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CONTINUED STUDIES OF BAT SPECIES OF CONCERN IN THE JEMEZ MOUNTAINS, NEW MEXICO

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by

**Michael A. Bogan, Thomas J. O'Shea, Ernest W. Valdez,
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ABSTRACT

Although some data on bats in the Jemez Mountains of New Mexico are available, the status and trends of bat populations, especially of species of concern, are not well known. In 1995, funding from Los Alamos National Laboratory (LANL) enabled us to initiate a three-year study to assess the current status of bat species of concern, elucidate distribution and relative abundance of bats in the mountains, and obtain information on roosting sites of bats; this effort has added considerably to our understanding of bats in the Jemez Mountains (Bogan et al., 1998). In 1998, LANL provided funding for an additional year to obtain more information on bat species of concern, especially the spotted bat, *Euderma maculatum*, and the big free-tailed bat, *Nyctinomops macrotis*.

During 1998 we captured and released 328 bats of 15 species (*Myotis californicus, M. ciliolabrum, M. evotis, M. thysanodes, M. volans, M. yumanensis, Lasiurus cinereus, Lasionycteris noctivagans, Pipistrellus hesperus, Eptesicus fuscus, Euderma maculatum, Corynorhinus townsendii, Antrozous pallidus, Tadarida brasiliensis,* and *Nyctinomops macrotis*). The most abundant species were *L. noctivagans,, M. evotis, M. thysanodes,* and *E. fuscus*. These species are typical inhabitants of ponderosa pine-mixed coniferous forests, where most of our study sites were located. The abundance of *L. noctivagans* is partly a function of their migration through the area in early summer. As noted in a previous report (Bogan et al., 1998), captured males outnumbered females for many species and in only one species, *M. volans*, were both sexes captured in equal numbers. Exact reasons for the observed distribution of sexes are unknown but weather, elevation, migration, gender-specific roosting requirements, and sites chosen for netting are likely explanations. We netted eight bat species of concern in the Jemez Mountains and frequently captured four of these species (*M. ciliolabrum, M. evotis, M. thysanodes,* and *M. volans*). In 1998, we also captured smaller numbers of the other four species of concern, and we found or know reliably of moderate- to large-sized roosting aggregations of two of these, *Euderma maculatum* and *Nyctinomops macrotis*. Moderately high levels of activity of *E. maculatum* were recorded along cliffs in Los Alamos Canyon at LANL, and both *E. maculatum* and

N. macrotis continued to use roosts in areas that we located in 1997. Numbers of *N. macrotis* counted at roosts varied over the course of the summer in 1998 and suggest that this species may have been using alternate roosting sites elsewhere. Our capture of only a single individual of *C. townsendii* and similar low capture frequencies in past years suggest that this bat is truly a species of concern for the Jemez Mountains region.

In 1998 we also attached radio-transmitters to five bats of three species (*E. maculatum, C. townsendii,* and *N. macrotis*) and tracked three of them to diurnal roosts. One female *E. maculatum* was tracked to a roost on a cliff face, near a roost of *N. macrotis*, whereas the male was not found. The single male *C. townsendii* was located in a cavity in a large boulder, near where the bat was captured. One of two tagged lactating female *Nyctinomops macrotis* returned to a roost originally located in 1997; the other individual was not found.

Work in 1998 helped refine our understanding of bat distributions in the Jemez Mountains, provided important information on site and roost fidelity in *E. maculatum* and *N. macrotis*, and enhanced the amount of available baseline information on status and trends of eight bat species of concern in the area.

INTRODUCTION

It is generally believed that bat populations have declined in recent decades in the United States and elsewhere (Bogan et al., 1996). Several species are listed as endangered or threatened by the U.S. Fish and Wildlife Service (USFWS), and additional species were listed as Category 1 and 2 Candidates for listing (e.g., 28 species or subspecies proposed by USFWS in 1994). In 1995, the USFWS stopped maintaining a list of Category 2 Candidate Species to concentrate on higher-priority listing needs (memorandum, Director, USFWS, July 1995). It is hoped that other entities, including the U. S. Geological Survey (USGS), other federal agencies, The Nature Conservancy, and individual states will assist in maintaining lists and acquiring information on these species of concern (former Category 2 Candidates) (Bogan et al., 1998).

Many states now protect bats and rank various species among taxa of special concern. The public has developed an increased interest in this diverse group of mammals, as exemplified by support for Bat Conservation International and bat societies in several states (e.g., Colorado). Federal land management agencies also have responsibilities relative to bat inventory, monitoring, and conservation, and carry out surveys in areas under their jurisdiction (see, for example, Bogan et al., 1996; Green et al., 1994; Lacki et al., 1993). Nonetheless, much remains to be learned of the distribution, abundance, natural history, and status and trends of bats in most areas.

The Jemez Mountains in north-central New Mexico support a diverse community of bats. Sixteen species are known (Bogan et al., 1998; Gannon, 1998), including eight species of concern (former USFWS Category 2 Candidate Species), and most of these species also occur on Bandelier National Monument (BNM) and Los Alamos National Laboratory (LANL). Previous work has been conducted on LANL and BNM by several investigators. Guthrie and Large (1980) used mist nets to sample several sites at BNM for bats, whereas both Arganbright (1987, 1991) and Judson (1990) concentrated on roosting colonies of *Tadarida brasiliensis* and *Myotis yumanensis* on BNM. Tyrell and Brack (1992) mistnetted three sites at LANL and one on BNM. Other investigators have netted bats on the Santa Fe National Forest (files and records, Museum of Southwestern Biology, University of New Mexico; Gannon, 1998) or listened for the audible echolocation cries of *E. maculatum* (Cryan, 1993). One additional species (*Myotis lucifugus),*

known from elsewhere in northern New Mexico (Findley et al., 1975; Valdez et al., in press), may occur in the Jemez Mountains, at least at lower elevations.

In 1995 the Midcontinent Ecological Science Center (MESC) of the USGS, LANL, and BNM initiated a multi-year study to determine the occurrence, distribution, and habitat use of bat species in the Jemez Mountains, New Mexico. We had seven major objectives: (1) compile and review available information on bats in the Jemez Mountains; (2) identify major information gaps for the area; (3) collect original field data on occurrence, distribution, roosting sites, and habitat use of bats in the Jemez Mountain region; (4) provide samples of common bat species to assess impacts of potential environmental contamination; (5) analyze and synthesize all data gathered; (6) provide recommendations for maintaining bats as part of the Jemez Mountains ecosystem; and (7) provide a baseline that will serve as a foundation for future bat monitoring programs.

During the summer of 1998 we captured bats at both old and new sites, instrumented a few bats with radio-transmitters, and monitored activity of *E. maculatum* and *N. macrotis* at roosts found in 1997. Work was conducted primarily on LANL and the Santa Fe National Forest, with some work at BNM.

