Section 6 Report Review

Attachment to letter dated November 19, 2003

Project: Identification and Protection of Roosts and Foraging Areas for the Mexican Long-Nosed Bat: Northeastern Mexico and the Trans-Pecos Region of Texas

Final or interim report? Final

Job #: WER 68 **Grant #:** E-18

Reviewer's Station: Austin ESFO

Lead station was contacted and concurs with the following comments:
___ Yes ___ No _X_ Not applicable (reviewer is from lead station)

Interim Report	Final Report
___ is acceptable as is	_X_ is acceptable as is
___ is acceptable as is, but the comments below need to be addressed in the next report	___ is acceptable, but needs minor revision (see comments below)
___ needs revision (see comments below)	___ needs major revision (see comments below)

Comments:

We look forward to receiving the addendum report on radio-telemetry data when it is completed.

Section 6 Endangered Species Project:
Identification and Protection of Roosts and Foraging Areas for the Mexican Long-Nosed Bat: Northeastern Mexico and the Trans-Pecos Region of Texas

FINAL Report
August 29, 2003

Submitted to:
Texas Parks and Wildlife Department
United States Fish and Wildlife Service
National Park Service

Submitted by
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This final report is in fulfillment of Memoranda of Agreement Texas Parks and Wildlife Department contract numbers 84190, 98639 and 114008.

Based on the Memoranda of Agreement, our objectives for the third (final) year included:

1) Locate new roosts in two of the six critical habitat areas (northeastern Mexico and Big Bend area of Texas) described in the species recovery plan.
2) Continue monitoring roosts and evaluate associated habitat.
3) Continue determining nightly foraging patterns and distances traveled.
4) Continue developing management guidelines for protection of roosts and foraging habitats.
5) Involve communities and local landowners in bat conservation efforts.
6) Write a final report. The final report shall address all three years of the study and shall be due on or before August 31, 2003.

In summary of the above objectives, we achieved the following:

1) Surveyed for Mexican long-nosed bats (*Leptonycteris nivalis*) roosts in Coahuila, Mexico, and the Big Bend area of Texas.
2) Collected crucial information on Emory Cave (the only documented Texas roost) and Cueva El Infierno in Nuevo Leon (the northernmost known maternity roost).
3) Attached radio transmitters to 33 *L. nivalis* (8 in 2002 and 25 in 2003) and tracked nightly movement patterns and distances traveled in the vicinity of the Emory Cave roost.
4) Continued gathering information necessary for developing management guidelines for protecting roosts and foraging habitats.
5) Involved local businesses, communities, and landowners in bat conservation efforts.
6) Provided this document.

We also added further information on a possible corridor where agave populations would be considered foraging habitat for migratory *L. nivalis*.

Research for this report was conducted under the following permits: Texas Parks and Wildlife Department permit number SPR-0201-141; National Park Service permits BIBE-2001-03, BIBE-2001-SCI-0008, BIBE 2001-SCI-0076, and BIBE-2003-SCI-0025; and U.S. Fish and Wildlife Service permit number TE039139-0.

INTRODUCTION

The Mexican long-nosed bat, *Leptonycteris nivalis*, was declared an endangered species in the United States in 1988 and in Mexico in 1991 (USFWS 1994).

> Several caves in central Mexico known to contain considerable numbers of bats in the past now contain only small colonies or lack bats altogether (Wilson 1985, Schmidly 1991). The reasons for the decline of this species are not entirely clear, but are probably associated with disruption and destruction of roosting sites and food sources (USFWS 1994).

Reclassification from endangered to threatened cannot occur until what constitutes a population and how a population migrates and uses habitat is understood (USFWS 1994).

The 1994 United States Fish and Wildlife Service Mexican Long-nosed Bat (*Leptonycteris nivalis*) Recovery Plan identified the need for locating and protecting both roosts and foraging habitat within six critical areas, including the northeastern region of Mexico and the Big Bend region of Texas (see Figure 1). As described within the Plan, *L. nivalis* relies heavily on the nectar and pollen of paniculate agaves throughout northeastern Mexico and the Texas Big Bend region. Through agave pollination, these bats may be critically important as pollinators of agave plants (USFWS 1994).

This project, initiated in 2000, was designed to evaluate the needs of these bats in relation to their roosting and foraging requirements in the Trans-Pecos region of Texas, including their northward migrations through northeastern Mexico. In support of the stated objectives, year one and two efforts focused on gathering known data from published and unpublished literature; building regional contacts with botanists, ecologists and landowners; conducting ground and aerial surveys to identify previously undocumented Texas and Mexico agave populations that could serve as bat food resources; and attempting to locate previously undiscovered bat day roosts. The third year's efforts focused on the use of radio telemetry to define flight distances, foraging habitat, and general habitat use, as well as developing a workable census method for Emory Cave in Big Bend National Park, the only known *L. nivalis* roost in Texas.

METHODS

Study Area:

Our study area spanned sites between the Recovery Plan's critical areas of Chihuahua/Texas/Coahuila and Coahuila/Nuevo Leon/Tamaulipas (see Figure 1). We searched for agaves in areas in Tamaulipas, western Nuevo Leon, a corridor from southeast to northwest Coahuila, northeast Chihuahua, and the Big Bend area of west Texas (see Figure 2). We conducted surveys of potential bat roosts in caves and mines in the mountainous corridor between Monterrey in Nuevo Leon and the Maderas Del Carmen Protected Area in Coahuila, as well as opportunistically in other areas where we worked. We mist netted for bats in Texas in Big Bend National Park (BBNP), Chinati Mountains State Natural Area, Davis Mountains State Park, and on private properties in the Davis, Glass, and Chinati Mountains. We monitored the El Infierno roost in Nuevo Leon and the Emory Cave roost in BBNP. We conducted radio telemetry in BBNP. Educational efforts were conducted opportunistically throughout the areas studied.

Distribution of Agaves:

We developed an aerial survey technique to visually locate large paniculate agaves at a distance over remote, densely wooded, or steep terrain. During winter surveys, our search pattern was for blue-green basal rosettes and straw-colored dead rosettes and bloom stalks. During summer surveys, we also looked for the large, bright yellow bloom panicles.

There are several plant species that could be confused with agaves during aerial surveys. Care was taken not to confuse the presence of yuccas (*Yucca* spp.) for that of agaves. Large yuccas commonly have a skirt of dead leaves that from a distance is a similar color to that of dead agave rosettes. However, usually the yucca's dead skirt will be topped by a robust shock of green leaves, and at certain points in the year, by white flowers. Dead agave rosettes are never topped by live, green leaves (pers. obs.).

Also, during winter surveys, it is possible to confuse the dead bloom-stalks of the smaller *Agave lechuguilla*. Lechuguilla blooms from April to August in the Big Bend area (West 2000), with a spicate bloom pattern (a tall spikelike stalk, lacking the out-reaching arms typical of the paniculate agave species – Gentry 1982)). Tall, spiculate stalks are also produced by the related sotol (*Dasylirion* spp. – West 2000). From above at a distance, all these stalk forms look like scattered matchsticks strewn across the mountainous landscape. However, both these lack the large, fleshy, basal rosette typical of the larger paniculate species. Determining the scale of the stalks compared to nearby vegetation is usually a good method to differentiate between the different species when flying too far away to see if the stalks have (or had) paniculate branches at the top.

During summer agave surveys, the presence of bright yellow blooms alone was not considered enough to indicate the presence of agaves, because a number of other flowering plants were observed to form clumps of yellow blooms at the same time of year. The presence of large green or straw-colored rosettes or dead bloom stalks seen in conjunction was required to positively identify the yellow as belonging to agaves.

The accuracy of the agave-density estimation technique was crosschecked by comparing aerial survey estimates to those generated from ground surveys.

Aerial surveys for paniculate agaves and other potential food sources were undertaken within and between the two northeastern recovery areas (see Figure 2). We focused survey flights on mountain ranges having elevations at or above 1200 m (4000 ft), based on *Agave havardiana*'s habitat preference for habitat above this height (Gentry 1982). In each area, we counted the number of standing paniculate agave stalks within an estimated circular 100-meter (328-foot) diameter plot. The approximate location of each plot was established using a global positioning system (GPS) unit.

The same agave census technique was also used for roadside agave clusters and columnar cacti while driving along Highway 101 between Ciudad Victoria and Reynosa, Tamaulipas, in the Glass and Davis Mountains, and by foot along roads and trails within Big Bend National Park (BBNP), Texas. Road sites were selected based on the presence of publicly accessible roads or landowner access permission, accessibility with a four-wheel drive vehicle, and mountainous areas near or above 1200 m (4000 ft) elevation. BBNP trail surveys were based on trails over 1200 m elevation which were deemed to be accessible during summer months by BBNP personnel.

In January 2001, Dr. Arnulfo Moreno-Valdez, Brian Keeley, and Angela England conducted aerial surveys for populations of paniculate agaves in Trans-Pecos areas of west Texas. With assistance from a local pilot, we conducted low-level flights 150-250 m (500-800 ft) above ground from a Cessna 172 airplane over the Chisos, Chinatis, Cuesta del Burro, Del Norte, Davis, Glass, Sierra Viejas, Eagle, Van Horn, Baylor, and Sierra Diablos Mountains.

In December 2001, Dr. Moreno and Keeley conducted low-level Cessna flights over a mountainous corridor extending between the city of Monterrey, Nuevo Leon, and up to the southern limit of the Maderas del Carmen Mountains in Coahuila, Mexico.

