Lactating
		7/13/2004	Female	Adult	Lactating
		7/1/2004	Female	Adult	Lactating
		7/13/2004	Female	Adult	Lactating
		7/1/2004	Female	Adult	Lactating
		7/1/2004	Female	Adult	Non-reproductive
		7/13/2004	Female	Adult	Non-reproductive
		7/1/2004	Female	Adult	Non-reproductive
		7/1/2004	Female	Adult	Non-reproductive
		7/13/2004	Female	Adult	Non-reproductive
		7/1/2004	Female	Adult	Non-reproductive
		7/13/2004	Female	Adult	Non-reproductive
		7/13/2004	Female	Adult	Post-lactating
		7/1/2004	Female	Adult	Pregnant
		7/1/2004	Female	Adult	Pregnant
		7/1/2004	g	Adult	Pregnant
		7/1/2004	Male		Scrotal
		7/13/2004	Male	Adult	Non-scrotal
		7/1/2004	Male	Adult	Non-scrotal
		7/1/2004	Male	Adult	Non-scrotal
		7/1/2004	Male	Adult	Non-scrotal
		7/1/2004	Male	Adult	Non-scrotal
		7/1/2004	Male	Adult	Non-scrotal
		7/1/2004	Male	Adult	Non-scrotal
		7/1/2004	Male	Adult	Scrotal
		7/1/2004	Male	Adult	Scrotal
		7/1/2004	Male	s	Non-scrotal
		7/13/2004	Male	Unknown	Unknown
Long-legged Myotis	<i>Myotis volans</i>	7/1/2004	Female	Adult	Lactating
		7/1/2004	Female	Adult	Pregnant
		7/13/2004	Male	Adult	Non-scrotal
		7/1/2004	Male	Adult	Non-scrotal
		7/1/2004	Male	Adult	Non-scrotal
		7/1/2004	Male	Adult	Non-scrotal
		7/1/2004	Male	Adult	Non-scrotal
		7/13/2004	Male	Adult	Unknown
Occult Little Brown Bat	<i>Myotis occultus</i>	7/1/2004	Female	Adult	Lactating
Pallid Bat	<i>Antrozous pallidus</i>	7/13/2004	Female	Adult	Lactating
		7/13/2004	Male	Adult	Scrotal
Silver-haired Bat	<i>Lasiomycteris noctivagans</i>	7/1/2004	Male	Adult	Non-scrotal

		7/1/2004	Male	Adult	Non-scrotal
Unknown	<i>Unknown</i>				
		7/1/2004	Unknown	Unknown	Unknown
Western Small-footed Myotis	<i>Myotis californicus</i>				
		7/13/2004	Female	Adult	Lactating
		7/13/2004	Male	Adult	Non-scrotal
		7/13/2004	Male	Adult	Non-scrotal
Yuma Myotis	<i>Myotis yumanensis</i>				
		7/1/2004	Female	Adult	Lactating
		7/1/2004	Female	Adult	Non-reproductive
		7/1/2004	Female	Adult	Pregnant
		7/1/2004	Female	Adult	Pregnant

Appendix B.

Siders, M.S., W. Jolley, C. Chambers, and D. Sinton. 2004. Bat Commuting: Night roosting and foraging behavior in an urban landscape of a Townsends big-eared Bat (*Corynorhinus townsendii*). North American Symposium of Bat Research, Poster.

Abstract

In the southwest, Townsend's big-eared bats are usually associated with caves and mines for roosting habitat, and are thought to be sensitive to human disturbance. Night-roosting has been documented in several species of bats, and has been described as ranging from short, solitary rests at random locations to relatively long respites in clusters that display fidelity to specific locations across multiple years. Nocturnal resting habits are still poorly described for most species. Night-roosting Townsend's big-eared bats have been observed using urban sites for night roosting in Spring and Fall for a number of years. In 2004, we attempted to document night-roosting and foraging behavior in an urban setting of a male Townsend big-eared bat using acoustic monitoring, and radio-telemetry techniques. Multiple day-roost locations were found in nearby canyon country during a two week period. During radio-tracking efforts, the male was observed commuting from his canyon day-roost to town; foraging over homes. Night-roosting and social calls were documented using an ANABAT acoustic station.

Study Area

The study was conducted in southern Utah, in and near the town of Kanab. The area is a matrix of urban, agricultural and wild lands (Map 1). The surrounding area is composed of sagebrush flats, pinyon-juniper woodlands, cottonwood riparian, and sandstone cliffs (see banner panorama photo).

Introduction

Night-roosting has been described as a convenient stop or short rest for an individual or group of individuals. These sites may be used as retreats to which food items are carried and consumed or simply as spots where the bat can hang up, rest, and digest food (Hill and Smith 1992: p132). While night roosting has been described in general, published information on night roosting behavior and habitat associations in North America is limited. Ecological attributes of night roosting are difficult to study, and those surveys or incidental observations that involve night roosting bats are rarely published and remain virtually unavailable as references (Ormsbee et al. 2004).

A home in Kanab has been used as a night-roost by Townsend big-eared bats in the Spring (mid-May through early-July) and late-Summer (September) for at least seven years. As many as eight individuals have been seen night-roosting in the garage, or four in the utility room. The night-roost has been used on occasion as a day-roost. Night-roosting was noted by both visual observations after dark, as well as fecal and moth wing remains at the roost sites. The purpose of this investigation was to:

- determine the sex of the roosting bats
- locate the day roost
- characterize the use patterns
- document foraging

This was the preliminary year of data collected.