METHODS AND MATERIALS

We captured bats in mist nets which were strategically placed in likely flyways, over streams, rivers, stock ponds, pools of water, and along cliff faces. On the Santa Fe National Forest we netted sites ranging from arid piñon-juniper forest at ca. 1800 m to mixed coniferous forests at elevations of 3200 m. On LANL we netted canyon bottoms and cliff walls with forests of mixed piñon-juniper and ponderosa pine at elevations around 2000 m. Netting methods followed those outlined by Kunz and Kurta (1988). Nets were deployed at dusk, monitored continuously while set, and taken down at varied times, based on the amount of bat activity or weather. When a bat was captured, investigators' names, the date, the time, bat species, sex, age (based on epiphyseal fusion; Anthony, 1988), and reproductive characteristics (scrotal, non-scrotal, pregnant, lactating, or post-lactating) were recorded. We also recorded position and elevation of net sites, using a global positioning system (GPS) and topographic maps. All

capture, handling, and radio-tagging of bats followed a written protocol approved by the MESC Animal Care and Use Committee. Recorded data were later entered into a computer database; completed data sheets and the computerized database are on file at the Albuquerque office of USGS-Biological Resources Division. Common and scientific names of bats follow Jones et al. (1997), with the exception of *Corynorhinus townsendii* (Tumlinson and Douglas, 1992).

We instrumented small numbers of *Nyctinomops macrotis*, *Euderma maculatum*, and *Corynorhinus townsendii* with miniaturized radio-transmitters (164MHz, Model LB2 & BD-2B, 0.5g & 0.6 g, Holohil Systems Ltd., Woodlawn, Ontario) that were attached with a medical adhesive (Skin Bond©) applied to the dorsum after trimming a small patch of hair in the interscapular area. After we attached radio-transmitters, bats were held for 30 minutes to allow for the adhesive to bond completely to the radios and bats. Bats were then released from point of capture and monitored with radio receivers and antennas. We followed radio-tracking techniques and procedures described by Wilkinson and Bradbury (1988). Unlike the summer of 1997, we did not use aircraft but instead located instrumented bats by means of ground searches. We used hand-held, 3-element Yagi antennae and portable receivers (Model TRX 1000-S, Wildlife Materials, Carbondale, Illinois, 62901).

During 1997, we collected 13 male *Antrozous pallidus* from locations on LANL for contaminant analysis. In 1998, we collected 3 additional male *A. pallidus* from lower Los Alamos Canyon, LANL, and 16 from the Santa Fe National Forest to serve as off-site comparisons. Relative age (adult or young), reproductive status, locality, date, and time were recorded, and the specimen was placed in a plastic contaminant bag with a LANL Chain-of-Custody form. These bats were deposited at LANL (ESH-20) under the supervision of Dave Keller.

As an adjunct, we also collected guano samples from most captured bats. As bats were taken from the net and identified, they were then placed in plastic, zip-lock bags. Time, date, species, and sex of the bat were written on the bag. Bats were held in the plastic bags for 10 to 15 minutes, then released. We collected guano primarily as a part of study examining relationships of *Myotis ciliolabrum* and *Myotis californicus*, but we included other bat species as well. *Myotis californicus* and *M. ciliolabrum* are often difficult to identify (Bogan, 1974).

Characteristics we used for distinguishing the two species in the field were lighter, more blonde pelage, and brown face mask in *M. californicus* and darker, longer pelage, and black face mask in *M. ciliolabrum* (Bogan, 1974). Constantine (1998) stated that the tail in *M. ciliolabrum* extends farther from the edge of the uropatagium than that of *M. californicus*. Thus far we have not found this character of great value in the Jemez Mountains, although this may be due to geographic variation in the two species. Guano samples were sent to Indiana State University for analysis and results are not available at this time. Small numbers of male and non-reproductive female *M. ciliolabrum* and *M. californicus* were kept to verify species identifications for the guano samples.

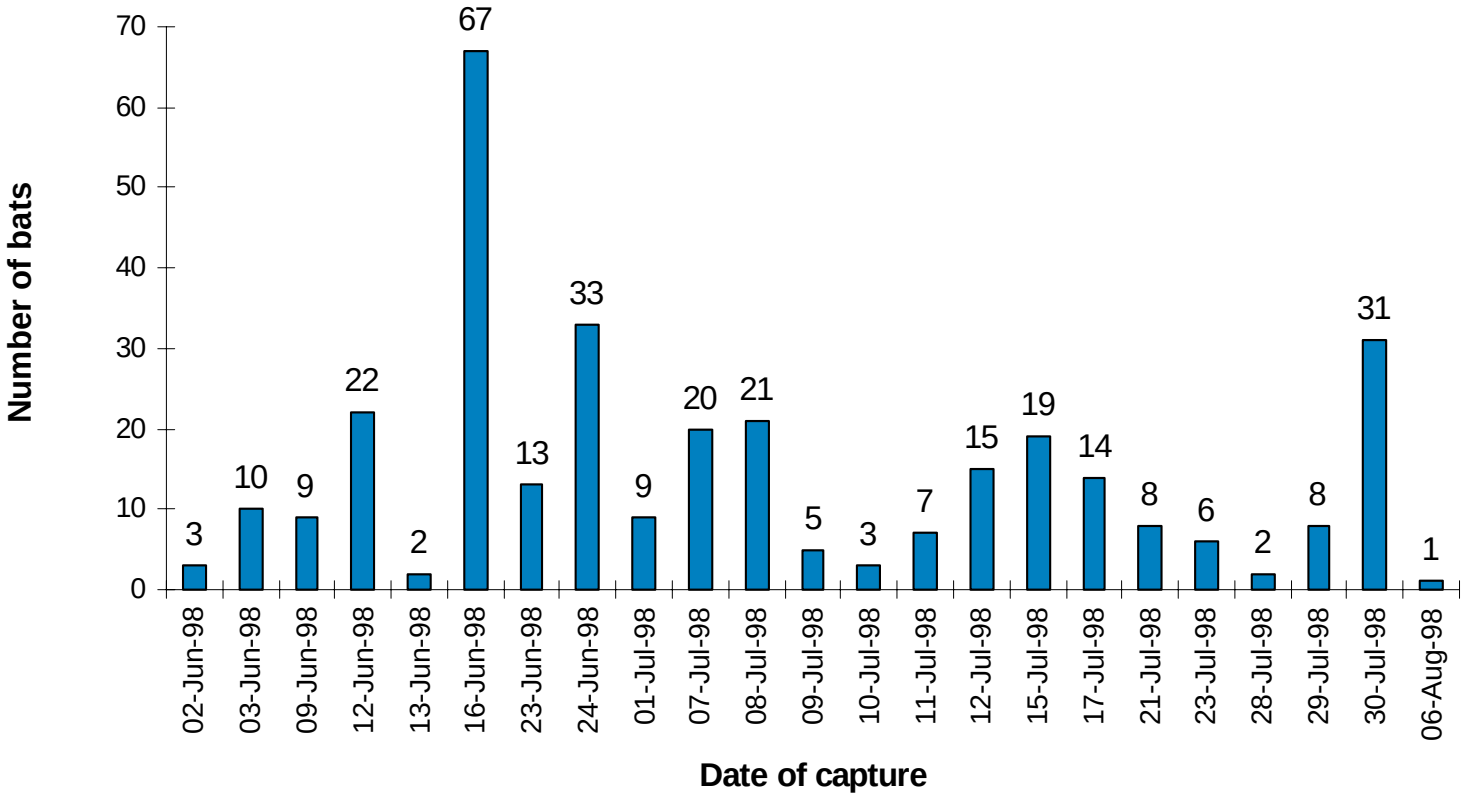
RESULTS AND DISCUSSION

Bat captures.--We deployed nets on 24 nights in 1998 and captured 328 bats of 15 species at a variety of habitats (Table 1 and Appendix). Netting success (numbers of captures) was slightly higher earlier in the season before the onset of summer rains; numbers of individuals declined at each capture site as the amount of available water presumably increased in the region (Fig. 1).