In June 2003, England completed the aerial agave surveys with a low-level Cessna flight 150-250 m (500-800 ft) above the Sierras and Maderas del Carmen in northwestern Coahuila and the Santa Elena Reserve in northeastern Chihuahua. Higher-level flights 600-750 m (2000-2500 ft) above ground were conducted around the Chisos and Dead Horse Mountains (northern Sierras del Carmen) in Big Bend National Park, Texas, due to flight restrictions imposed by the park to protect nesting peregrine falcons.

Bat Capture:

In 2001 and 2002, our capture technique focused primarily on the strategic positioning of mist nets near blooming agaves or in areas potentially used as flyways. Techniques we used follows that employed by Dr. Arnulfo Moreno, scientific literature, and personal communications with other researchers. Nets were set adjacent to blooming agaves or in vegetative structure and geologic features (e.g., drainages, rock walls, etc.)

were suspected to serve as flyways. The nets were tucked against vegetative cover to reduce detection where possible. To avoid capturing non-target species, we typically did not set nets over water.

In 2001, Brian and Annika Keeley mist netted at or near agaves on the Mills Ranch in the Glass Mountains on the nights of June 3-5. Netting at agaves in the Davis Mountains was conducted June 18-22 at Davis Mountains State Park (Angela England and volunteer Tim Schumann), Prude Guest Ranch (England and Schumann), Cherry Creek Ranch (A. Keeley and volunteer Krishna Costello-Gifford), and Buffalo Trails Boy Scout Ranch (B. Keeley and volunteer Jeff Renfrew). Agaves at the Cibolo Ranch in the Chinati Mountains were netted on the nights of June 18-20 and 25-26 (B. Keeley and Arnulfo Moreno-Valdez). Agaves in the Chisos Mountains of BBNP were netted June 21 and 23 (England, A. Keeley and Moreno-V.). Mist nets were set up at Emory Cave, BBNP, on June 28 (B. Keeley and Moreno-V.).

In 2002, mist net surveys were conducted at agaves on the Cherry Creek Ranch in the Davis Mountains on the nights of June 10-15 by Brian Keeley. Agaves at the Chinati Mountains State Natural Area were netted June 22-27 by B. Keeley and volunteer Kei Yasuda. Agaves in the Chisos Mountains of BBNP were netted on the nights of June 18 and 20-26 by Angela England, Meg Goodman, volunteers Anna Strong, Pat Brown and Bob Berry.

In 2003, mist netting was conducted in BBNP to obtain bats for telemetry, on the dates of June 25, 26, 27, and July 1 by Angela England, Meg Goodman, Dave Dalton, and Sandy Wolf, assisted by volunteers. Our primary focus for the third year was to investigate how the bats used the habitat surrounding the roost during the night. In order to begin telemetry as soon as possible, we focused netting efforts outside the Emory Cave roost, where we were most assured of capturing bats in a timely manner. One 9-m (30-ft) mist net was erected within the overhang just inside the main opening to Emory Cave on the nights of June 25, 27, and July 1. Nets were also placed around flowering agaves on the nights of June 26 and 27, using the same technique as in previous years.

Each captured *L. nivalis* was aged, sexed, weighed, and positively identified to species using the keys found in Schmidly (1991) and Hoffmeister (1986). Juvenile bats weighing less than 22 grams were released immediately as being too small to carry the radio transmitters.

Radio Telemetry:
No radio telemetry was undertaken in 2001.

In 2002, the radio-tracking effort focused on three objectives: finding new day roosts, gathering foraging habitat information, and attempting to determine if bats are dispersing to new locations. Tracking was accomplished by attaching 0.65-gram Holohil transmitters onto the backs of 8 *L. nivalis*. Fur was carefully trimmed from between the scapulae of bats selected for tracking. VetBond veterinary cement was applied to the clipped area and the radio transmitter, and the tag was then put into place and fur from the surrounding area was combed over any exposed cement. It was held for 5 minutes to allow the cement to cure, and the bat was then released.

An aerial telemetry crew, consisting of Dr. Patricia Brown and Bob Berry, was employed to fly for 2 hours pre-dawn and post-sunset, in hopes of locating new day roosts. The aerial crew flew a Cessna 172 airplane with 2-element antennas on each wing, connected to two Communications Specialists R-1000 telemetry receivers that were both programmed to scan concurrently through the frequencies of any activated transmitters. The screens of both receivers were videotaped, and the recorded data was later entered into a spreadsheet. The pilot provided estimated positions of each bat based on subjective analysis of a variety of data including airplane position and bearing, and signal strength from both receivers.

Ground crews used Telonics TR-2 receivers and handheld 2- and 3-element antennae tuned to the appropriate frequencies to locate and follow the signals of the transmitters. Ground-based telemetry typically lasted from sunset until between midnight and 2am.

To locate new day roosts, crews were instructed to determine where the signal first emerged during the evening and then disappeared during the morning. Foraging habitat information was collected while the crews were tracking for day roost locations and later into the night during netting efforts with a focus on learning where the bats were spending the majority of their time. Because of the limited reception range of ground crew receivers in mountainous terrain, the collection of dispersal information was primarily the responsibility of the aerial crew. The location and time of all transmitter numbers and locations were recorded to eventually create a map of the bats' activities.

In 2003, we attached 0.65-gram transmitters from Holohil Systems, Ltd., onto the backs of 25 *L. nivalis*. Fur was carefully trimmed from between the scapulae of bats selected for tracking. After trimming, an alcohol-soaked cotton-tipped swab was used to remove oils from the skin and surrounding fur. Once the alcohol had evaporated, Skinbond brand ostomy glue was applied to the clipped area and the radio transmitter, and allowed to "cure" for 5 minutes. At that time, the transmitter was put into place, and fur from the surrounding area was combed over any exposed glue. The bat was released, and tracked for 30 seconds to ensure it left the area.

Telemetry receivers included Communications Specialists model R-1000, Wildlife Materials model TRS-2000S, and Lotek model STR-1000. Five-element antennas were mounted on 2-meter-tall masts, which were then stood upright in tripod footings. Compasses were attached to the mast with alignment brackets to minimize observer error. GPS readings were taken for each telemetry-receiving location, and bearings toward beacons placed at known locations throughout the study area were used to calibrate for magnetic variation. Telemetry stations were chosen each night based on height above surrounding terrain, bat activity from previous nights, and 1-3-hour accessibility from established roads and trails.

Frequencies for all activated transmitters were scanned throughout the night from as many as 7 receiving stations throughout the area. CB radios were used to communicate and coordinate data collection between stations. When a signal from a tag was received, that station would communicate the tag number to the other stations, and if no other signal was being tracked all other receivers would switch to the new frequency. Bearing were recorded for 3 minutes at the beginning of each minute, based on GPS-system calibrated watches.

Field plotting of rough bat positions was done for a few sets of bearings that seemed "interesting." Minutes for which at least 3 bearings were recorded for a given frequency were selected. Observer position and bearing (after beacon-calibrated correction for magnetic variation) were entered into the DeLorme 3-D TopoQuads version 2.0 software, and a series of position estimates and associated error estimates were then plotted in the computer subjectively.

NOTE - Because the field work was just completed, additional computer analysis of telemetry results achieved during the grant period will be forthcoming. Methods to be used will be fully described in any future addendum report.

Monitoring of Emory Cave Roost:
In 2001, three trips were made to Emory Cave. On the morning of June 23, Dr. Arnulfo Moreno-Valdez, Angela England, and Annika Keeley entered the cave in order to estimate roost size and collect guano samples. On the evening of June 24th, Brian Keeley and the aforementioned crew again went to Emory Cave, to install Hobo temperature data loggers inside and outside the cave and observe the emergence. Dr. Moreno-Valdez and Brian Keeley again went to the cave on June 28 to make second population count and collect tissue samples, which were subsequently sent to Dr. Rodrigo Medellin at the Universidad Nacional Autonoma de Mexico for population genetic analysis.

In 2002, 3 trips were made into Emory Cave on June 16 (Brian Keeley), 20 (B. Keeley and Meg Goodman), and 29 (volunteers Anna Strong and Kei Yasuda) to try to determine when *L. nivalis* first arrives, to make a population estimate, and to search for bats with transmitters. A survey consisted of inspecting all accessible regions within the cave for signs of recent use by *L. nivalis*. If *L. nivalis* was present, internal and sometimes external counts were made. Internal counts were done by estimating the cluster size. External counts were done by sitting quietly at the entrance, preferably with a night vision scope, and counting the number of individuals exiting minus those re-entering. A transmitter search required the use of a receiver and antenna and a light source to look and listen for activated transmitters within and around the cave.

In 2003 we visited Emory Cave 6 times. The first trip was made June 17 by Angela England and 3 volunteers to observe the exit flight visually and with a night-vision scope, and attempt to see where the bats emerged from the upper "skylight" entrance. After the bats exited, England and one volunteer entered the cave to check for the presence of the characteristic yellowish guano that is indicative of this bat when it is feeding on the nectar and pollen of agaves. We also evaluated the physical layout inside the cave to assess the feasibility of temporarily blocking the skylight exit, in order to encourage all bats to exit via the main entrance for census filming.

The second trip was made by Faith Watkins and one volunteer on June 24. The goal of the trip was for Watkins to climb up to the interior passage leading to the skylight entrance after the bats had left for the night, and use aluminum screening to block bat access to that exit, prior to census efforts planned for the next night.