Methods

Acoustic Monitoring

A remote acoustic monitoring station (ANABAT II and CF Z-Caim) was placed in the night-roost from 28 May through 31 May 2004. Calls were collected from 1800 to 0630 hrs each night. Call files were then analyzed to determine the likelihood of being from Townsend's big-eared bats for individual calls, the number of call files each

hour, the number of individual calls each hour, and the chronology of bat call activity was assessed. A low frequency filter was developed to attempt to pull out social calls for analysis.

Radio Telemetry

A single male Townsend's big-eared bat was captured at the home night-roost using a hoop net on 15 June 2004 at 0210 hrs (Photo 1). Calculations were made based on weight to make sure that the radio was less than 5% of its body weight. A 0.041 g radio transmitter (Holohil BD-2; Photo 2) was attached with skin bond between the scapula. The bat was held for approximately 20 minutes for processing and radio attachment, and was released at 0230 hrs. Standard radio telemetry techniques were used to follow that individual and try to locate day roost locations.

Foraging

The tagged male Townsend's big-eared bat was tracked for four nights (21-25 June, 2004) to document foraging behavior. Two observers recorded compass bearings every 15 minutes from sunset (approx. 2053 hrs) to sunrise (0611 hrs). Biangulations were calculated using Universal Transverse Mercator (UTM) coordinates of the observers and bearings for each time interval possible (Fig. 1).

Results

Day Roost

Three general night-roost locations were determined for the tagged male over six nights (15-20 June 2004; Photo 3). All roosts were in the same general location, approximately 2.1 to 2.9 km from the capture (night-roost) location (Map 1). Roost sites appeared to be high on rocky cliffs, and the male seemed to move roosts every day or two. Roost sites were difficult to pinpoint due to the inaccessibility of the sites, and at times radio transmitter bounce. Bi- or triangulation to day roost sites was only possible early in the morning as the bat was returning to the roost, and for a slightly longer time period in the evening as the bat was waiting to exit the roost. Once the bat entered into the roost crack, the signal from the transmitter would disappear. Daytime searches for day-roost locations were completely unsuccessful.

Acoustic Monitoring at Night-roost

Bat calls in the frequency range of Townsend's big-eared bats were detected throughout the night at the night-roost location (M. O'Farrell and C. Corbin, pers comm.). We acknowledge that calls may have belonged to other species, but night-roosting was not observed at the site of any other bat species. Bat activity was greatest by far in the early evening (2000 and 2100 hrs) for both number of bat call files and number of individual bat calls (Fig. 2 and 3). If we remove the early evening calls from the graph, we can see that bat activity continues throughout most of the night, declining in the very early morning hours.

Mixed in the calls were many social calls (Fig. 4). A low frequency filter was used in ANALOOK to mark low frequency social calls for further analysis. While many "dirty" individual social calls were not detected by the filter, we felt that this was a conservative estimate of social call activity at the night-roost. Social calls were seen throughout the night, with more activity detected on Day 1, and appeared to decline over the three days (Fig. 5).

Foraging

Once the day-roost was located, the remaining transmitter time was committed to documenting the foraging behavior of the bat. The tagged male appeared to spend most, if not all of the night, foraging in and around the town of Kanab. In general, he exited the day-roost and flew to town at approximately 2200 hrs (approximately 1 hr after sunset [US Naval Observatory database]). The bat foraged in and around the town of Kanab until approximately 0430 hrs when he flew toward the day-roost area, arriving to the day-roost area by approximately 0500 hrs (approximately 1 hr before sunset). With only two observers, biangulated locations are highly approximated, but should show the general movement of the bat over the night. Each of the three nights had slightly different foraging locations (Map 1).

On night one (21-22 June), the tagged male spent much of the early part of the night (2245-0130 hrs) foraging in a neighboring horse pasture (Map 2 at A); made a trip to the edge of town (0153-0200 hrs; B); return to the horse pasture; then east of town (0215-0300 hrs; C); return to the horse pasture (0300-0345); through town to the very north end of town (0400-0430 hrs; D); then headed toward the day roost area at approx. 0500 hrs.

On night two (22-23 June), the tagged male spent much of the night in or near the dry irrigation ponds (Map 3 at A), with three large side trips (B at 2238 hrs; C at 0300-0400 hrs); then toward the day roost area at 0514 hrs (D).

Night three (23-24 June) had equipment problems resulting in only one observer radio tracking. The tagged male again appeared to forage through town starting at approximately 2200 hrs and heading for the day-roost at about 0500hrs. Due to the single observer even approximate locations could not be determined.

On night four (June 24-25), the tagged male spent much of the early part of the night in or near the dry irrigation ponds again (2345-0015 hrs; Map 4 at A). The radio signal was lost by one observer until approx 0230 hrs when the bat appeared to be mid-town (B); then far east of town (0245-0315 hrs; C and D); moved to a pasture (0345 hrs; E); then headed toward the day roost area at 0347 hrs.

Discussion

Day Roosts

Female Townsend's big-eared bats form maternity colonies in caves and sometimes buildings in the early Spring, and abandon maternity colonies by late-Summer (Kunz 1999). Little is known about the summer habits of males.

Our single tagged male Townsend big-eared bat appeared to roost in cracks in cliffs. It is unknown whether he roosted singly or with others at the day roost due to the inaccessibility of the roosts. However, the roost cracks appeared to be either quite deep or there was a twist in the passage to block the radio signal. Other bat species tagged with similar radio transmitters this season were more readily located in cliff habitat. He did change roosts at least three times, possibly four during the six days that we tracked him to day roosts.