Table 1. Bats netted during 1998 with percent of males and percent frequency of total count. Asterisks denote Species of Concern.

Species	Male	Female	Total	% Male	% Frequency of Total
M. californicus	6	2	8	75	2.43
* M. ciliolabrum	7	4	11	63	3.35
* M. evotis	38	27	65	58	19.82
* M. thysanodes	33	23	56	58	17.10
* M. volans	17	17	34	50	10.37
* M. yumanensis		3	3	0	0.91
L. cinereus	8		8	100	2.43
L. noctivagans	76	1	77	98	23.48
P. hesperus	1		1	100	0.31
E. fuscus	23	12	35	65	10.67
* E. maculatum	1	1	2	50	0.60
* C. townsendii	1		1	100	0.31
A. pallidus	19		19	100	5.79
T. brasiliensis	4		4	100	1.21
* N. macrotis		3	3	0	0.91
Myotis sp.	1		1	100	0.31
TOTAL	235	93	328	71	100

Fig. 1. Number of bats captured per night during 1998



As in previous years, *L. noctivagans* was the most abundant bat in our samples (Fig. 2), a result of its migration through the state in late spring as well as the summer-long occurrence of males at high elevations. Other species captured in moderate numbers were *M. evotis, M. thysanodes, E. fuscus,* and *M. volans*. Of these four species, only *E. fuscus* is not a species of concern. All five species are common inhabitants of ponderosa pine and mixed coniferous forests and have been frequently captured in previous years of the study (Bogan et al., 1998). Species composition of our total sample of captured bats is probably a function of netting locations and habitat variables at those sites, including proximity to roosting sites.

Some species are captured more regularly during netting attempts than others. Those species that were captured most often (numbers of nights) included *M. evotis, M. volans, M. thysanodes, E. fuscus,* and *L. noctivagans* (Fig. 3). As noted in earlier reports, those species captured less frequently or in small numbers may be more active at elevations below where we conducted most of our work. The most widespread species, as indicated by numbers of sites where they were captured were *M. thysanodes*, *M. evotis*, *M. volans*, *E. fuscus*, and *L. noctivagans*. Other species were caught at one to six different sites (Fig. 4).

Reproduction.--Male bats continued to dominate our captures in the Jemez Mountains (Table 1); only *M. volans* was captured in equal numbers of males and females. Sampling error may account for the absence of females in species captured in low numbers. Gender-specific aspects of maternity roost selection by females probably contributes to the observed pattern as well. The general picture in the Jemez Mountains is one of males appearing to be widespread in time and space whereas females are more restricted in occurrence. We have no reason to suspect that females are actually less abundant than males, although this is a possibility.

About two-thirds of female bats captured in 1998 were reproductive (pregnant, lactating, or post-lactating; Fig. 5) with about equal numbers of pregnant and lactating females (Table 2). Females captured early in the season may not have been detected as pregnant when in fact they were, and reduced netting efforts late in the season may have reduced the numbers of post-lactating females captured. Only about 20% of the males captured were noted as reproductively active but again, reduced netting efforts late in the season may have affected these data (Fig. 6,