The third trip was made June 25 by Angela England, Faith Watkins, Dave Dalton, Meg Goodman, and one volunteer. The purpose of the trip was to net for bats and familiarize Dalton with the difficulties observed regarding our plan to block the skylight.

The fourth and fifth trips were made to mist net for bats, on June 27 by Dave Dalton, Sandy Wolf, and two volunteers, and on July 1 by Dalton, Wolf, and four volunteers. Each time, the cave was entered by Dalton and one volunteer after emergence and netting were completed, in order to check for downed transmitters within the cave, using 3-element antennas and Communications Specialists R-1000 receivers.

The final trip to the cave was made July 9 by Angela England, Raymond Skiles, Dave Dalton, Sandy Wolf, and four volunteers. The purpose of the final trip was to videotape the emergence flight for a population census and do a final search for downed transmitters. A 3-m by 5-m sheet of shade cloth was hung in the restriction between the first and second chamber of the cave, in order to block the bats' exit from the main entrance. The shade cloth was supported by stacked mist-net poles which were wedged into place. The filming was conducted using a Sony digital video camera model DCR-TRV19 using NightShot mode. Supplemental lighting was provided by two banks of infrared LEDs, models irlight3 and irlight6 (IRLight.com). Two filming locations were chosen, one outside the cave about 8 meters downhill from the main entrance, pointing up to attempt to film bats exiting from the skylight. The second filming location was inside the first chamber of the cave, immediately inside and to the left of the entrance, aiming at the restriction between the first and second chambers of the cave.

Searching for New Roosts:
Conversations with landowners and land managers throughout the study area included both education about bats in general and this species in particular, as well as asking if they had any potential bat roosts on their property that we could survey. In the course of fieldwork, we watched the landscape for any signs of caves, mines, cliff overhangs, and abandoned buildings. If time allowed, we were able to obtain permission of the property owner, and the site could be reached safely, we searched each structure for the presence of bats or any indicator of nectar bat use, specifically their musky-sweet smell, yellow guano splats, or bat skeletons.

RESULTS

Distribution of Agaves:
Aerial and ground-based agave surveys have allowed the elucidation of a potential nectar corridor of food resources between the El Infierno maternity roost in Nuevo Leon and the Emory Cave post-maternity roost in Texas, approximately 530 km (330 mi) to the northwest (see Figure 3).

Using the aerial agave bloom density estimation technique, we achieved our goal of locating agave populations and comparing the densities of agave bloom stalks on a landscape scale. Our surveys show that the paniculate agave populations occurring within the Texas and northeastern Mexico (states of Tamaulipas, Nuevo Leon, and Coahuila) mountain ranges typically occur above 1200 meters (4000 ft) in elevation. However, one lowland agave population can be found in the state of Tamaulipas, Mexico, along Highway 101, and another can be found to the east of the Glass Mountains along Highway 385 to the north of Marathon, Texas. In the mountains around and south of Monterrey, Nuevo Leon, there are abundant high-elevation agave populations with *L. nivalis* roosts and foraging habitat documented in the region (Moreno-Valdez pers. obs.). Our aerial surveys revealed that high-elevation agave populations extend from these abundant populations in a linear fashion from Monterrey to the Maderas Del Carmen Mountains along the Mexico/Texas border. *L. nivalis* has not yet been documented within these linear agave populations.

Bat Capture:

In 2001, mist netting around agaves in the Chisos (estimated 15 net-hours), Chinati (estimated 130 net-hours), Davis (estimated 130 net-hours), and Glass Mountains (estimated 25 net-hours) yielded the capture of 46 *Antrozous pallidus* (pallid bats), 6 *Corynorhinus townsendii* (Townsend's big-eared bat), and 1 *Pipistrellus hesperus* (western pipistrelle). Some of these other nontarget-species bats were covered with pollen, presumably from the nearby agaves. Five *L. nivalis*, 1 *M. thysanodes*, and several *C. townsendii* were netted at Emory Cave (estimated 2 net-hours); hair and tissue samples were collected from the *L. nivalis*.

In 2002, mist netting at agaves in the Davis and Chinati Mountains (135 and 168 net-hours, respectively) yielded 5 *A. pallidus*, 2 *M. thysanodes*, 1 *Tadarida brasiliensis* (Mexican free-tailed bat), and 1 *Myotis* spp. (escaped prior to identification), but no *L. nivalis*. A total of 52 net-hours at agaves in the Chisos Mountains produced 16 *L. nivalis* (8 were released without transmitters) and 1 *A. pallidus*.

In 2003, 18.5 net-hours at mist nets set around flowering agaves within the Basin on the nights of June 26 and 27 resulted in the capture of 1 *Myotis* spp. And one elf owl (*Micranthene whitneyi*), but no *L. nivalis*. Nets set at Emory Cave (8.5 net-hours) caught 31 *L. nivalis* (25 were transmittered), 40 *M. thysanodes*, 13 *C. townsendii*, and 3 *E. fuscus*.

Radio Telemetry:

No telemetry was performed in 2001.

In 2002, we radio tracked 8 *L. nivalis* within Big Bend National Park for a total of 54.75 receiver-hours. No new roosts were located, despite an emphasis on collecting telemetry data during the 2 hours at the beginning and end of each night.

The majority of the habitat used during the period several hours post-sunset and pre-dawn was primarily within the Basin, an area of approximately 13 square kilometers (five sq. miles) surrounded by the highest Chisos Mountains. Emory Cave is located high in the southwestern corner of the Basin. Occasionally, a signal was received by the aerial survey crew outside the Basin rim, but this seemed to be an exception. Little ground-based telemetry took place outside the Basin.

One evening, however, either one or two transmittered bats left the Chisos Mountains area. On the evening of June 27, the aerial survey crew picked up the signal of a transmittered bat as it left the Basin at 10:15 pm and headed west-northwest out of BBNP towards the town of Terlingua. For logistical reasons the aerial crew had to return to the Lajitas airport, cutting short pursuit, therefore it was not clear where or how far that bat eventually flew, but the signal was very loud as they approached the airport at 10:45 pm, approximately 43 kilometers (27 miles) west of the Chisos. After landing, the "air" team attempted to locate the bat by road, but was unsuccessful. This tag was never again detected for the duration of the surveys.

While searching for the first transmitter's signal, the grounded air team did pick up a strong signal from a second bat from their listening vantage near Terlingua, Texas, approximately 27 kilometers (17 miles) west of Emory Cave. This bat had been stationary within the Basin as late as 10:30 pm. The signal was strong from 23:35 until 00:05, when it faded. The next evening this bat was heard once again emerging from Emory Cave.

In 2003, we radio tracked 25 *L. nivalis* within BBNP for a total of 317 receiver-hours. We were deterred from tracking bats in areas to the south and east of the Chisos Mountains, such as Pine Canyon, Juniper Canyon, and the South Rim, due to unseasonable rainfall which washed out vehicle access, and frequent lightning storms in the area, which contraindicated long-distance hikes to and multi-night stays in high, remote areas. Thus, we focused efforts to the north and west of the Chisos, at sites which were generally accessible with a 1- to 3-hour hike and/or drive.

In addition to using the Basin, on multiple occasions transmittered bats left the Basin area and were found using areas to the west, north, and northeast of the Chisos, and then returning to Emory Cave in the morning. The area of foothills to the north of the Vernon Bailey-Pulliam Bluff range was used repeatedly by a number of bats. Detailed analysis of radio-telemetry data is still pending, and will be submitted in an addendum report when complete.

Monitoring of Emory Cave Roost:
In 2001, we visually observed between 3,000-5,000 *L. nivalis* in the visually accessible portions of Emory Cave. Bat calls in the frequency range audible to humans (species unknown) were heard from inaccessible portions of the cave.

In 2002, although a cluster of approximately 75 *Myotis thysanodes* (fringed myotis) and approximately 200 *Corynorhinus townsendii* (Townsend's big-eared bats) were seen during the first trip into the cave on July 17, no *L nivalis* were seen. Bats could, however, be heard in inaccessible reaches of the cave. During the second trip on July 20, no *Leptonycteris* were visible, but signals from two of the three active transmitters could be detected by climbing to the furthest accessible region of the cave and reaching the antenna around the corner. No population counts were attempted after this.

In 2003 we visited Emory Cave 6 times. During the first trip to Emory Cave on June 17, we estimated the emergence from the main and skylight entrances to total approximately 50-75 bats. This total included both *L. nivalis*, which we identified by its large body shape, broad wings, and noisy flight, as well as vespertilionid bats which had a smaller body size, narrower wings, and more rapid flight. Little of the characteristic yellowish guano indicative of *L. nivalis* was seen within the physically accessible areas of cave on this date, and most of it looked dry and flaky, as if it had been deposited there the previous summer. England did not believe the layout of the cave looked promising for our chances of successfully accessing the constriction leading to the skylight exit without technical climbing equipment.

During the second trip on June 24, Watkins noted water dripping over the main entrance of the cave. She was able to negotiate the climb up to the interior passage leading to the skylight entrance, but found that there was no easy way to block bat access to that exit. The dimensions of the area to be covered were approximately 3 m high by 1.3 m wide (10' x 4.5'), with the width tapering toward the top. She was unable to climb up to access the top of the opening, and believed it would be nearly impossible to hang screening.