Night-roosts

Acoustic monitoring indicated that the night-roost site in a home was used throughout the night by bats. While the acoustic signatures indicate that they were probably Townsend's big-eared bats, there are other species that have similar calls. The large numbers of social calls at the night-roost site is, however, intriguing. Video monitoring of the site may be more informative of the interactions and use of this night-roost site, and deserves more detailed study.

Foraging

Our single tagged male Townsend big-eared bat, while foraging in an urban setting, seemed to mimic those foraging behaviors previously described for this species. Similar to what Kunz (1999) describes, the male appeared to be foraging along habitat edges between the deciduous trees of home sites and the open pastures adjacent to the homes. While biangulations did not place the tagged bat exactly at the known roost site, he was sighted there on a number of occasions. Also, the estimated biangulations did place the tagged bat in the neighborhood on numerous occasions.

Activities of these bats appear to be seasonal (Spring and late-Summer). Are they using urban night-roosts to warm themselves when the nights are cool? We were unable to capture more than one of the night-roosting bats, so were not able to determine if this was a male-only night-roost. The numerous social calls begs the question as to what they are up to. Additional study is needed to determine the purpose of this night-roost.

Literature Cited

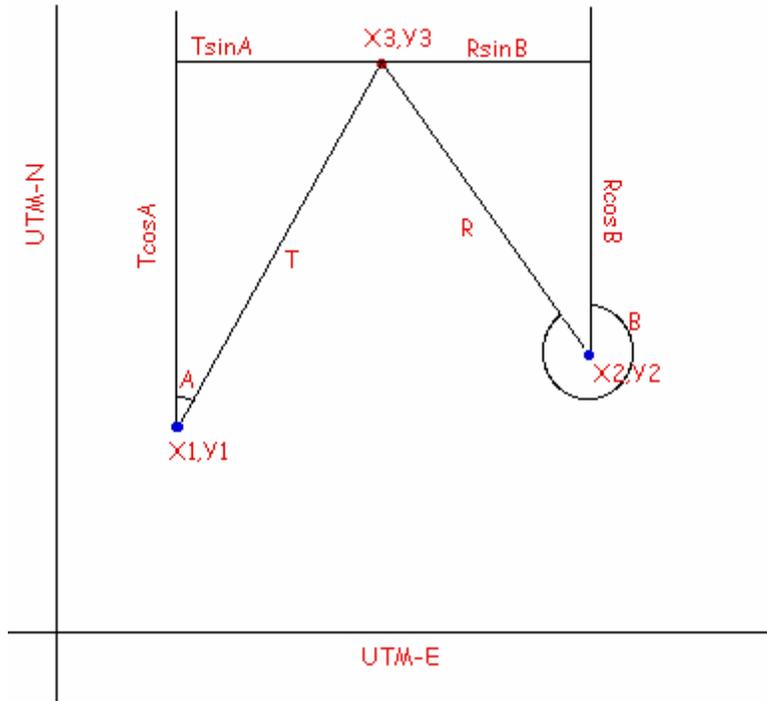
- Adams, R.A. 2003. Townsend's big-eared bat, pg 135-138 in *Bats of the Rocky Mountain West: Natural history, ecology, and conservation*. University Press of Colorado. Boulder, CO.
- Hill, J.E. and J.D. Smith. 1997. *Bats: A Natural History*. University of Texas Press, Austin Texas
- Ormsbee, P.C., J.D. Kiser, and S.I. Perlmeier. 2004. Importance of night roosting to the ecology of forest bats. *Second Bats and Forest Symposium and Workshop*. March 9-12, 2004, Hot Springs, AR.

Sinton, D. and K. Yasuda. Unpublished. From Here to There: Calculating a Universal Transverse Mercator location (Easting [X3], Northing [Y3]) from two known locations (X1, Y1 and X2, Y2) and compass bearings (A and B). U.S. Naval Observatory. Astronomical Applications Department, Complete Sun and Moon Data for One Day. Web Application: Available at <http://aa.usno.navy.mil/>

Wilson, D.E. and S. Ruff. 1999. Townsend's big-eared bat. Pages 121-123 *in* The Smithsonian book of North American mammals. Smithsonian Institution.

Figures

Fig. 1. Formula for calculating biangulation UTM coordinates (X3, Y3) from two observers at known locations with UTM coordinates X1, Y1 and X2, Y2 and compass bearings A and B (Sinton and Yasuda, Unpublished).



$$x_3 = x_2 + \left[\frac{(y_1 - y_2) \sin A + (x_2 - x_1) \cos A}{\cos B \times \sin A - \sin B \times \cos A} \right] \sin B$$

$$y_3 = y_2 + \left[\frac{(y_1 - y_2) \sin A + (x_2 - x_1) \cos A}{\cos B \times \sin A - \sin B \times \cos A} \right] \cos B$$

Fig. 2. Total number (lower) and detailed look at number (upper; excluding 2000-2100 hrs) of bat call files detected at night-roost location for 28-30 May 2004.