Fig. 2. Number of bats captured during 1998

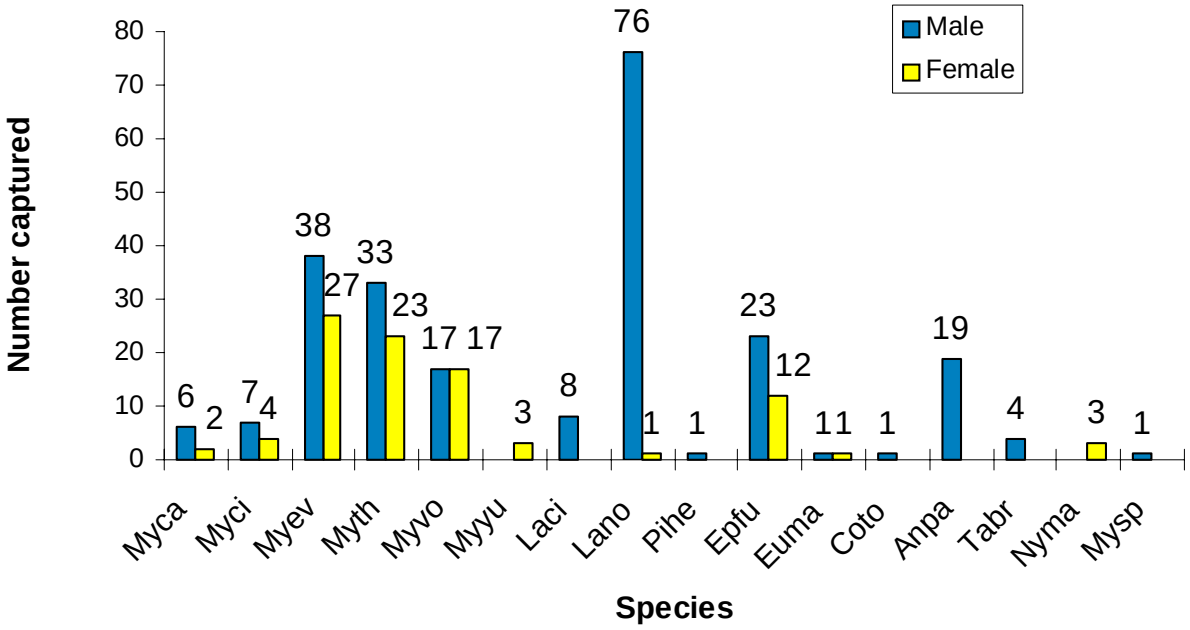


Fig. 3. Number of nights bat were captured during 1998

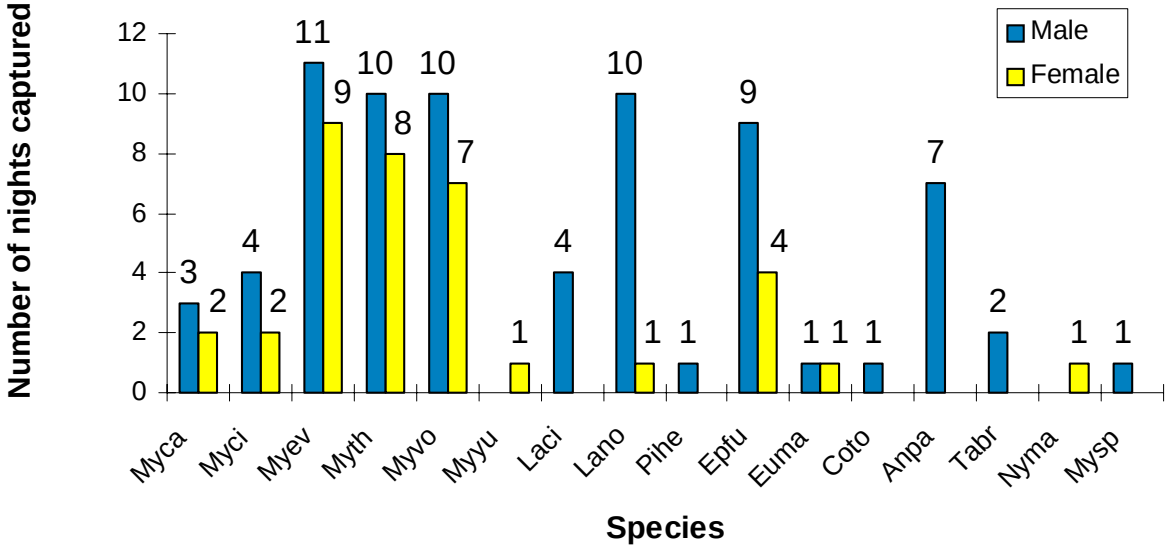


Fig. 4. Number of capture sites for each species during 1998

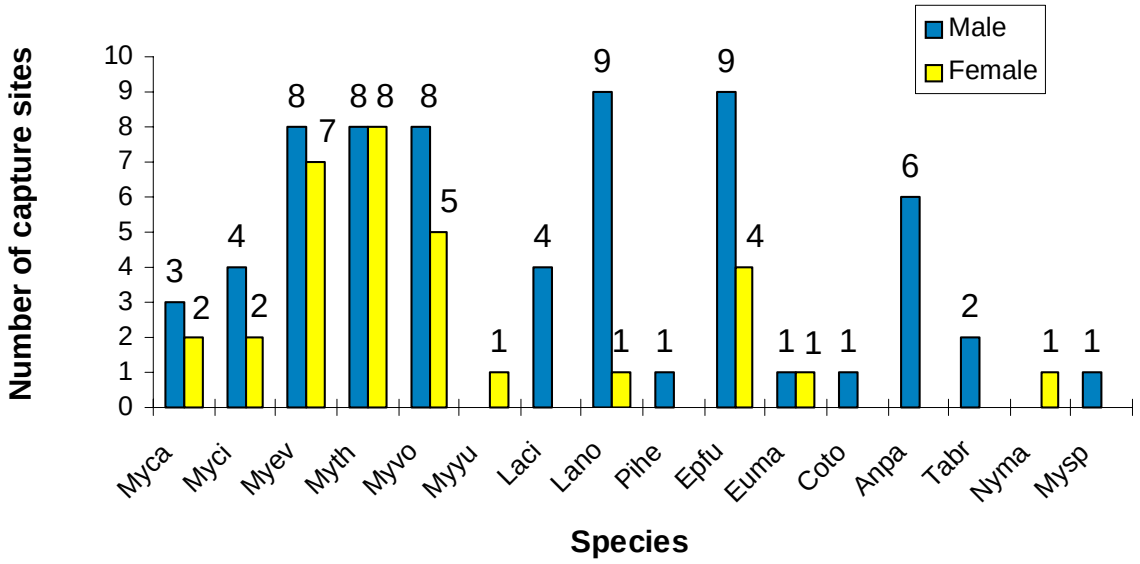


Fig. 5. Number of reproductive and non-reproductive females captured during 1998

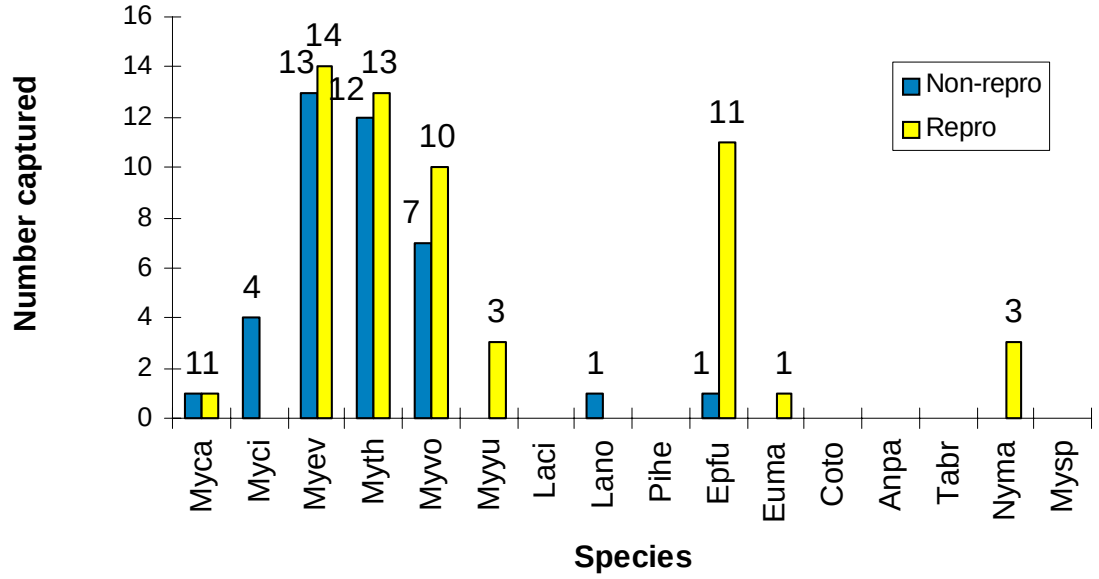


Fig. 6. Number of reproductive and non-reproductive males captured during 1998

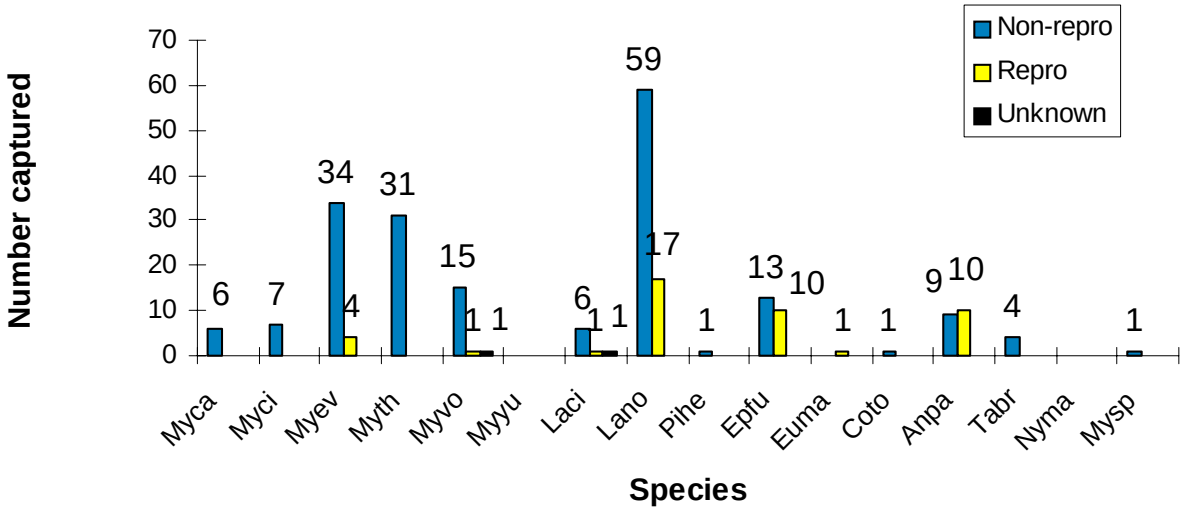


Table 3). Male bats in north temperate zones typically produce sperm late in the summer and into fall.

Table 2. Reproductive status of female bats captured during 1998.

Species	adult	lactating	pregnant	postlactating	juvenile
M. californicus	1	1			
M. ciliolabrum	4				
M. evotis	13	3	11		
M. thysanodes	11	5	8		1
M. volans	7	6	3	1	
M. yumanensis		3			
L. cinereus					
L. noctivagans	1				
P. hesperus					
E. fuscus	1	3	8		
E. maculatum		1			
C. townsendii					
A. pallidus					
N. macrotis		3			
T. brasiliensis					
TOTAL	38	25	30	1	1

Table 3. Reproductive status of males captured during 1998.

Species	adult	scrotal	juvenile	unknown
M. californicus	6			
M. ciliolabrum	7			
M. evotis	34	4		
M. thysanodes	30		1	
M. volans	15	1		1
M. yumanensis				
L. cinereus	6	1		1
L. noctivagans	59	17		
P. hesperus	1			
E. fuscus	13	10		
E. maculatum		1		
C. townsendii	1			
A. pallidus	9	10		
N. macrotis				
T. brasiliensis	4			
Myotis sp.	1			
TOTAL	186	44	1	2