The third Emory Cave trip on June 25 revealed several miniature waterfalls coming down across the main entrance; Watkins estimated twice as much water as on the previous night. We were unable to see if similar run-off was impeding bat access to the skylight entrance. After netting until 01:00, Dalton entered the cave to evaluate the cave layout. He agreed that the plan to block the interior restriction to the skylight was infeasible.

No run-off waterfalls were present on the fourth or fifth trips on June 27th and July 1. On the July 1 trip, 2 of the 15 previously activated transmitters were found detached within Emory Cave.

On July 9 during our final trip to the cave, there was a steady light drip from the entrance run-off waterfalls, but not to the extent seen on the second or third visit. We erected the shadecloth between the first and second chambers of the cave. A visual and nightvision scope exit count revealed that approximately 26 bats emerged from the main entrance between 21:15 and 22:00, though a great deal of audible bat calls could be heard from behind the curtain. No bats were filmed emerging from the skylight exit before 22:00, so at that time we decided to pull down the curtain and film the emergence from the first chamber. After the curtain was removed, the video camera recorded 295 bats exiting before 22:55.

After the emergence, Dalton and Skiles entered the cave, and counted an additional 100 bats remaining in the areas of the cave they were able to access. Two transmitters were recovered from within the cave, and another 2 were heard from within cracks in the cave floor, but were not accessible for recovery.

Searching for New Roosts:

Potential roost structures were searched in Texas (Davis, Glass, Chinati, and Chisos Mountain areas), in Coahuila (Sierras del Carmen, Maderas del Carmen, and some of the mountainous areas between there and Monterrey), and western Nuevo Leon and Tamaulipas. Though a variety of other bats were found, no new *Leptonycteris* roosts were located.

Community Education and Landowner Involvement:

In 2001, education packets containing nectar bat materials were included in mail-outs to 210 U.S. borderland schools. During discussions with landowners about the *L. nivalis* project, we provided material packets describing the project and general natural history information of bats in the area with a focus on the importance of nectar bats to increase appreciation of these beneficial animals.

In 2002, we did not focus on educational initiatives to the general public, but we worked more closely with local businesses, agencies, and landowners to educate them about the benefits of local bat populations, including nectar bats. We provided material packets describing the project and general natural history of bats in the area with a focus on the importance of nectar bats.

In 2003, Meg Goodman (BCI/TPWD Texas Bat Coordinator) began a hummingbird feeder monitoring program in Terlingua, Texas, with assistance from David Long at TPWD's Barton Warnock Environmental Education Center. She also gave a bat education workshop in the Big Bend area, which was attended by over 30 people including personnel from the National Park Service, Texas Department of Transportation, Texas Parks and Wildlife Department, and various communities. Plans are underway to build an artificial roost capable of housing several thousand insectivorous bats under a bridge in Presidio County, Texas. Potential plans for a collaborative bat education project with the Chihuahuan Desert Institute are being developed for their next fiscal year.

BCI's Borderlands Project has reached over 900 educators through 12 in-service education workshops along the U.S.-Mexico border. Bilingual education materials were distributed to over 1,600 teachers, libraries, community centers, and environmental education organizations.

A Mexican Bat Conservation and Management Workshop was held in Monterrey, Mexico in January 2003, led by Dr. Arnulfo Moreno-Valdez. It was so successful that the director of Cumbres National Park has invited BCI back for a series of workshops, and is in the process of designing bat management plans for all national parks within Nuevo Leon.

In northern Mexico, Dr. Moreno-V. has collaborated in the establishment of a 900-acre area to protect *L. nivalis* on land privately owned by a 75-family *ejido* community. Recently, another ejido made up of 190 families agreed to participate in habitat restoration for bats on their land. Due in large part to education efforts by Dr. Moreno-V., over 75,000 agaves were planted last season by communities for the purposes of erosion control. He is working closely with state and local government officials in Laguna de Sanchez, Santiago, and Nuevo Leon, where the agave-planting program complements an existing program to support fire prevention and restore burned areas.

Discussion

Agave Survey Methods:

The aerial survey technique we developed proved successful at visually locating large paniculate agaves. There were several advantages to using this method, compared to ground-based survey techniques. Flying was significantly faster, gave a better view of high intermountain vegetation, and was not deterred by rough surface terrain. This method also did not require landowner permission to view areas not easily seen from publicly accessible roads.

There are a few additional considerations regarding this method. It is somewhat more costly in terms of vehicle rental, gasoline, and pilot fees. Arrangements must be made in advance if flight plans include trips across international borders (though with minimal hassle once they determine that you do not intend to land), military operations areas, and with any agencies whose airspace you intend to fly through (National Park Service, in this case). At certain seasons, NPS or other agencies may have flight ceiling restrictions; for example, NPS does not allow flights below 2000-feet-above-ground during peregrine falcon nesting season (March through July 15). Weather can also be more of a factor to an airplane than a car, especially turbulence associated with clouds or even daytime heating, and potentially the airsickness that can accompany turbulence. It takes some experience to be able to accurately identify agaves from a distance, and misidentification is a real possibility, therefore ground-truthing of aerial-collected plant data is strongly recommended whenever possible. Despite all these potential drawbacks, we feel that the aerial survey method was the most effective method available to do landscape-scale agave surveys in a timely manner. Other remote sensing techniques we evaluated have not proven feasible to provide the level of information required to make useful decisions about broad-scale agave population distributions and bloom density estimates.

The aerial survey method appears reasonably accurate for estimating the number of standing agave stalks within a 100-meter (330-ft) diameter plot. More importantly, there currently is no definition of a suitable bloom density for *L. nivalis* within migratory corridors or in the vicinity of roosts. This technique provides a reproducible method of comparing agave populations that are widely distributed across roadless and rugged terrain spanning multiple states in two countries. For future flight surveys, it should be possible to use low-level flights to determine the area of each agave population. Combining the area of extent with bloom-density estimates of agave populations could provide the information necessary to develop a method of modeling habitat needed by for *L. nivalis*.

Distribution of Agaves and Implications for Nectar-feeding Bats:

Our surveys have confirmed the presence of an agave-based nectar corridor connecting El Infierno and Emory Cave roosts (Figure 3). It is believed that the bats follow the bloom cycle of these plants between the roosts on their migration northward (USFWS, 1994). According to Gentry (1982), several different species occur within this corridor, though distinguishing the differences between each species is often difficult. Future studies should include not only the collection of botanical samples to determine where which species is found, but also physical on-the-ground surveys to determine when each species blooms.

Due to financial and logistical reasons, we were not able to determine the exact timing or longevity of the agave bloom cycles within the chain of Mexican agave populations between El Infierno and Emory Caves. In populations to the south of Monterrey, the agaves may bloom continuously from late March through early October. Determining the pattern of agave blooming between these two caves should allow a better understanding of when and where the northward and southward migrations take place. Ideally, agave bloom surveys should be combined with mist netting to confirm not only the presence of the nectar corridor but also *L. nivalis*' use of it.

Depending on the year and population location, the majority of the agaves within the Texas populations appears to begin blooming in mid May and last into late July, with staggered blooming that seems related to elevation and topographical aspect. For example, within contiguous populations, it is not uncommon for the lower 1200-m (4,000-ft) elevation agaves to finish their bloom cycle 2 weeks prior to the agaves blooming in the 1500-1800-m (5,000-6,000-ft) elevation, even within the same canyon. Minor differences in aspect also seem to play a role in local distribution and in initiating and completing the bloom period. In the Glass Mountains, we found that the agave bloom period extended from late May to mid-June at the higher altitudes, but at the lower altitudes the bloom period seemed closer in timing to that of Chisos Mountain agaves. It is possible that the higher altitude Glass population was a different species than that found in the lowlands.

Agaves believed to be *A. havardiana* (found in the Chisos Mountains) were observed within the Chinati, Davis, and Glass Mountains. It is possible that the smaller paniculate species *Agave neomexicana* exists in the mountains to the north of our study area (Gentry 1982) in low numbers and were not detectable from the air, however, it is not known if *L. nivalis* uses *A. neomexicana* as a food source.

Based on three years of surveys in the Glass, Davis, and Chinati Mountains, we believe that *L. nivalis* does not use the agaves in these regions on any kind of regular or extensive basis during the June agave-bloom period. According to Mollhagen (1971 and pers. comm.), some agaves in the Chinati region bloom as late as August. The one previous capture of *L. nivalis* from the Chinati Mountains was during this period. We recommend that any future surveys for *L. nivalis* in the Chinati Mountains focus on determining the late-summer bloom cycle of the local agaves and netting nearer the period when the Mollhagen capture occurred.

If migratory *Leptonycteris nivalis* truly do rely on the chain of "sky island" agave populations to complete their journey to Emory Cave, then it is critically important to preserve the chain continuity of each agave population. Preliminary estimates between the Mexican agave populations indicate that *L. nivalis* should easily be able to fly the distances between these "island" populations, most of which are less than 20 kilometers (12 miles) apart, well within the 40 km (24 mi) predicted flying distance of *L. nivalis* (USFWS 1994).