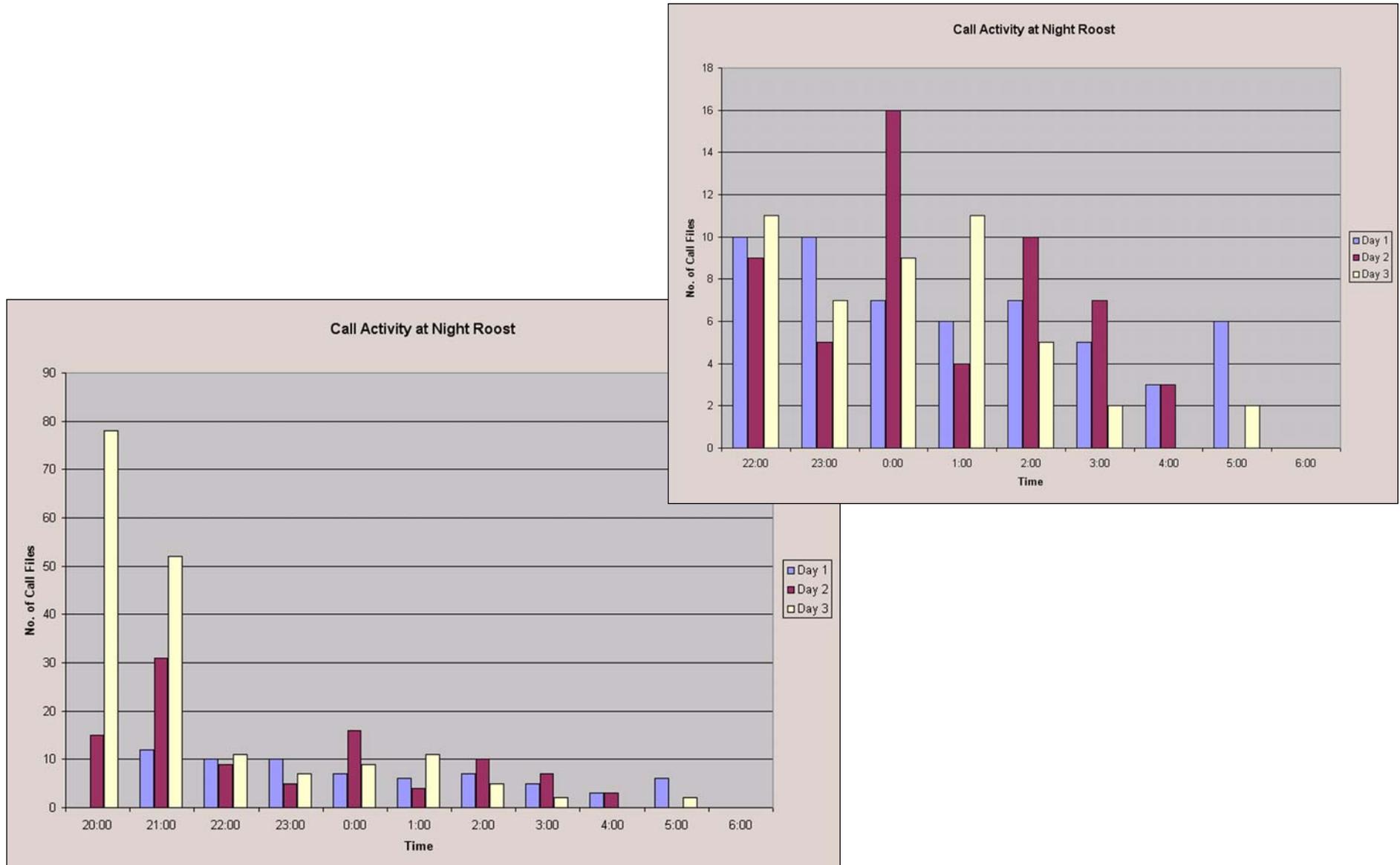


Fig. 3. Total number (lower) and detailed look at number (upper; excluding 2000-2100 hrs) of individual bat calls detected at night-roost location for 28-30 May 2004.