A few specific observations on reproduction follow: females of *M. volans* were found pregnant as early as 16 June, lactating on 7 July, and post-lactating by 6 August 1998. All male *M. volans* captured were adult, with only one of these recorded as being "scrotal" (30 July 1998). Three lactating female *M. yumanensis* were netted in San Diego Canyon on 23 July 1998. Only one of eight adult male *L. cinereus* was recorded as "scrotal" (15 July). The first scrotal male *L. noctivagans* was netted 24 June 1998. The first scrotal male *E. fuscus* we observed was on 23 June 1998. The first pregnant *E. fuscus* was netted on 12 June 1998, and the first lactating female of this species was netted 15 July 1998.

Radio-tracking and roost observations.--We spent approximately 25 days observing known roosts of *E. maculatum* and *N. macrotis* that were found in 1997 as we wanted to assess roost fidelity across years. Additional time was spent radio-tracking instrumented bats of these two species as well as one *C. townsendii*.

Because of our successful capture of flying young-of-the-year *E. maculatum* in lower Los Alamos Canyon in 1997, we monitored activity of this species in both Los Alamos and Pueblo canyons on LANL. Although we always listened for this species when netting (and we usually

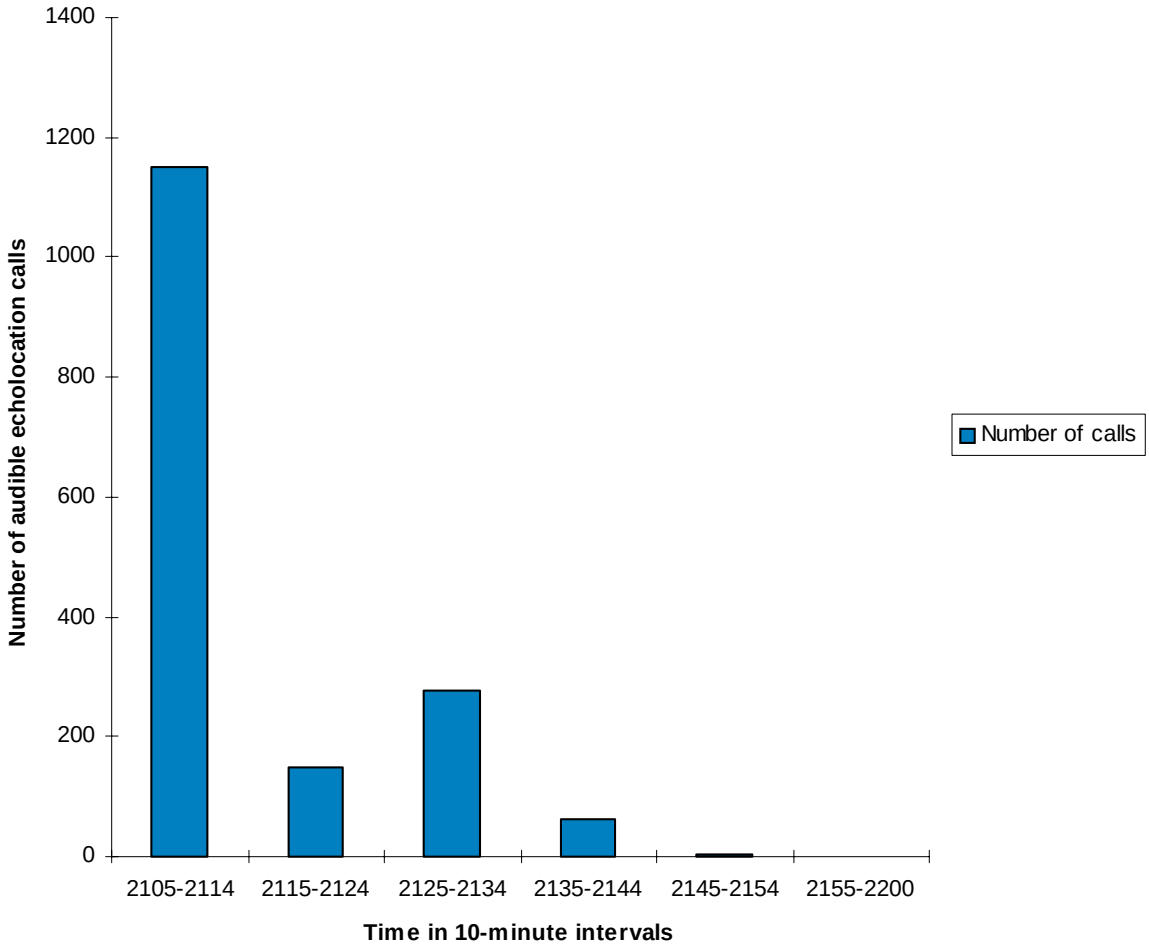
heard one or more), our observations in these two canyons were obtained by stationing ourselves at the bases of cliffs before the bats flew and then counting numbers of individuals and audible calls of *E. maculatum*. We also recorded the direction that the bats were flying. We observed considerable activity of spotted bats along cliffs in Los Alamos Canyon where bats had been radio-tracked to roosts in 1997. It appears that *E. maculatum* uses the same roosts, or at least the same general area, across years.