However, these agave populations do not appear extensive, and seem limited to specific mountaintops. In addition, agaves are regionally harvested in Mexico for a variety of reasons, including relatively large numbers for the production of mescal (USFWS 1994). The agaves harvested for fermentation to produce mescal are those full of sugars, just prior to blooming (Gentry 1982). A 2001 visit to a local distillery in Bustamante, Nuevo Leon, revealed that several hundred agave piñas are harvested annually to maintain the business. The agave distribution map shows how the chain of island populations could easily be broken if high harvests coincided with a low bloom density. Because a suitable bloom density remains undefined, any activity that limits agave distribution and density within these island populations may create a burden for bats at a time when females are attempting to complete inherently stressful migrations during pregnancy and lactation. The loss of northward migrations of these bats into Texas would be a step in the wrong direction for species recovery.

Limited information exists about *L. nivalis* foraging needs during migration or while roosting in the Chisos Mountains. Such information could provide valuable clues as to what food resources the bats require and where they are willing to go to fulfill their needs. Dr. Gretchen Jones, a palinologist with the U.S. Department of Agriculture, has produced scanning electron micrographs from pollen collected during 2001 and 2002 from *L. nivalis, A. pallidus, M. thysanodes,* and regional flowering plants. The preliminary information is being used to further pursue a determination of what flowering plant species are available and being used by these bats, and what it might mean to *L. nivalis* conservation efforts. In 2003, because of our emphasis on netting at the cave entrance at the beginning of the night, most of the bats captured had no obvious pollen loads on their fur. We did collect the pollen from the fur of 1 *L. nivalis* that was captured around 00:00 when it returned to Emory Cave (presumably to night roost after foraging), as well as guano samples from the floor of the Emory Cave roost. These samples have been sent to Dr. Jones for analysis.

Bat Capture:

The 2001 netting efforts focused on areas where *L. nivalis* has never been documented, and generally prior to *L. nivalis'* known arrival dates at Emory Cave, some 120-160 kilometers (75-100 miles) to the south. Although we netted at the time when the agaves appeared to be at the peak of their bloom, we now believe that the timing of mist-net surveys in the Glass, Davis, and possibly Chinati Mountains may have been timed too early in 2001 and 2002 to be successful. This is based on arrival times of the third week in June for the

Emory Cave population. However, just because we did not capture them does not necessarily mean they are not there. Because no *L. nivalis* has ever been captured in the Glass or Davis Mountains, and the fact that the agaves appear to bloom too early, it is unclear if the bats actually make the journey.

Our efforts indicate that *L. nivalis* are relatively easy to capture when abundant. In 2002, survey crews easily captured the number of bats needed to conduct that year's radio-tracking efforts. Because the density of bats is very high near large roosts, emerging bats must spread out across the landscape to forage, therefore survey efforts taking place relatively close to the day roost will have a better likelihood of capturing the bats. Our inability to capture bats in the Chinati Mountains may have been the result of not being near a day roost. If *L. nivalis* are indeed present in the region, it should be possible to overcome this issue by continually moving mist net locations in hopes of encountering an area in the vicinity of a day roost.

The concept of lunar phobia is mentioned throughout bat capture literature with differing opinions about its validity and its effect on different species, but no information is available on *L. nivalis*' reaction to moon phase. According to the lunar phobia theory, bats may avoid flying in areas with strong moonlight in order to reduce the risk of predation from large owls or ground-based predators such as ringtails, raccoons, cats, and skunks.

The ability of bats to visually see nets in open habitats can pose a real problem for the researchers hoping to catch them, especially during a bright full moon. In 2002, a portion of the surveys coincided with the full moon, and capture rates in the Chisos dropped to zero after moonlight hit the nets. However, nets were usually taken down shortly thereafter, so it is impossible to conclusively say that there was not simply a lull in the bats' foraging activity by that time. It is also not clear if the bats were then able to see the nets, or if the bats avoided using moonlit areas. *L. nivalis* may simply have switched their foraging strategy to utilize areas still in the shadow of tall mountains.

If *L. nivalis* is lunar phobic, the fact that we were able to capture a good number in the several hours before moonrise during the week immediately past the date of the June 2002 full moon may have been due to the nets' position in the mountain-cast shadow of the rising moon. In 2003, the limited mist netting at agaves located very near the successful 2002 capture sites did not produce any captures of *L. nivalis*. This netting effort fell during the dark phase of the moon, when there would have been no reason for the bats to concentrate feeding in those areas. This netting data argue somewhat for lunar phobia in *L. nivalis*. The radio-telemetry data from 2002 were not sufficiently fine-scaled enough to determine whether the landscape use was concentrated in shadowed areas.

Radio Tracking Surveys:
Detailed analysis of radio-telemetry data is still pending, so the following discussion should be considered preliminary.

No differences in landscape use between adult and juvenile bats are immediately obvious from the 2002 and 2003 data. Both seem to use regions where no agaves are found. Such flights consume energy, so there must be some benefit to this behavior. The reasons for the bats' excursions to these areas are unknown, but could include exploring for new day roosts, visiting night roosts, or searching for new food resources.

Weather had a significant impact on telemetry efforts in 2003. The rainy season in Big Bend usually begins in mid-July, but began a month early this year. Official weather records are available on the Internet from the NOAA Cooperative Institute for Regional Prediction (via the BBNP webpage) for 2003, but the 2002 and previous years' data are not available there. Discussions with park personnel indicated that many believed the weather to be unusual for the time of year, which matches with what we observed in 2001 and 2002.

Locally heavy rainfall washed out portions of unpaved roads leading to Pine and Juniper Canyons, which limited our access to eastern portions of the Chisos. Thunderstorms with frequent lightning were present within visual distance practically every night, and concerns about lightning hazards and volunteer safety caused us to limit overnight hikes to areas that could be reached within 1-3 hours of either trails or roads.

This impacted our plans to do telemetry from Toll and Emory Mountains and along high spots in the Blue Creek/Dodson/South Rim areas in the southern portions of the Chisos. Limited data from other positions did indicate probable bat use of the south and east portions of the Chisos, which we expected from agave distribution patterns; however, since most of these data are bearings from a single position, no triangulation is possible to allow further delineation of the type or amount of use of these more remote areas.

In 2002 we documented that 1 bat left BBNP and headed west past the Lajitas air strip, and was not heard from again during the 1 night remaining in the study session. Because the transmitter may have been shed, and we only listened for several hours on the next night, we cannot be certain that the bat itself did not return to the park, either without its transmitter or after we stopped listening. Thus, we have no way of knowing if the bat was dispersing to a new area, or simply exploring the landscape. The distance from Emory to Lajitas is approximately 27 km (17 mi), which is near the 25-km (16-mi) nightly foraging-excursion distance documented for *Leptonycteris curasoae* (Horner et al. 1990, Sahley et al. 1993). We were not set up to specifically document this sort of behavior in 2003, so we cannot contribute any solid evidence to support or deny it, but at least one bat was never heard from after its release at Emory Cave.

The emphasis of the telemetry effort each year clearly reflected on the type of data collected. In our 2002 search for new roosts, limited data were collected on foraging areas because of the post-emergence and pre-return timing of data collection. In 2003 we found that the behavior of bats during the first and last 2 hours of the night was not necessarily indicative of its movements during the rest of the night.

There were several factors that limited the usefulness of our 2002 telemetry data collection. The 2002 nighttime air crew had the mobility to be able to chase bats leaving the area, which was lucky, since one did. It is unlikely that road-based telemetry crews would have been able to maintain radio contact with the bat as long as the air crew did. Another factor was flight timing. Due to restrictions imposed by the local airport, the air team was unable to fly past 23:00 when the airport turned on runway lights specifically for them. For dawn flights they had to take off from the airstrip without airport lighting, relying only on the light of the full moon. Because of these issues and various equipment problems ranging from cable, video recorder, and laptop failures, as well as crew fatigue, only about 15 hours of air-based data was collected. Additionally, a 2-person team was inadequate for our needs for the air telemetry data processing. A third crew member to simply handle data entry and preliminary analysis would have let the air crew turn around the data in a timely manner, and aided in planning the next night's efforts.

The quality of the telemetry data collected by the airplane-based crew was handicapped by only having one beacon transmitter in the area. Although scanning for beacon frequencies takes time away from scanning for transmittered bats, the calibration of bat signals against known coordinates on the ground would have allowed increased confidence in their position estimates of the tagged bats. Among the telemetry literature surveyed (Bookhout 1996, Kenward 2001, Millspaugh and Marzluff 2001, White and Garrott 1990), there were no protocols given for triangulating ground-based with aerial-based telemetry data, and without careful calibration, we did not feel confident in developing an algorithm from scratch. Therefore, we were not able to combine the aerial and ground-based bearings in a rigorous manner.

Also, because we split our 2002 efforts between two active field sites that were 130 km (80 mi) apart (the Chisos and Chinatis), it was impossible to shuttle people or telemetry gear back and forth on a regular basis, especially given the remoteness of the Chinati site. One of the two receivers left with the Chisos team was shortly determined to be unable to hold a battery charge, and the team was left with only one working receiver until a second could be borrowed from NPS. Additionally, the three-person team in the Chisos was charged with not only collecting agave data during daylight periods, but also netting at least every other night in order to have enough transmitters active to be able to track. This generally left only one or two people for ground-based telemetry each night, since two people were needed to tend the mist nets.