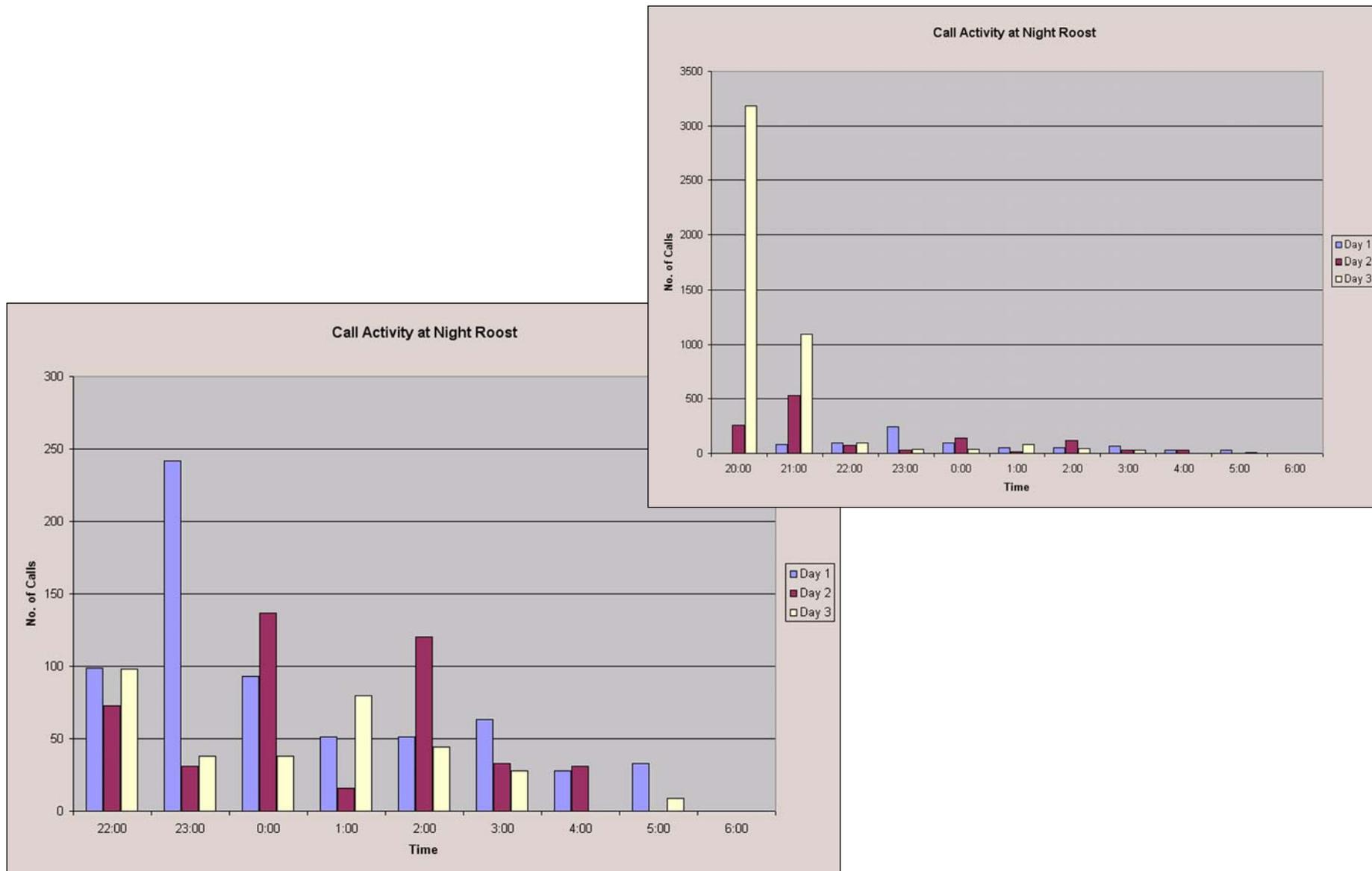


Fig. 4. Example Townsend's big-eared bat social calls displayed in ANALOOK (F5) detected at night-roost location 31 May 2004.

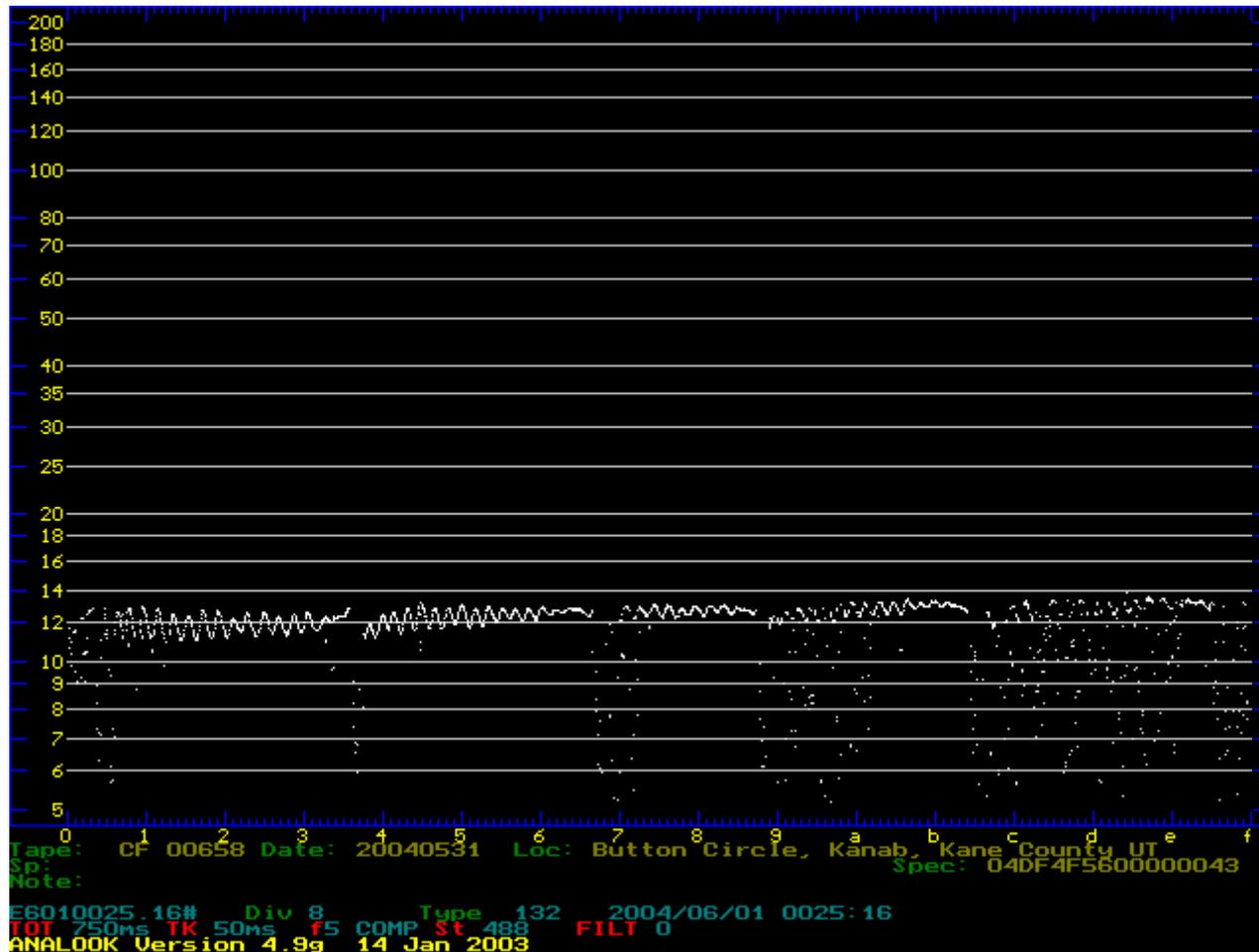


Fig. 5. Total number of social bat calls detected at night-roost location for 28-30 May, 2004.