On the night of 2 June 1998, for example, we heard audible cries of spotted bats soon after sunset right at the cliffs, and saw and heard individuals flying along and just above the canyon walls. This early period, which would coincide with what may be an immediate post-emergence "reconnaissance" of the roosting area by resident bats, was characterized by a great deal of activity as measured by counts of audible echolocation calls (Fig. 7). These calls peaked right at dark, then dropped off as bats presumably left the roosting area to forage farther afield. Our observations of *E. maculatum* in 1997 verified that this species uses high cliff walls for roosts, and lower Los Alamos Canyon has an ample number of potential roosting sites.

Although these bats were present in the same general roosting areas as in 1997, no *E. maculatum* were netted on LANL during 1998. However, on 15 July 1998, we netted a scrotal male and a lactating female at the East Fork of the Jemez River (Santa Fe National Forest). Both were fitted with radio-transmitters and then released. The lactating female was tracked to the same cliff face in lower San Diego Canyon that a colony of *N. macrotis* was using in 1997. Based on observations at emergence, this individual apparently shared the roost with 9 to 11 other *E. maculatum*. We were not able to locate the male *E. maculatum* after it was released.

A non-scrotal male *Corynorhinus townsendii* was netted over the Guadalupe River in the Santa Fe National Forest and radio-tagged on 12 July 1998 . This bat was later tracked to an exposed cavity in a large boulder about 0.2 mi SW of the capture site. This bat appeared to be roosting by itself, typical for solitary males of this species. No female *C. townsendii* were captured nor did we find any maternity colonies in the Jemez Mountains. A single capture of *C. townsendii* may indicate how uncommon these bats are in the region. Bats of this species are very maneuverable and may be able to avoid our nets somewhat more easily than other species.

Figure 7. Number of distinctive audible echolocation calls of spotted bats heard by a single observer in a section of cliff at Los Alamos Canyon where spotted bats were known to roost from radio tracking studies in 1997. Calls peak right after sunset when bats emerge but decline thereafter, presumably as the bats disperse to feed.



We netted three lactating *N. macrotis* at the East Fork of the Jemez River and placed radio-transmitters on two of them. One of the females was subsequently located in San Diego Canyon at the same roost that was used by radio-tagged *N. macrotis* during the summer of 1997. The second bat was not located despite intensive searches.

We continued to monitor roosts of *Nyctinomops macrotis* in San Diego, Capulin, and Alamo canyons. We watched for the silhouetted forms of *Nyctinomops macrotis* against the sky and counted bats conservatively in groups of 100 to 200 individuals as they emerged. We observed the roost in San Diego Canyon every seven days from 1 June 1998 to 10 Aug 1998. Initially, the number of bats exiting the roost was about 20 individuals. This number peaked to 6000 individuals on 22 June, followed by a dramatic decrease on 30 June (Fig. 8). Unfortunately, our data on this colony for 1997-1998 do not completely overlap across years but we believe the colony was present most of the summer in 1997 and that young bats were fledged at the site. The reduction in number in late June of 1998 is likely due to movement (or migration) and suggests that the colony moved to another site to give birth and raise young. The fact that we tracked one lactating female *N. macrotis* to this site in mid-July demonstrates the site was still being used as a maternity colony, although perhaps by fewer bats. We observed a peregrine falcon capture a *N. macrotis* in flight as the bat exited the roost.

In addition to counting the number of *N. macrotis* exiting the roost in San Diego Canyon, we also counted the numbers of "warbled chirps" we heard, chirps which we believe are coaxing calls from adults to young (Fig. 9). We observed what we believe were adults flying near the roost and giving warbled chirps to which young bats in the roost responded. Our data on vocalizations are not consistent with numbers of bats observed as we heard the greatest number of chirps about two weeks after we counted the greatest number of emerging bats. Both types of estimates are subject to considerable observer error, and in the absence of sophisticated equipment to monitor individuals or vocalizations, we are reluctant to draw any conclusions. However, there can be no doubt that this particular site, or ones very close to it, were used by lactating female *N. macrotis* to give birth and raise young in both 1997 and 1998. Only the actual numbers are in doubt.

Roosts in Capulin and Alamo canyons (BNM) were not monitored until July. We visited the roost in Capulin Canyon used by *N. macrotis* in 1997 three different times. On 14 July 1998, we counted 68 *N. macrotis* exiting the roost; on 27 July 1998, we counted 103; and on 12 August 1998, we counted 46 bats exiting from the roost. These numbers were similar to those counted at about the same time during 1997. The increase in numbers on 27 July 1998 may be due to bats

Fig. 8. Number of *Nyctinomops macrotis* counted exiting a maternity colony during the summer of 1998

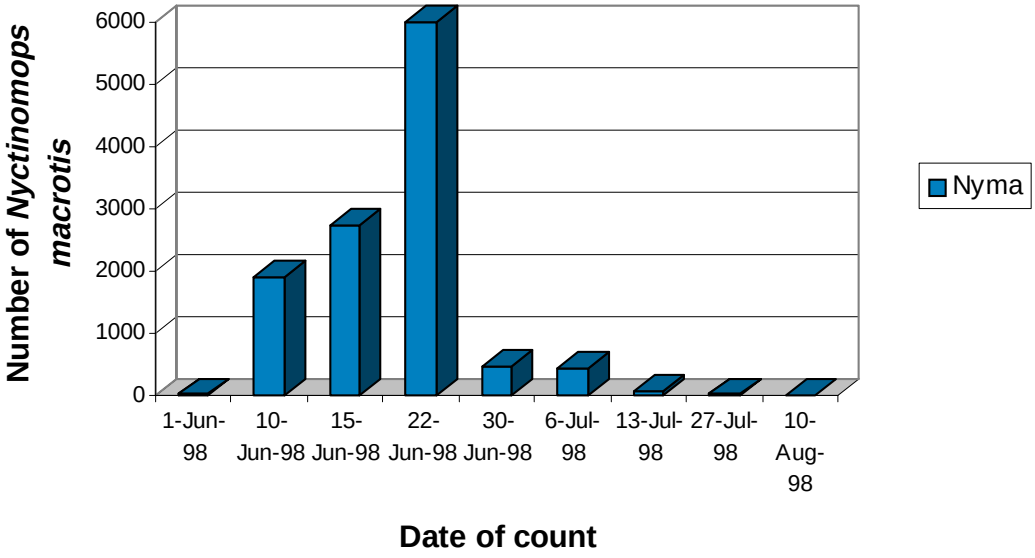
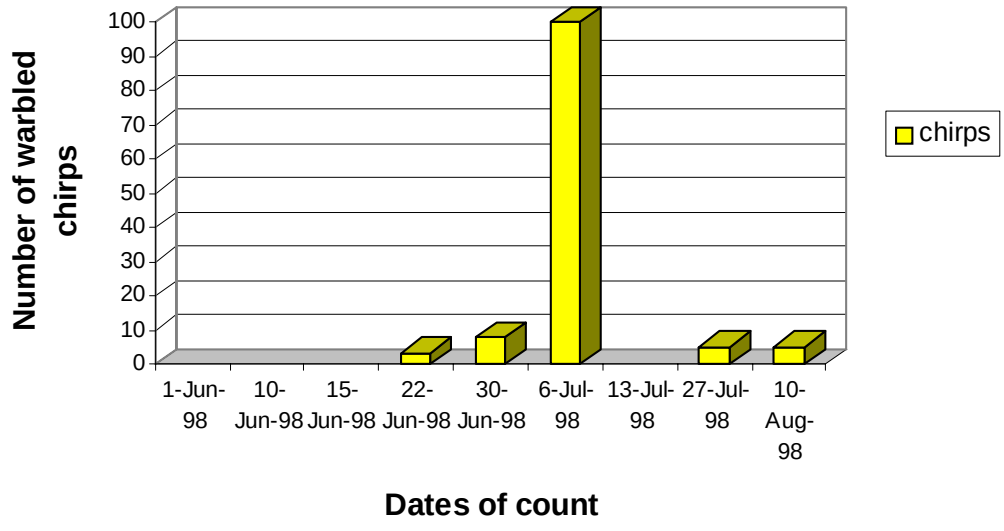