In 2003 we used the lessons learned from the previous year's telemetry lessons. Agave distributions throughout the area were mapped during the week before the telemetry began, so that afterwards our sleep schedules could be switched entirely to nocturnal. We brought in outside experts with experience running large-crew radio telemetry projects, and then spent a day and a half thoroughly training all personnel on telemetry equipment and data-collection protocols. Additionally, we procured more telemetry equipment and manpower for the 2003 session, and focused all our efforts on determining *L. nivalis* movements in a field site where we were reasonably certain they could be captured. We then went to the site that was most likely to let us get the netting effort over quickly so we could focus on the telemetry data collection. One to two people nightly were in charge of a semi-mobile base station from where they directed team efforts, ensured everyone's safety, dealt with equipment problems, and called in data on bats that were generating lots of telemetry hits or seemed to be doing "interesting" things. Unfortunately, we were unable to schedule someone to do daytime data entry and analysis, but enough was learned during base station analysis to guide the next night's deployment priorities.

Notes Regarding the Emory Cave Roost:

A few comments about the structure of Emory Cave may be useful for the reader to understand limitations associated with surveying this roost. Emory Cave is dangerous, even for experienced, agile climbers. Unlike dissolution caves formed from water action with rock, Emory Cave appears to have resulted from geologic movement that formed a very large crack. The ceiling and floor are formed by unstable, wedged rocks which create platforms supporting loose rock. There is at least one boulder approximately 2 by 2 by 4 m in size that must weigh several tons, which rocks gently when touched. Caving helmets are required safety gear for all personnel who would enter this cave, as pebbles and rocks of all sizes can be expected to fall at any time. Anyone entering should tread gently, speak softly, and avoid displacing rocks of any size. No one should enter the cave without someone else present, in case of emergency.

Human access within Emory Cave is limited to standing and walking on these highly inclined wedges now covered with slick bat droppings. Human access ends after a semi-technical climb to a ledge within a 3-6 meter (10-20 ft) wide crack that extends about 18 meters (60 feet) above and below. The crack continues around a corner where bats have been heard each year of our surveys. At least 3 species of bats roost in the cave in substantial numbers - *Corynorhinus townsendii*, *Myotis thysanodes*, and *L. nivalis* (Easterla 1973).

Population Counts within the Emory Cave Roost:

In 2001, between 3,000-5,000 *L. nivalis* were observed roosting in the humanly accessible portions of Emory Cave, and more may have been roosting in remote areas of the cave. On June 20, 2002, no *Leptonycteris* were visible, but signals from 2 transmitters could be detected from inaccessible areas, confirming that *L. nivalis* was roosting in areas that could not be visually surveyed. In 2003, we believe the majority of *L. nivalis* arrived at the cave sometime between June 17 and June 24, though actual numbers were not estimated for that time period.

The inherent difficulties associated with collecting reliable internal or external population counts, combined with humanly inaccessible roost locations, leads to the conclusion that the *L. nivalis* population numbers, arrival dates, and roost type conclusions (i.e., maternity or not) for all previous Emory Cave *L. nivalis* reports should be re-evaluated. Although overall arrival times and population counts from past reports may be unreliable, there is useful information that can be gleaned, such as limited population composition (i.e., age, sex, and reproductive status), minimum population counts, and presence (recorded "absence" may have been due to the bats roosting within inaccessible regions).

The 2003 roost emergence patterns do lend additional information to support the conclusion that *L. nivalis* shows moonlight-avoidance behavior. On the first and second trips to Emory Cave, there was little or no moonlight, and numerous bats were observed flying near the presumed location of the skylight entrance. During the final trip to the cave specifically for census purposes, we planned to block the main entrance and force all the bats to exit from the skylight, however, by that week the skylight area of the cliff face was in full, strong moonlight, and even with supplemental infrared lighting, few to no bats were observed there. As soon as the curtain was removed from the restriction leading to the main entrance, bats began pouring out. The main entrance remained in the cliff's shadow until after we left the area at 00:30. We believe the bats were unwilling to risk the increased predation risk by flying directly into the moonlight at the skylight entrance, choosing instead to delay emergence and the beginning of foraging until the disturbance at the main entrance went away.

Video Protocol Recommendations for Future Population Monitoring at Emory Cave Roost:

Our recommendations for future monitoring are as follows:

1 – Winter 2003/4 – While the bats are gone for the winter, attempt to determine where the "skylight" entrance is, from vantage points above and below the site, and where the best places to view emerging bats likely may be. In order to accomplish this, someone will need to enter the cave and climb up to the restriction leading to the skylight entrance. This person will light a smoke bomb and communicate to outside viewers that it has been lit. The viewers from several sites above and below the main opening will watch for smoke emerging, and communicate which ones have the best "view." That site should be logged into a GPS and careful notes taken for how to get there again. A series of photographs may also be helpful.

2 – Winter/Spring 2004 - NPS should acquire at least one Sony digital video camera with the "Night Shot" feature, 1-2 supplemental infrared lights (such as those available from Irlight.com), a tripod suitable for holding the camera and lighting, and batteries and video tape to last 3 hours.

3 – NPS biologists should time their annual Emory Cave monitoring between June 25 and July 31, to fall approximately 2-4 days past the first-quarter moon, when the local moonset time is between 02:00 and 04:00. This should ensure that strong moonlight falls on the skylight entrance around 21:30 to 23:00, which we believe will discourage bat use of the skylight. An ideal night will have few clouds, and no heavy rain in the area for the previous several days. The video camera and infrared lighting should be set up just inside the entrance to the first room of the cave, focusing the field of view on the restricted area leading to the second room. Begin recording at 21:00 and continue until at least 23:00, switching tapes as needed. The census biologist(s) should sit quietly near the camera or just outside the cave.

4 – If a second video camera and associated gear are available, they should be positioned outside the cave in the position determined during the winter smoke bomb survey and run concurrently with the camera inside the cave.

5 – After recording is complete, the biologists should take a quick look through the cave, and note if anything seems unusual. Signs of bat mortality, human visitation, predators, or rock falls should be noted. If skeletons or carcasses of dead bats of any species are found, they should be collected and retained in the park collection for future scientific study.

6 – Back at the office, the tapes should be reviewed in a timely manner, in case any problems dictate that the survey should be redone. This tape review can be done either at full speed or slowed down for increased accuracy of species identification. For each minute of the tapes, the number of *L. nivalis* exiting and entering the cave should be tallied and recorded (see Table 3 – Sample Census Data Form).

Searching for New Roosts:

Although no new *Leptonycteris nivalis* roosts were located during this survey, it does not mean that there are no other roosts. This species is highly mobile, and there is a lot of landscape to cover between the known roosts. We believe that with additional research, it will simply be a matter of time before additional sites are located.

Community Education and Landowner Involvement:

Progress is being made in both the United States and Mexico to educate land owners and managers as well as the general public about the benefits of bats and the needs of this species.

Priorities for Future Research:

-More Mexican aerial and ground surveys are needed to determine the distribution, extent, and bloom cycle of agave populations. This information is crucial to detect weak links along the migratory corridor's chain of sky islands, and to direct future restoration and/or education efforts.

-Ground surveys in key locations are needed to determine where and when *L. nivalis* migrations occur.

-Additional surveys of potential roosts along the nectar corridor between Monterrey and Big Bend should take place, in order to secure safe rest stops for the bats as they migrate.

-Local people and government agencies should continue to be encouraged to plant agaves as a method of erosion control. They must also be educated about the bats' need for the agaves, in order to prevent the planted crops from being harvested for the production of alcoholic beverages.

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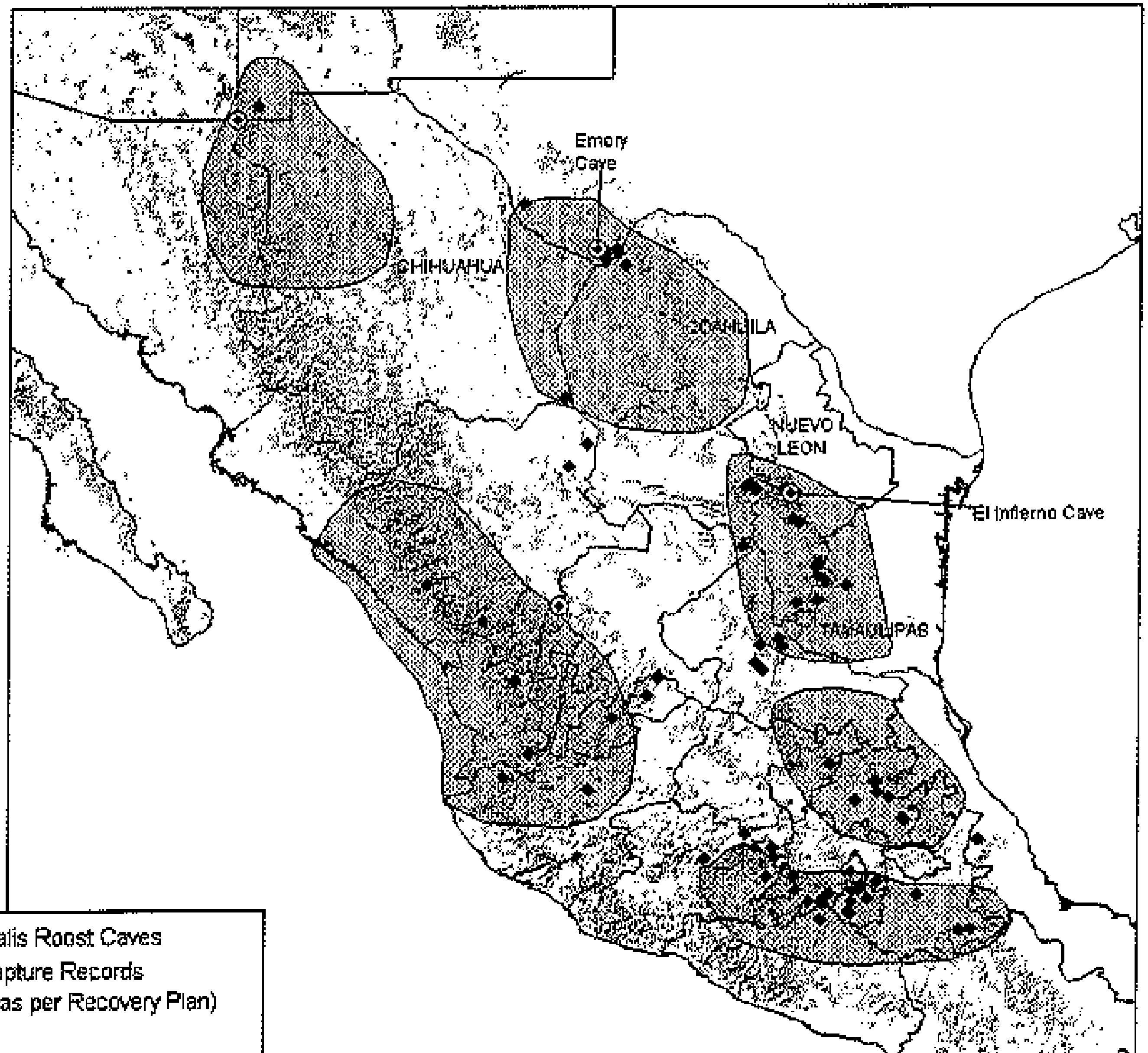
Figure 1