Photos

Photo 1. Male Townsend's big-eared bat captured at night-roost on 15 June 2004 at 0210 hrs. Forearm 43 mm; Ear length 31 mm; Weight 8.75g (5% \pm 0.437g).



Photo 2. Holohil BD-2 radio transmitter. Weight 0.41 g.

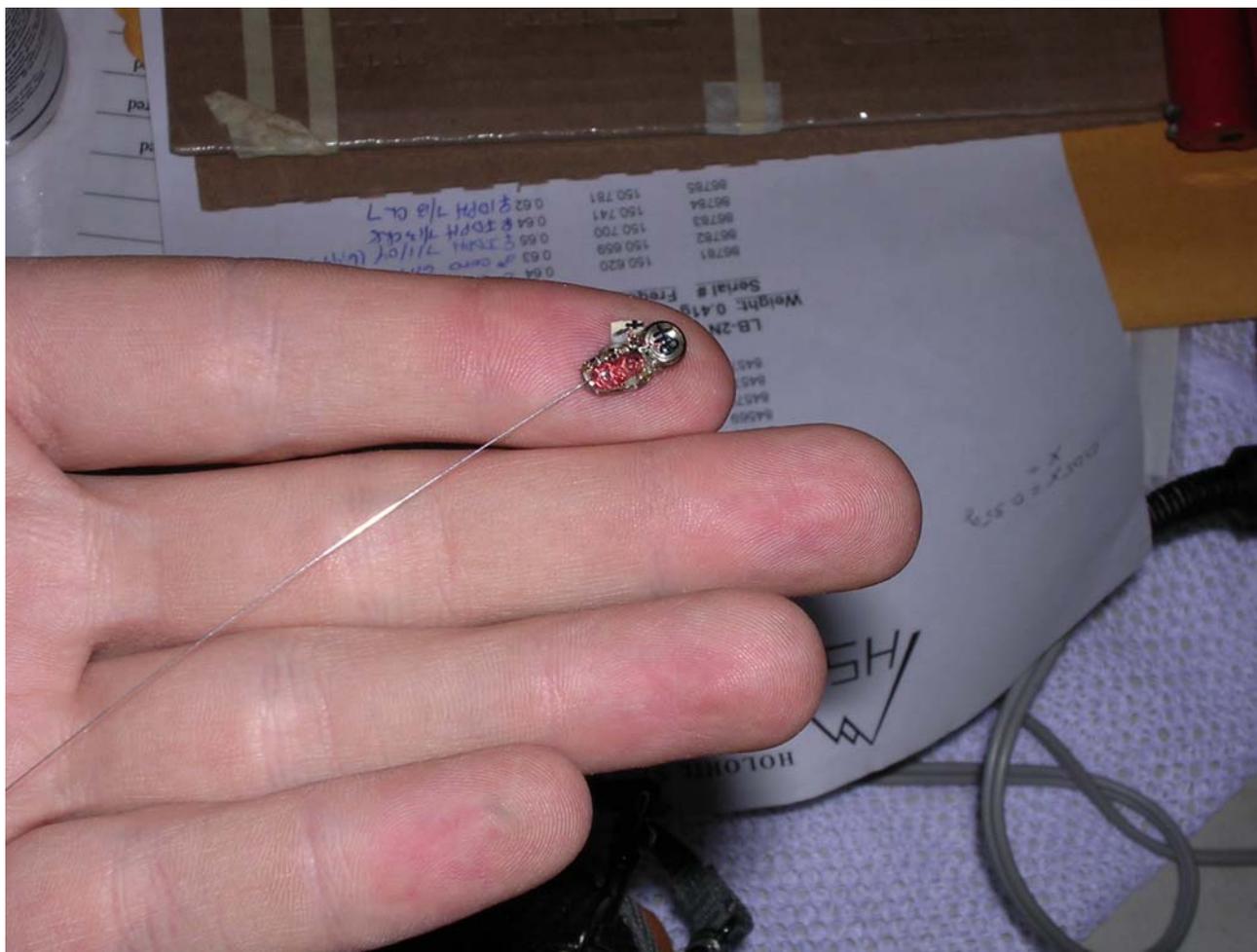
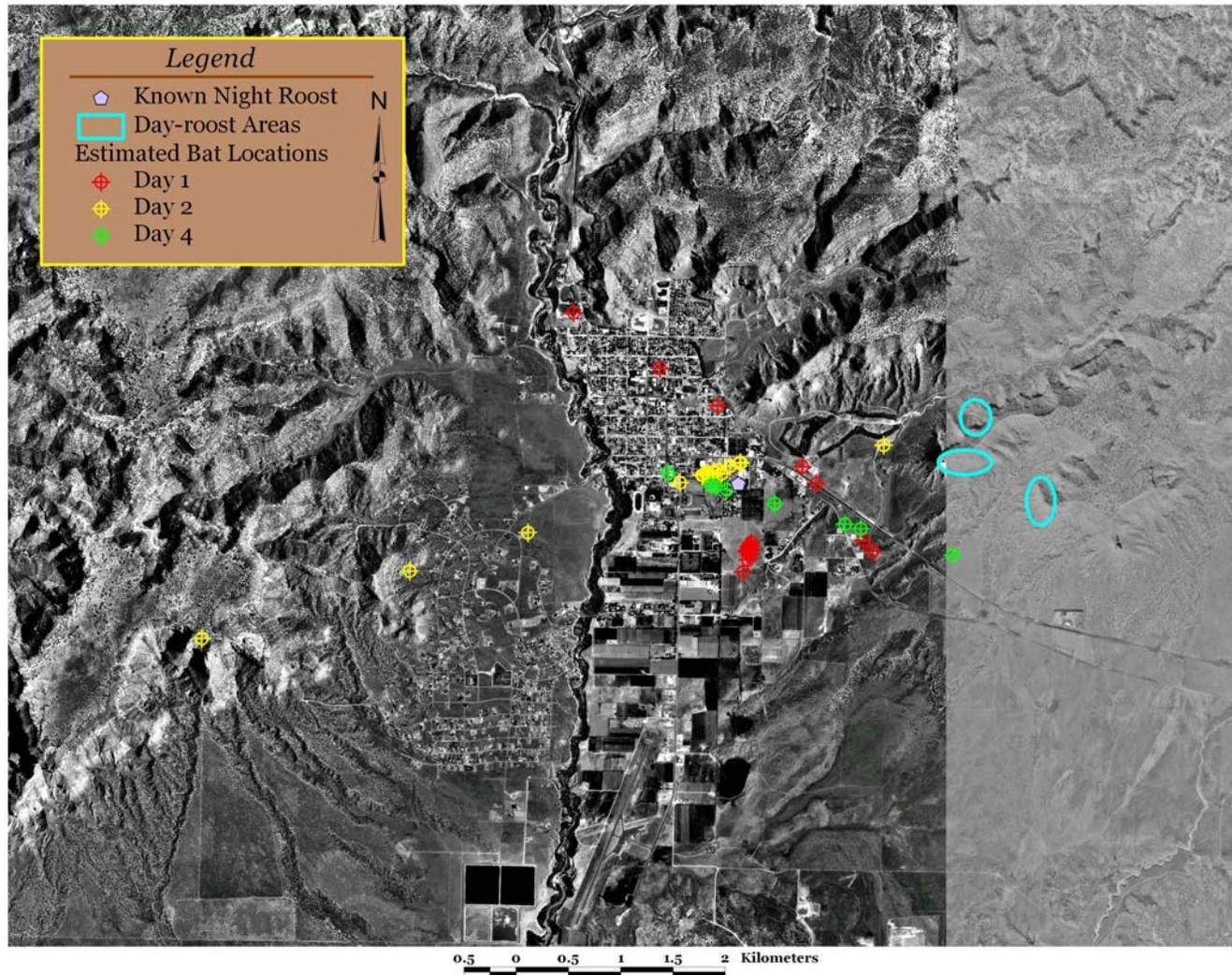