Fig. 9. Number of warbled chirps counted at a *Nyctinomops macrotis* maternity roost approximately 20 minutes after emergence.



exiting from different, but nearby, areas of the cliff face. When this roost was first located in 1997, there were about 200 bats exiting, and numbers then declined to levels similar to this year. We did not see any *N. macrotis* at the roost in Alamo Canyon that was located last year, but we observed about six bats of this species flying down the canyon during our visit.

As we did in 1997, we observed an apparent transient colony of *T. brasiliensis* using a roost in a portion of a cliff wall near a roost of *N. macrotis* in San Diego Canyon. On 1 June 1998, we saw between 300 to 600 bats emerging from this site; they did not return that night and were not present on subsequent visits to this area. We observed transient roosts of *T. brasiliensis*, each with a few hundred bats in them, in Pueblo Canyon on LANL in previous years (Bogan et al., 1998). Although such roosts may be used only during migration, they are likely important in terms of the temporary shelter that they provide.

SUMMARY

In 1998 we captured and released a total of 328 bats of 15 species (*Myotis californicus, M. ciliolabrum, M. evotis, M. thysanodes, M. volans, M. yumanensis, Lasiurus cinereus, Lasionycteris noctivagans, Pipistrellus hesperus, Eptesicus fuscus, Euderma maculatum, Corynorhinus townsendii, Antrozous pallidus, Tadarida brasiliensis,* and *Nyctinomops macrotis*). The most abundant species were *L. noctivagans, M. evotis, M. thysanodes,* and *E. fuscus*. As noted in previous years, captured males outnumbered females for many species and in only one species, *M. volans*, were both sexes captured in equal numbers. Reasons for the observed distribution of sexes are unknown but weather, elevation, gender-specific differences in roosting sites, and locations chosen for netting are likely explanations. We netted eight bat species of concern in the Jemez Mountains and frequently captured four of these species (*M. ciliolabrum, M. evotis, M. thysanodes,* and *M. volans*).

By monitoring previously-discovered roosts and radio-tracking additional individuals, we obtained additional information on roost selection and numbers of three additional species of concern: *E. maculatum, C. townsendii,* and *N. macrotis*. We located diurnal roosts of all three species in rocky canyon habitats. *E. maculatum* and *N. macrotis* consistently used high cliff walls as a roost source, as observed in 1997. The only radio-tracked *C. townsendii* was found

alone in an overhang of a large boulder, not uncommon for single males of this species and similar to findings on two males radio-tagged in 1997 at LANL. The numbers of *E. maculatum* observed flying in lower Los Alamos Canyon were similar to those observed in 1997. We also observed between 9 and 11 individual *E. maculatum* using a crevice as a roost in San Diego Canyon. Numbers of *N. macrotis* using a roost in San Diego Canyon varied, and numbers differed from those observed in 1997. Numbers for *N. macrotis* ranged from 5 to 6000 individuals during the summer. Reasons for this variability are uncertain and published data on numbers, movements, and roosts of *N. macrotis* are few, but the fluctuations we observed may be due to movements of bats among a network of roosts, either locally or regionally. More data are needed to resolve reasons for the movement of *N. macrotis* in the Jemez Mountains.

Many of the bat species in the Jemez Mountains roost in trees, both living and dead (Bogan et al., 1998), and the needs of these species should be incorporated into forest management plans (see also Barclay and Brigham, 1996). Other species use rocky cliffs and although most such roosts seemed secure, some of them might be susceptible to human disturbance (e.g., rock climbing) and such activities should be monitored where appropriate. Continued radio-tracking and monitoring of roosts will allow determination of exact roost requirements of these species and the extent to which species move among various roosts. Species known to be capable of long-distance flights may use water sources that are some distance from the roost. Those species not capable of flying long distances are likely to seek roosts and water sources that are in close proximity. In both cases, management of stock ponds, stock tanks, creeks, and rivers, especially in arid regions (Mollhagen and Bogan, 1997), is critical for long-term survival of bat species in the Jemez Mountains.

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APPENDIX

Descriptions of sites netted on Los Alamos National Laboratory, Bandelier National Monument, and Santa Fe National Forest during 1998. Elevation of each site in meters is enclosed in brackets. Names in parentheses (e.g., P5) are names used to monitor water sources at Bandelier National Monument.

Cebollita Spring [2833]: This is one of two Cebollita springs located on Santa Fe National Forest (the two springs are 2.25 mi from each other). This spring feeds a dirt tank with an open water expanse of about 8.3 m by 6.6 m. The tank is in an area with aspens and mixed conifers, next to Forest Service (FS) road 606, and is frequently used by cattle.

Cebollita Spring at junction of FS roads 606 and 608 [2733]: This is the other spring by this name and is south of the first spring. The spring flow is piped into a 2 m by 1 m rectangular tank that overflows, causing a small pool to form; the area also is frequented by cattle. The surrounding area consisted of an open meadow with nearby forests of aspen and mixed conifers.

Corral and Water Tank [2220]: A concrete water tank, 1 m by 1 m, is located on the west side of FS road 416 in the Santa Fe National Forest. The surrounding habitat consists primarily of piñon-juniper with scattered ponderosa pines. An old corral made of wooden posts and barbed wire is located near this tank. This site is on USGS Puye, NM, 7.5 minute quadrangle, T20N, R7E, Sec 29.