***Leptonycteris nivalis* Section 6 Project**

Recovery Populations & Known Localities of Mexican Long-nosed Bats



◈ Major Leptonycteris nivalis Roost Caves
◆ Leptonycteris nivalis Capture Records
Recovery Populations (as per Recovery Plan)

Figure 2

Leptonycteris nivalis
Section 6 Project

Agave Survey Regions

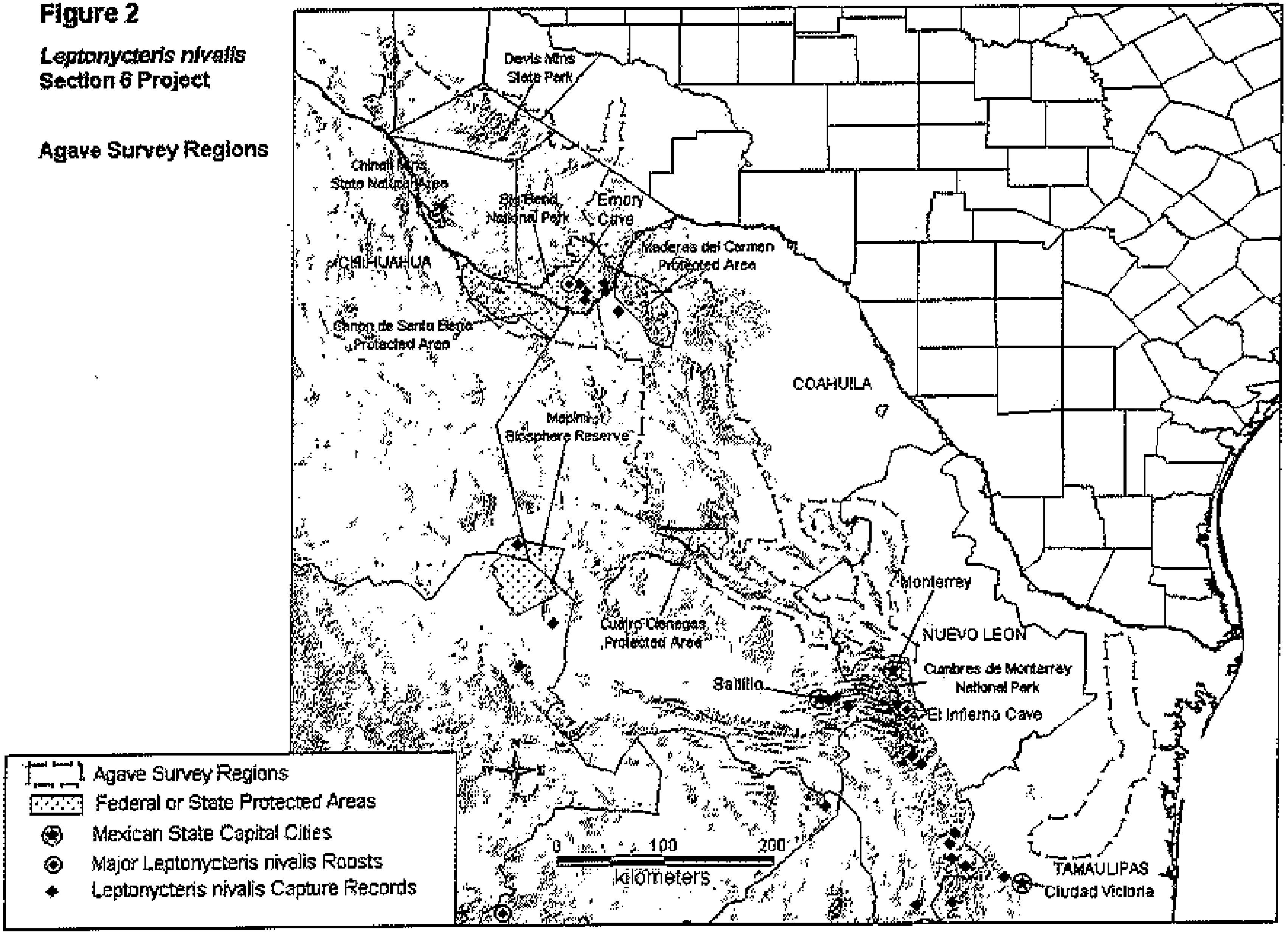


Figure 3

Leptonycteris nivalis
Section 6 Project

Agave Survey Results

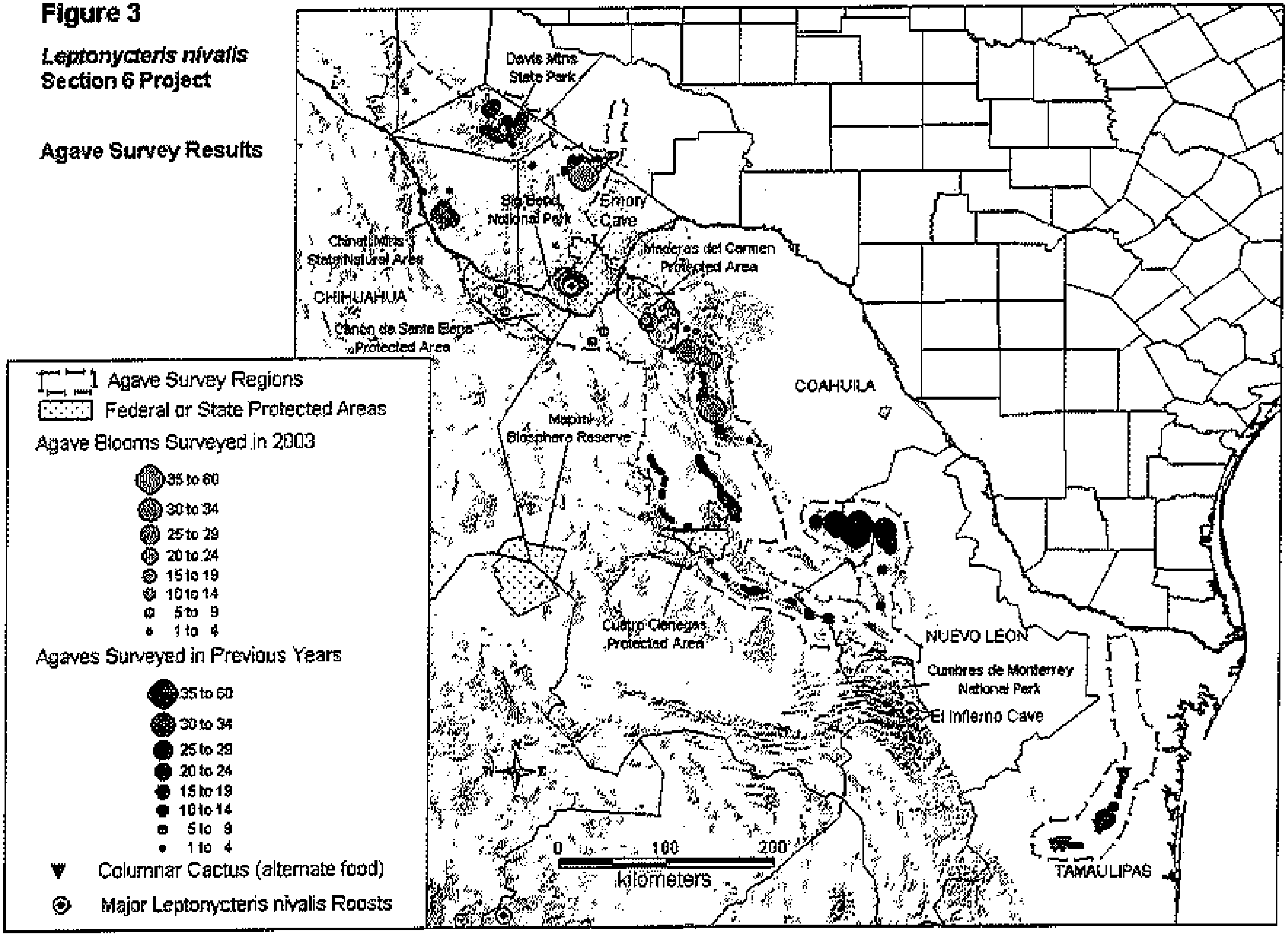


Table 1: 2002 Telemetry Results

Night of	Tag 858 adult	Tag 877 adult	Tag 943 adult	Tag 659 adult	Tag 760 juvenile	Tag 1064 juvenile	Tag 960 adult	Tag 1081 adult
June 18-19	Tagged (Basin)	Tagged (Basin)	Tagged (Basin)					
June 19-20	Heard (Basin, Emory Cave in AM)	Heard (Basin, over N wall of Basin?, Emory Cave in AM)	Heard (Basin)					
June 20-21	Heard (Basin)	-	Heard (Basin)	Tagged (Green Gulch)				
June 21-22	Heard (Basin)	-	Heard (Basin)	Heard (S. Rim / Juniper?)				
June 22-23	Heard (Basin, Emory in AM)	-	Heard (E of Ward Mtn, Emory in AM)	Heard (S. Rim, Emory in AM)	Tagged (Basin). Heard (Basin, Emory in AM)	Tagged (Basin). Heard (Green Gulch, Basin, Emory in AM)		
June 23-24	Heard (Emory in PM, Basin, Emory in AM)	-	Heard (Emory in PM, Basin, E of Ward Mtn, Emory in AM)	Heard (Emory in AM)	Heard (Emory in PM, Green Gulch, Basin, Emory in AM)	Heard (Basin, Green Gulch, Emory in AM)		
June 24-25	-	-	Heard (Basin)	-	-	Heard (Basin, Emory in AM)		
June 25-26	-	-	Heard (Ward Mtn, Downed in AM Ward Mtn)	-	-	Heard (Green Gulch, Emory in AM)	Tagged (Basin)	Tagged (Basin)
June 26-27	-	-	Downed	-	-	Heard (Emory in PM, Basin, Green Gulch)	Heard (Emory in PM, Basin)	Heard (Emory in PM, Basin)
June 27-28	-	-	Downed	-	-	-	Heard (Emory in PM, Basin)	Heard (Emory in PM, Basin, Oak Canyon, W past Lajitas)
June 28-29	-	-	Downed	-	-	-	Heard (Emory in PM, Basin, over N wall of Basin)	-
June 29-30	Downed In Emory Cave	-	Downed On Ward Mtn	Retrieved In Emory Cave PM	Retrieved In Emory Cave PM	Retrieved In Emory Cave PM	Heard (Emory Cave PM)	-

Table 2-a: 2003 Telemetry Results (preliminary, pending analysis) part 1 – first set of transmittered bats.

Night Of	Tag 000 juvenile female nonrep	Tag 022 juvenile female nonrep	Tag 044 juvenile female nonrep	Tag 064 juvenile male nonrep	Tag 104 adult female nonrep	Tag 680 adult female nonrep	Tag 690 adult female nonrep	Tag 701 adult female nonrep	Tag 710 adult male nonrep	Tag 740 adult female lac	Tag 761 adult female nonrep	Tag 780 juvenile female nonrep	Tag 792 adult female lac	Tag 832 juvenile male nonrep	Tag 850 adult female postlac
June 25-26						Tagged (Emory)	Tagged (Emory)	Tagged (Emory)	Tagged (Emory)						
June 26-27						-	Heard (Basin, N of Basin)	-	Heard (Basin, N of Basin)						
June 27-28	Tagged (Emory) Heard (Basin)	Tagged (Emory) Heard (Basin)	Tagged (Emory) Heard (Basin)	Tagged (Emory) Heard (Basin)	Tagged (Emory) Heard (Basin)	-	Heard (Basin, N of Basin)	-	Heard (Basin, N of Basin)	Tagged (Emory) Heard (Basin, N outside Basin)	Tagged (Emory) Heard (Basin)	Tagged (Emory) Heard (Basin)	Tagged (Emory) Heard (Basin)	Tagged (Emory) Heard (Basin, N outside Basin)	Tagged (Emory) Heard (Basin, N outside Basin)