Photo 3. Townsend's big-eared bat day-roost area. Roosting areas were located on both sides of the mesa. Day-roost was approximately 2.4 km east of the capture (night-roost) location.

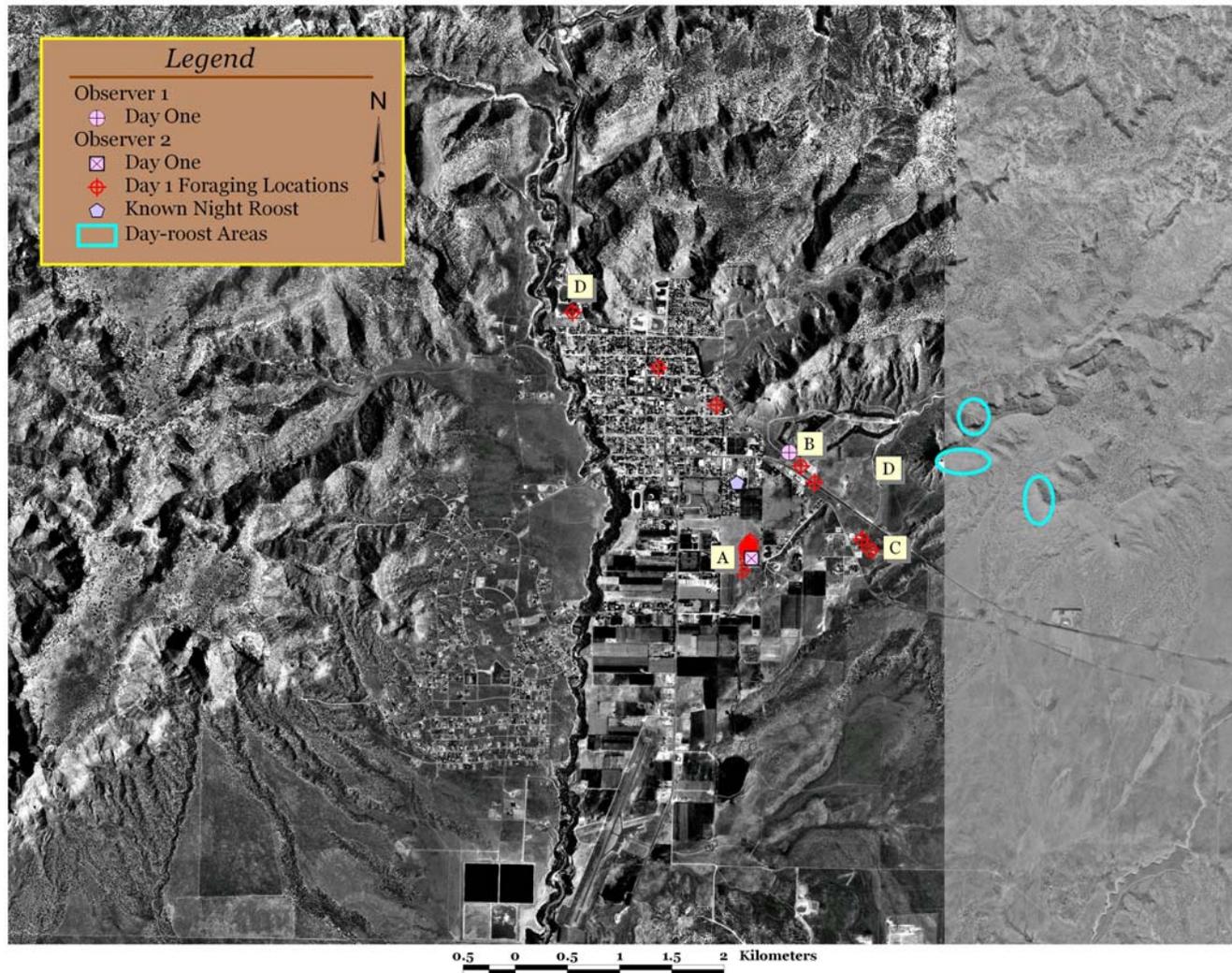


Maps

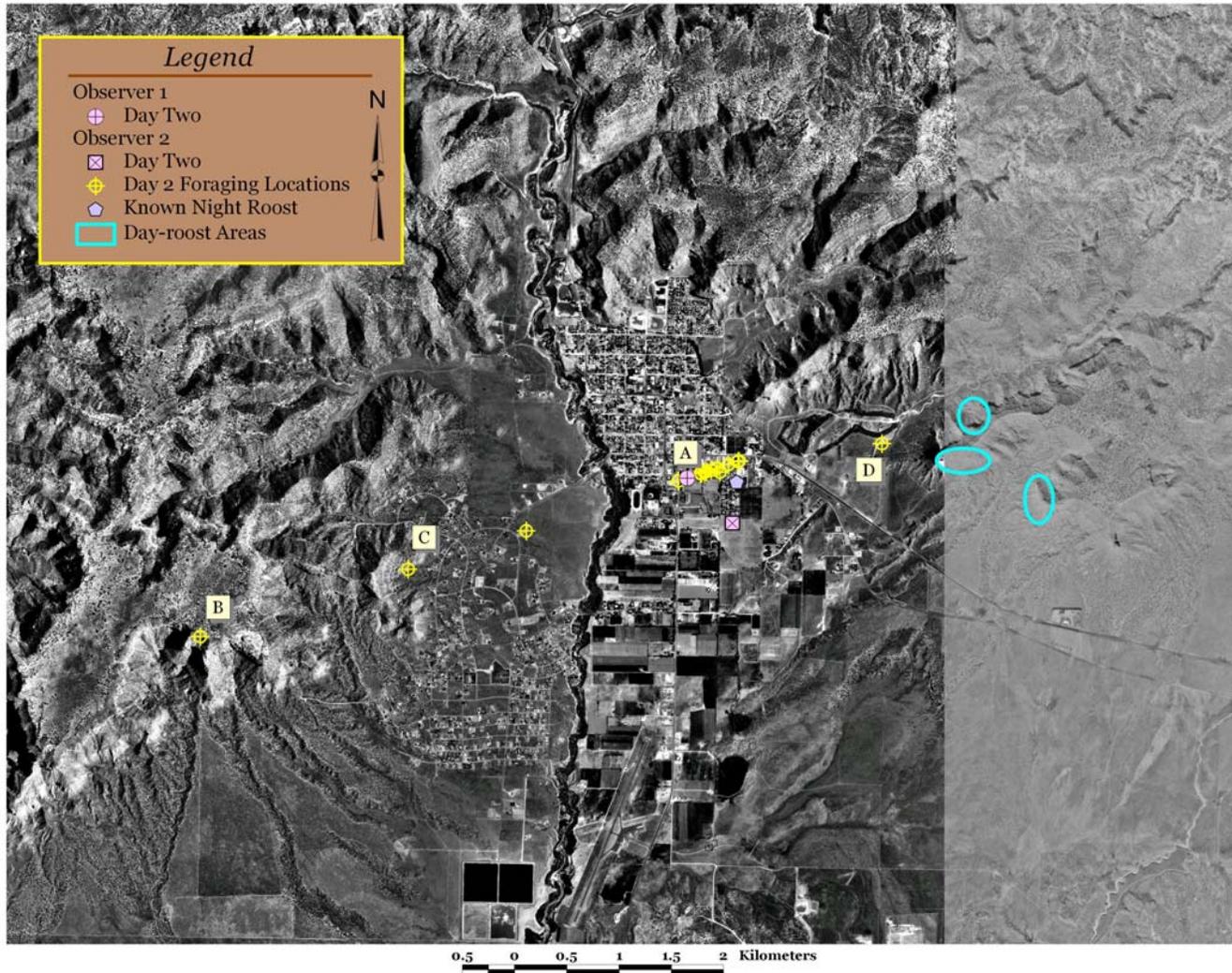
Map 1. Foraging locations for a male Townsend's big-eared bat in Kane County, Utah (21-25 June 2004).



Map 2. Foraging locations for a male Townsend's big-eared bat in Kane County, Utah (21-22 June 2004).



Map 3. Foraging locations for a male Townsend's big-eared bat in Kane County, Utah (22-23 June 2004).



Map 4. Foraging locations for a male Townsend's big-eared bat in Kane County, Utah (24-25 June 2004).