East Fork of Jemez River [2423]: We netted along the East Fork of the Jemez River about 50 m southeast of where it passes beneath State Road 4, south of the Baca land grant. Tree species in the surrounding forest include ponderosa pine and spruce with grasses prevalent along the open banks.

Frijoles Creek at Rainbow House Crossing [1835]: We netted Frijoles Creek where it widens to form a flat, gentle stretch about 60 m long and less than 30 cm deep. This location is 0.1 mi. along the horse trail that descends from the stables at Frijoles Creek. Trees and woody perennial plants within the canyon include box elder, alder, mountain birch, ponderosa pine, cottonwood, currant, and willows.

Guadalupe River [2013]: This site is located on the west side of San Diego Canyon on the Santa Fe National Forest. Here the river flows between high canyon walls. There are scattered junipers and willows in the bottom of the canyon. At the deepest, the river is about 1 m deep. There are two large tunnels, through which highway 485 passes, above the netting site. GPS readings for this locality are 340757e, 3955656n.

Icehouse Pond [2348]: This is a perennial pond near the entrance to TA-16. This site was netted by Tyrell and Brack (1992), who called it Pond TA-16. Ponderosa pine forest mostly surrounds the pond. During 1998 the pond was similar in depth and size to previous years. The site is on USGS Frijoles, NM, 7.5 minute quadrangle, about three-quarters of a mile north of the intersection of routes 501 and 4; the pond is on the east side of Route 501.

Los Alamos Canyon, Lower [1982]: We netted over several small pools in the bottom of the canyon where the creek bed flattens out and runs through open forest of ponderosa pine. This location is on USGS White Rock, NM, 7.5 min. quadrangle and was accessed through a locked gate west off Route 4 in the canyon, about 0.75 mi. south of the intersection of routes 4 and 502, as Route 4 heads south to White Rock.

Lower Los Alamos Canyon, near TA-2 [1982]: This part of lower Los Alamos Canyon is located near the eastern boundary of TA-2 and the nuclear reactor. The habitat consists of ponderosa pine, grasses, forbs, and an intermittent stream.

Los Alamos Canyon - Cliffs [2012]: These sites were against cliffs in lower Los Alamos Canyon where we found guano, likely from night-roosting bats, in excavations in the cliff walls. GPS readings were 398311e, 3969956n and 388617e, 3970178n. Vegetation consisted of piñon and juniper.

Pine Spring [2400]: This spring is located on the eastern section of Santa Fe National Forest north of Los Alamos. The spring has been developed with a 0.66 m concrete wall and is at the base of a large ponderosa pine; there is a foundation of an old cabin near the spring. There are several pools from the spring that fill a small drainage, which follows the road. The surrounding habitat is a dry ponderosa pine forest. This site is on the USGS Guaje, NM, 7.5 minute quadrangle, T20N, R6E, Sec 22.

Pond near FS road 376 [2627]: This pond is in the Santa Fe National Forest 6.5 mi N, 1.7 mi W of Jemez Springs. A spring, which feeds the pond, is under a large ponderosa pine and is on the east side of FS road 376. The spring fills a small barrel and overflows into the meadow and eventually into the pond. This pond is in a meadow at the bottom of a wide canyon. The surrounding vegetation is primarily grasses with ponderosa pine and scattered aspen trees. The pond is about 18.33 m by 13.33 m wide. The edges of the pond are filled with cattails and there is some vegetation covering the surface of the water. GPS readings for this locality are 0344876e, 39702137n.

Rio Cebolla [2490]: We netted the Rio Cebolla near the crossing of Rio Cebolla and FS road 376 in the Santa Fe National Forest. The surrounding habitat is an open meadow at the bottom of a wide, shallow canyon. The vegetation of the meadow was primarily grasses with some cattails in the wet areas of the meadow. The river was about 2 m wide and 0.66 m deep where we netted. Along the edge of the canyon were coniferous forests. GPS readings for this locality are 0340653e, 3969168n.

San Antonio Creek near San Antonio Spring [2750]: This creek is located in mixed coniferous forest on the Santa Fe National Forest on FS road 376 north. The creek runs through a wide, shallow canyon with a grassy meadow on the banks of the creek. We netted north of the parking area for the San Antonio Hot Spring. This site is located on USGS Seven Springs, NM, 7.5 minute quadrangle, T20, R3E, Sec29.

San Diego Fishing Access [1933]: This is a pullout along the Jemez River on the Santa Fe National Forest. The vegetation is similar to Spanish Queen Picnic Area (below). GPS readings for this locality are 0343752e, 3952990n.

Seven Springs [2686]: This site is along Rio Cebolla just north of Seven Springs on Santa Fe National Forest. The river flows through a wide canyon with a grassy, meadow bottom and surrounding walls consisting of mixed coniferous forest and scattered aspens. GPS readings for this locality are 348463e, 3978127n.

Ski Trailhead Pond (P 5) [2723]: This is a perennial stock pond 150 m south of the (cross-country) ski trailhead located on the south side of State Route 4, 100 m east of the intersection of State Route 4 and Highway 289. The pond is approximately 10 m by 25 m and is 1 m deep. The pond faces an open field of timothy to the north and is surrounded by mixed conifer forest on all other sides consisting of Gambel oak, juniper, spruce, ponderosa pine, aspen, Douglas fir, and currant**.**

Spanish Queen Picnic Area [1966]: This is a pullout picnic area along the Jemez River south of Jemez Springs on the Santa Fe National Forest. The canyon is arid and rocky with junipers growing at the base of the canyon walls and cottonwoods, willows, and saltcedar growing along the banks of the river. GPS readings for this locality are 0344819e, 3954683n.

Stock Pond [3218]: This stock pond is located on the Santa Fe National Forest 2 mi S, 1 mi W of Las Conchas campground and is also about 1 mi N of two radio towers. This pond is surrounded by tall douglas fir, ponderosa pine, and aspen trees. The pond is about 13.33 m by 10 m and appears to be used by cattle. GPS readings for this locality are 0361902e, 3962039n.

Ted Spring [2666]: Ted Spring is located on the Santa Fe National Forest near the Dome Wilderness area. A collapsed and abandoned mine is near the road under a pile of pumice. We found the spring at the bottom of a ravine and it had a pipe that dripped into a 1.33 m oval stock tank. There was only about 0.66 m of water in this tank. The vegetation surrounding the tank

consisted of dense scrub oak and conifers. The UTM reading for this site is 371600e, 396850n on USGS Bland, NM, 7.5 minute quadrangle.

Trick Tank [2392]: This is one of two trick tanks that we found on the eastern section of Santa Fe National Forest 3 mi N, 2 mi E Los Alamos. This 8.33 m diameter metal tank with a 2 m fence around the rim, is located on a mesa with junipers and scattered grasses. This tank also was surrounded by a barbed-wire fence. The water in the tank was about 1.5 m deep. This site is arid with soil that consisted of pumice and Bandelier Tuff. This site is on USGS Guaje, NM, 7.5 minute quadrangle, T20N, R6E, Sec 25.