June 28-29	Heard (Basin)	Heard (Basin, NW outside Basin)	Heard (Basin, N & NW outside Basin)	Heard (Basin, W outside Basin)	Heard (Basin)	Heard? (S of Basin?)	Heard (Basin)	-	Heard (Basin, N & NW outside Basin)	Heard (Basin)	Heard (Basin & Green Gulch)	Heard (S of Basin)	Heard (W of Ward Mtn)	Heard (Basin, W outside Basin)	Heard (Basin, W outside Basin)
June 29-30	Heard (Basin, N oustide Basin)	Heard (Basin, NW & N & NE outside Basin)	Heard (Basin, NW outside Basin)	Heard (Basin, W outside Basin)	-	-	Heard (Basin, NW & N & NE outside Basin)	-	Heard (Basin, NW & N & NE outside Basin, Burro Mesa)	-	-	Heard (Basin, N outside Basin)	Heard (Basin, SW outside Basin)	Heard (Basin, N outside Basin)	Heard (Basin, NW outside Basin)
June 30-July 1	Heard (Basin, NW & N & NE outside Basin)	Heard (Basin, NW & N & NE outside Basin, S of Slickrock?)	Heard (Basin, N outside Basin)	Heard (Basin, NW outside Basin)	Heard (E of Paint Gap Mtn)	-	Heard (S of Basin)	-	Heard (Basin, NW & N & NE outside Basin)	-	Heard (S of Basin)	Heard (Basin)	-	Heard (Basin, NW & N & NE outside Basin)	Heard (Basin, N outside Basin)

July 1-2	Heard (Basin, N outside Basin)	Heard (N outside Basin)	Heard (Basin, N outside Basin)	-	-	-	Heard (N outside Basin)	-	Heard (N outside Basin)	-	Heard (Basin)	Heard (Basin)	-	-	-
July 2-3	Heard (Basin)	-	Heard (Basin)	Heard (Basin)	-	-	Heard (Basin)	-	Heard (Basin)	-	-	Heard (Basin)	-	Retrievd in Emory Cave	Retriev in Emory Cave
July 3-4	Heard (N outside Basin)	Heard (Basin)	Heard (Basin, W outside Basin)	-	-	-	Heard (W outside Basin)	Heard ? (NE outside Basin?)	-	-	Heard (NE outside Basin)	Heard (Basin, N outside Basin)	-		
July 4-5	?	?	?	?	?	?	?	?	?	?	?	?	?		
July 5-6	Heard (N outside Basin, Croton Peak)	-	-	-	-	-	Heard (SW outside Basin)	-	-	-	-	-	-		
July 6-7	?	?	?	?	?	?	?	?	?	?	?	?	?		
July 7-8	?	?	?	?	?	?	?	?	?	?	?	?	?		
July 8-9	?	?	?	?	?	?	?	?	?	?	?	?	?		
July 9-10	-	-	Retrieved in Emory Cave	Retrieved in Emory Cave	-	-	-	-	-	-	-	-	-		

Table 2-b: 2003 Telemetry Results (preliminary, pending analysis) part 2 – second set of transmitted bats.

Night Of	Tag 640 adult female lac	Tag 659 adult female lac	Tag 688 adult female postlac	Tag 722 adult female lac	Tag 739 adult female lac	Tag 760 adult female postlac	Tag 778 adult female nonrep	Tag 798 adult female lac	Tag 820 adult female lac	Tag 839 adult female lac
July 2-3	Tagged (Emory). Heard (Basin)	Tagged (Emory). Heard (Basin)	Tagged (Emory). Heard (Basin)	Tagged (Emory). Heard (Basin)	Tagged (Emory).	Tagged (Emory). Heard (Basin)	Tagged (Emory). Heard (Basin)	Tagged (Emory). Heard (Basin)	Tagged (Emory). Heard (Basin)	Tagged (Emory). Heard (Basin)
July 3-4	Heard (Basin)	Heard (Basin, N outside Basin)	Heard (Basin, N outside Basin)	Heard (Basin, N outside Basin)	-	Heard (Juniper? /S. Rim?)	-	Heard (Basin, N outside Basin)	Heard (Basin, N outside Basin, Juniper?)	Heard (Basin, W outside Basin)
July 4-5	?	?	?	?	?	?	?	?	?	?
July 5-6	Heard (N outside Basin)	Heard (N outside Basin)	-	-	-	Heard (N outside Basin)	-	-	Heard (N outside Basin)	Heard (N outside Basin)
July 6-7	?	?	?	?	?	?	?	?	?	?
July 7-8	?	?	?	?	?	?	?	?	?	?
July 8-9	?	?	?	?	?	?	?	?	?	?
July 9-10		Retrieved in Emory Cave							Retrieved in Emory Cave	

Table 3: Sample Census Data Form

BAT CENSUS DATA SHEET

SITE	Big Bend National Park, Emory Cave	DATE			
SPECIES	*Leptonycteris nivalis*	START		STOP	
NAME		FINAL COUNT			

TIME	#OUT	#IN	NET/ MIN	NET OUT	TIME	#OUT	#IN	NET/ MIN	NET OUT